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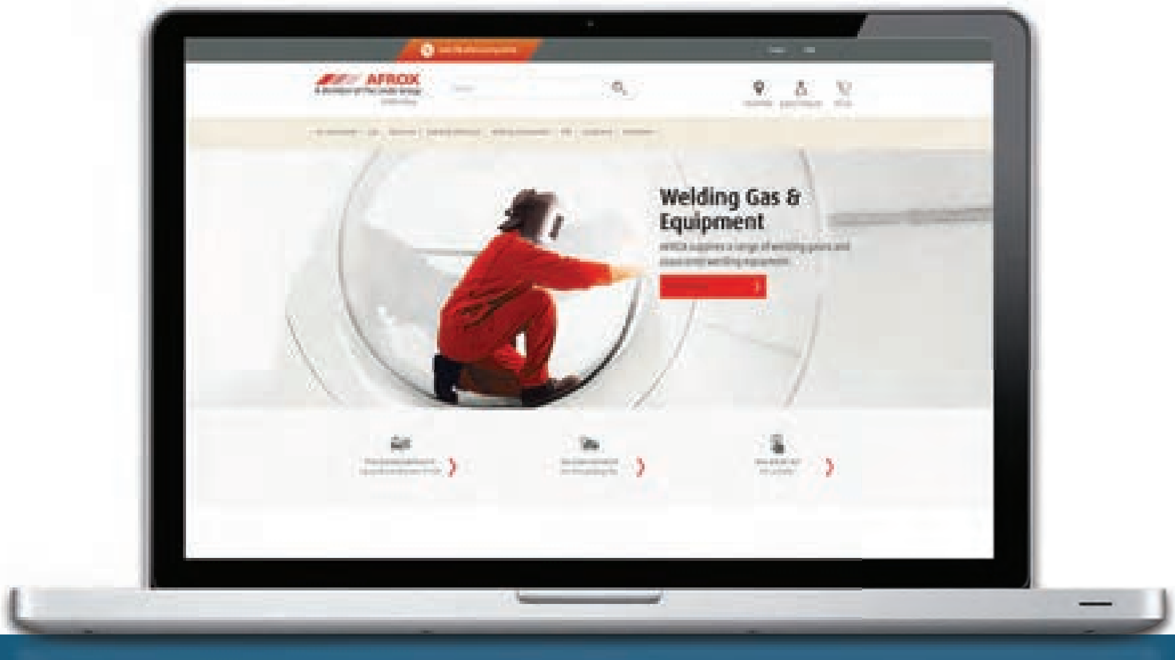

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AFROX
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Our national Customer Service Centre uses a computerised event tracking system enabling and empowering our entire service and sales organisation to meet your needs.

Afrox customers in South Africa can place orders and make account and general enquiries by simply phoning one number: 0860 020202.

HAVE AN ORDER TO PLACE FOR DELIVERY?

Phone	0860 020202
Fax	0860 020201
E-mail	customer.service@afrox.linde.com
Shop online	www.afroxshop.co.za
Internet	www.afrox.com

DISCLAIMER
Whilst great care has been taken to ensure the accuracy of the information contained in this Product Reference Manual, this does not exempt the user from verifying his/her own responsibility involved in the application of this information.

WARNING
Welding can give rise to electric shock, excessive noise, eye and skin burns dues to the arc rays, and a potential health hazard if you breathe in the emitted fumes and gases. Read all the manufacturer's instructions to achieve the correct welding conditions. Refer to www.afrox.com.

Gas & Gear and Sales Centre Contact Details in South Africa

Gauteng

Alrode	011 908 9418
Boksburg*	011 894 1076
Booysens*	011 493 1717
Carletonville	018 787 4168
Krugersdorp	011 762 1000/2286
Germiston	011 255 5092/3/5
Midrand	011 315 0263
Pretoria	012 380 0239
Roodepoort*	011 858 9507
Silverton	012 804 7854
Spartan	011 392 3660
Springs	011 362 2353
Vereeniging	016 455 1592
Wadeville	011 827 5971
Wynberg	011 262 4043

Mpumalanga

Middelburg	013 246 2921
Nelspruit	013 753 2971
Trichardt	017 638 0055
Witbank	013 655 6301

Limpopo

Steelpoort	013 230 3810
Lephalale	014 763 6771
Phalaborwa	015 781 2221
Polokwane	015 297 3739

North West

Klerksdorp	018 462 5755
Mafikeng	018 381 0175
Potchefstroom	018 297 1702
Rustenburg	014 596 5071

Free State

Bethlehem	058 303 6908
Bloemfontein	051 406 0519
Welkom	057 391 4707

Eastern Cape

East London	043 731 1511
Port Elizabeth	041 486 1200

Northern Cape

Kathu	053 723 1635
Kimberley	053 833 2582
Postmasburg	053 313 1136
Springbok	027 712 1181
Upington	054 332 1803

KwaZulu-Natal

Empangeni	035 787 1351
Kokstad	039 727 1879
Newcastle	034 375 7861
North Coast Road	031 564 0622/3
Pietermaritzburg	033 342 9188
Pinetown	031 702 6798
Pongola	034 413 2301
Port Shepstone	039 682 0330
Richards Bay	035 789 1309
Stanger	032 551 4356
Umbilo Road	031 202 3140

Western Cape

Cape Town/Epping	021 530 1124/27
George	044 802 8812/00
Montague Gardens	021 551 8100
Ottery	021 704 4690
Paarden Eiland	021 511 2196
Paarl	021 862 6197
Stikland	021 948 4710/11
Vredenburg	022 713 2277
Vredendal	027 213 1717
Worcester	023 342 2474

Trading Hours: Mon - Fri: 08h00 - 16h30 *Sat: 09h00 - 13h00

National Customer Service Centre
Tel: 0860 020202
E-mail: customer.service@afrox.linde.com
Shop online at www.afroxshop.co.za

Other African Countries

Botswana

Afrox Botswana Oxygen
Plot 20595 Mabutswe Road
Gaborone
Botswana
Tel: +267 390 5030

Kenya

BOC Kenya
14 Kitui Road
Industrial Area
Nairobi
Kenya
Tel: +254 20 69 44 000 / 733 687 078

Malawi

Afrox Malawi Limited
Johnstone Road
Ginnery Corner
Blantyre 3
Malawi
Tel: +265 1 87 1611

Lilongwe
Plot No 29/9
Alimaunde
Kanengo
Lilongwe
Malawi
Tel: +265 1 713 238 / 710 374

Mauritius

Lez Gaz Industriels LTD
Pailles Road
G.R.N.W
Mauritius
Tel: +230 212 8306

Mozambique

BOC Gases – Afrox Mozambique Limitada
Av. Das Industrias 600
Machave
Maputo
Mozambique
Tel: +258 21 750 336 / 752 631/4

Beira
Tel: +258 23 354336

Namibia

IGL (Pty) Limited
T/A Afrox Namibia
131 Mandume Ndemufayo Ave
Southern Industrial Area
Windhoek
Namibia
Tel: +264 61 387 000

Tsumeb
PO Box 499
Tsumeb
Namibia
Tel: +264 67 220 043

Walvis Bay
PO Box 1598
Walvis Bay
Namibia
Tel: +264 64 205 818

Zambia

Afrox Zambia Ltd
Chisokone Avenue
Plot No 901
Ndola
Zambia
Tel : +260 212 611 801/5 / 621 608/9 / 621 582

Lusaka
Sheki Sheki Road
Plot No 4278
Light Industrial Area
Lusaka
Zambia
Tel : +260 211 240 954 / 246 665 / 242 272 / 247 666

Zimbabwe

BOC Zimbabwe (Pty) Limited
BOC House
Cnr. Hull & Glasgow Roads
Southerton
Harare
Zimbabwe
Tel: +263 4 757 171-5 / 755 750-65

Bulawayo
Steelworks Road
Westgate
Zimbabwe
Tel: +263 9 634 91-5

Gweru / Electrode Factory
Bristol Road
Gweru
Zimbabwe
Tel: +263 54 216 24/6

PLEASE NOTE: Not all products shown in this catalogue are available outside of South Africa

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INTRODUCTION

1

African Oxygen Limited (Afrox) is sub-Saharan Africa's market leader in gases and welding products. Our business was founded in 1927, listed on the JSE in 1963, and has prospered by constantly meeting the needs of customers and developing solutions that add value to customers' applications.

We operate in South Africa and in seven other African countries and manage operations in five others on behalf of our parent company, The Linde Group; a world leading gases and engineering company with more than 50 000 employees working in over 100 countries worldwide. Linde's strategy is geared towards earnings-based, sustainable growth that focuses on the expansion of its international business with forward-looking products and services. Linde acts responsibly towards its shareholders, business partners, employees, society and the environment in each of its business areas, regions and locations across the globe. Linde is committed to technologies and products that unite the goals of customer value and sustainable development.

At Afrox, we believe technology holds the key to operating safely, protecting the environment and delivering unique solutions for our customers' requirements. Manufacturing of our gases and other products takes place on 48 different sites throughout southern Africa, comprising 33 units and 15 on-sites (automated plants not requiring operators), with some manufacturing sites hosting more than one unit. We continue to energise our efforts to introduce new equipment, design and manufacturing techniques and exploit cutting-edge technologies and research available as a member of The Linde Group.

GENERAL GASES

2

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GENERAL GASES INFORMATION

How do I safely connect a gas cylinder to an appliance?

When connecting your gas appliance to the gas cylinder, always ensure that the connection is made correctly and is gas tight. A smell of gas will be detected if the connection is not tight. All gas appliances have rubber or fibre washers to seal the gas tightly at the point of connection to the gas cylinder. Always check that this washer or seal is in place and in good condition. The rubber or fibre seals and hoses do wear and need to be checked periodically and replaced occasionally. Some 'Handi' tips:

- Only open valve 1½ turns
- When lighting gas appliances that don't have auto ignition:
  First light the match or lighter, hold it to the gas burner, then open the gas. The gas will ignite immediately and the flame temperature will go from 0 to 1 970°C instantly. To ensure that fresh air is always available, have a window slightly open when using gas appliances, even in cold weather
- Ensure LPG cylinders are always placed on a firm surface
- Always shut off the gas supply at the cylinder valve when the appliance is not in use
- It is very important to keep the gas jets clean. Before connecting the appliance to the gas cylinder, make sure that the valve is free of dirt and dust.

Like all electrical installations, it is legally required that fixed LPG appliances are fitted and piped to a gas cylinder(s) outside, and they must be installed by a certified LPG installer. Contact your Handigas dealer or Afrox Customer Service Centre on 0860 020202.

2

Identification of Bulk Cryogenic Products

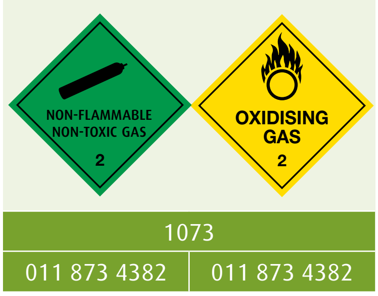
OXYGEN (0_2)

SHIPPING NAME: Oxygen, Refrigerated Liquid

UN Number: 1073

ERG: 122

Oxygen is a colourless, odourless and tasteless gas that supports life and combustion. All elements, except rare gases, react with oxygen, over a wide range of temperatures, to form oxides. Oxygen is 1,1 times heavier than air and is slightly soluble in water.



NITROGEN (N_2)

SHIPPING NAME: Nitrogen, Refrigerated Liquid

UN Number: 1977

ERG: 120

Nitrogen is colourless, odourless and tasteless. It is non-flammable, will not support combustion and is not life-supporting. The gas is slightly lighter than air and is only slightly soluble in water. When liquid nitrogen is vaporised and then heated, it consumes a large amount of heat, making it an ideal coolant.

ARGON (Ar)

SHIPPING NAME: Argon, Refrigerated Liquid

UN Number: 1951

ERG: 121

Argon is a colourless, odourless, tasteless and non-toxic gas. Argon, along with helium, neon, krypton, xenon and radon, is also known as a "rare" gas. Argon forms no known chemical compounds. The gas is 1,38 times heavier than air and is slightly soluble in water.

CARBON DIOXIDE ($C0_2$)

SHIPPING NAME: Carbon Dioxide, Refrigerated Liquid

UN Number: 2187

ERG: 120

Carbon dioxide is a slightly toxic, odourless, colourless gas with a slightly pungent, acidic taste. It will not burn or support combustion. It is 1,52 times heavier than air and is very soluble in water, forming carbonic acid. Carbon dioxide will sublime at atmospheric pressure and -78°C to solid form (dry ice).

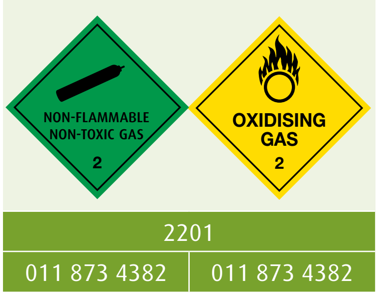
NITROUS OXIDE (N_20)

SHIPPING NAME: Nitrous Oxide, Refrigerated Liquid

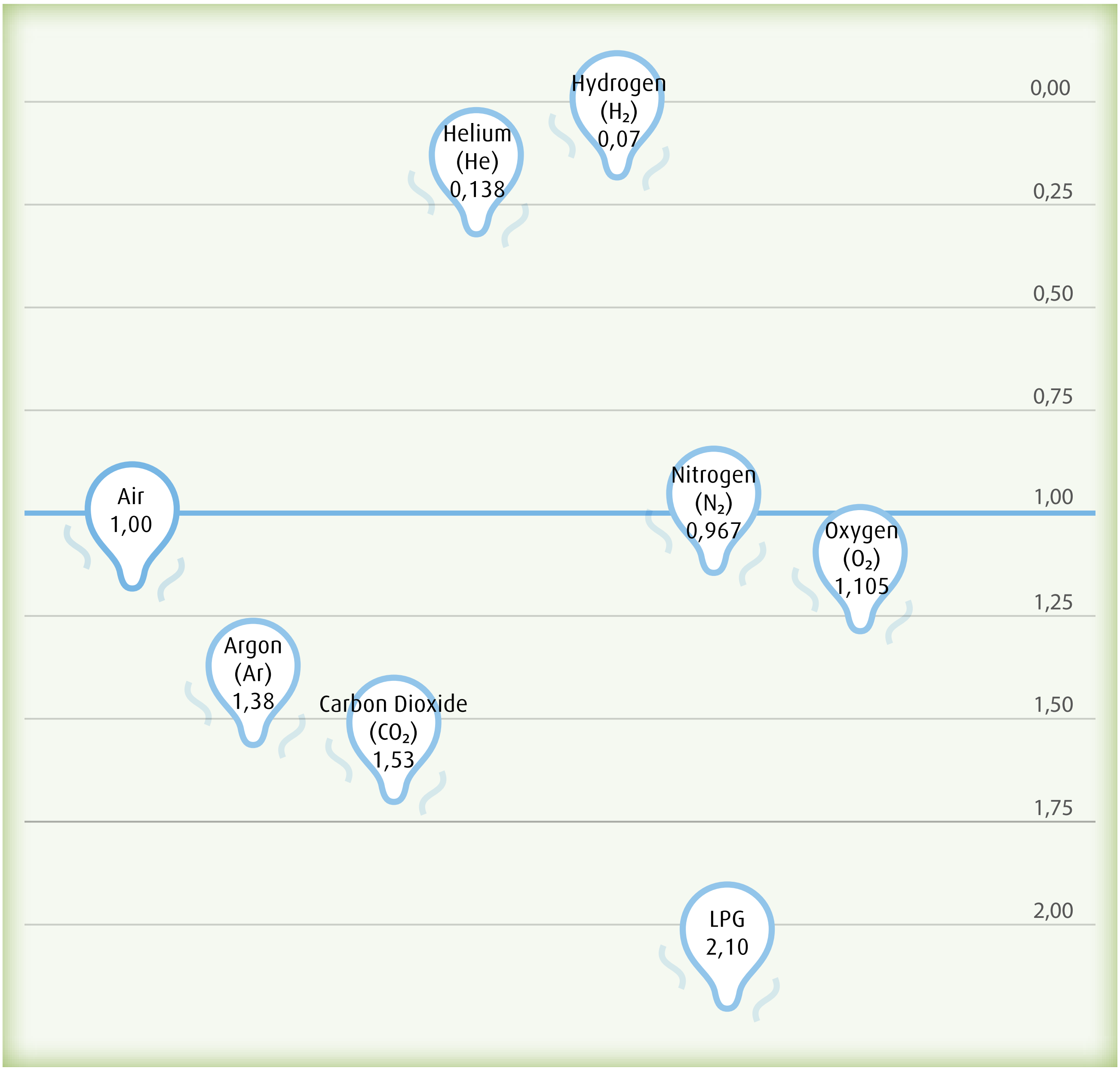
UN Number: 2201

ERG: 122

The chemical formula symbol for nitrous oxide is N_20 - two atoms of nitrogen and one of oxygen. The gas is also known as laughing gas because about 180 years ago, a young British scientist name Sir Humphrey Davy discovered that inhaling N_20 resulted in strange uncontrolled behaviour. He was working on the effects of certain gases on the body and had almost killed himself by inhaling methane to see what would happen. In 1801, he caused a sensation at a public lecture by giving N_20 to volunteers from the audience.



Relative Gas Densities

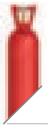


Gas Conversion and Reference Tables

Pressure Equivalents Quick Reference Chart

Millibar							
kPa	**bar**	**mb**	**atms**	**kg/cm^2**	**psi**	**mm Hg**	**Metres H_2O @ -20°C**
1,0	0,010	10,000	0,010	0,010	0,145	7,501	0,102
100,000	1,0	1,000,000	0,987	1,020	14,504	750,063	10,216
0,100	0,001	1,0	0,001	0,001	0,015	0,750	0,010
101,325	1,013	1,013,250	1,0	1,033	14,696	760,001	10,351
98,067	0,981	980,665	0,968	1,0	14,223	735,560	10,018
6,895	0,069	68,948	0,068	0,070	1,0	51,715	0,704
-0,133	-0,001	-1,333	-0,001	-0,001	-0,019	1,0	0,014
9,789	0,098	97,890	0,097	0,100	1,420	73,424	1,0

Characteristics Summary

	Gas	Symbol	Cylinder Colour	Characteristics
	Acetylene	C_2H_2	Maroon	Distinctive garlic smell. Will ignite and burn instantly when in contact with ignition sources. However, it is lighter than air. Requires minimum energy to ignite in air or oxygen. Never use copper or alloys containing more than 70% copper or 43% silver with acetylene.
	Argon	Ar	Peacock blue	Odourless. Heavier than air. Does not burn. Inert. Will cause asphyxiation in absence of sufficient oxygen to support life. Will readily collect in the bottom of a confined area. At high concentrations, almost instant unconsciousness may occur, followed by death. The prime danger is that there will be no warning signs before unconsciousness occurs.
	Carbon dioxide	CO_2	Light brundswick green	Odourless and slightly acidic gas. Will cause asphyxiation. Heavier than air. Will collect in ducts, drains and low lying areas.
	Helium	He	Mid brown	Inert but asphyxiant at high concentrations. Lighter than air.
	Hydrogen	H_2	Signal red	Odourless. Much lighter than air. Will collect at the highest point in any enclosed space unless ventilated at a high level. Fire and explosion hazard. Very low ignition energy.
	Nitrogen and oxygen-free nitrogen	N_2 or N	Shoulder black and body French Grey	Odourless. Does not burn. Inert, except at extremely high temperatures, but does not support life, so will cause asphyxiation if insufficient oxygen is present. At high concentrations, almost instant unconsciousness may occur, followed by death. The prime danger is that there are no warning signs before unconsciousness occurs.
	Oxygen	O_2	Black	Odourless. Generally considered non-toxic at atmospheric pressure. Will not burn, but supports and accelerates combustion. Materials not normally considered combustible may be ignited by sparks in oxygen rich atmospheres. For more information, contact Afrox before using any materials for oxygen service that have not been supplied for use with oxygen and marked accordingly.
	LPG	Approx. 60% C_3H_8 40% C_4H_{10}	Dark admiralty grey (Branded Handigas)	Standard LPG sold by Afrox is 'stenched' (odourised) and has a fish-like smell. Will ignite and burn instantly in contact with ignition sources. Is heavier than air and will collect in ducts, drains, etc., and low lying areas. Fire and explosion hazard. Requires minimum energy to ignite in air or oxygen.

* **Know Your Gases** – Users should always have Afrox material safety data sheets for each of the gases stored and used. Other industrial gases, special gases and medical gases are available from Afrox. If you transport, store or use any of these gases, you should always possess the relevant Afrox material safety data sheets and other safety information. Some special gases may be either toxic, flammable or corrosive and you need to take special precautions when handling them.

Note: MSDS available from www.afrox.com

Gas Volume Conversion

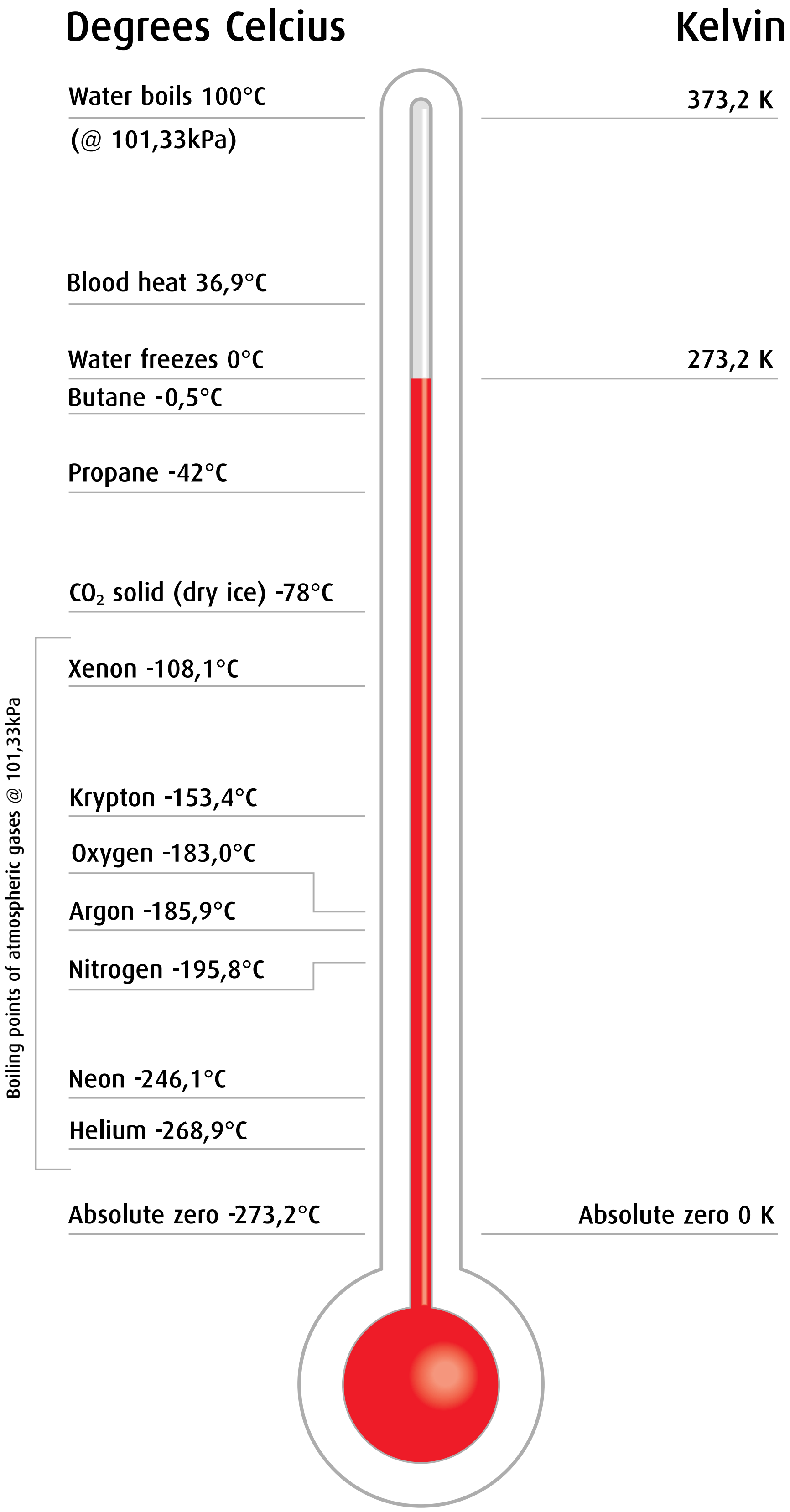
Gas	**Cubic Metres Gas @ 20°C and 101,33 kPa (Atmosphere)**
	1 kg
Acetylene	0,917
Air	0,829
Argon	0,601
Carbon dioxide	0,544
Helium	6,01
Hydrogen	11,96
Methane	1,497
Nitrogen	0,858
Nitrous oxide	0,543
Oxygen	0,751
LPG	0,484
Note: 1 m³ = 1 000 ℓ	

Gas	**Storage Conditions**	**Liquid Volume @ Storage Condition (ℓ)**	**Mass (kg)**	**Gas Volume @ 20°C and 101,33 kPa (m³)**
Argon (Ar)	-185,9°C B.Pt @ 101,33 kPa	1,0	1,39	0,84
		0,72	1,0	0,60
		1,20	1,66	1,0
Carbon dioxide (CO_2)	-26°C and 1 500 kPa (g)	1,0	1,03	0,56
		0,97	1,0	0,54
		1,78	1,84	1,0
Nitrogen (N_2)	-195,8°C B.Pt @ 101,33 kPa	1,0	0,81	0,69
		1,24	1,0	0,86
		1,44	1,16	1,0
Oxygen (O_2)	-183,0°C B.Pt @ 101,33 kPa	1,0	1,14	0,86
		0,88	1,0	0,75
		1,17	1,33	1,0
*LPG	20°C and 750 kPa (g)	1,85	0,54	0,26
		2,10	1,0	0,49
		3,81	2,06	1,0
*Propane	20°C and 870 kPa (g)	1,0	0,51	0,27
		1,96	1,0	0,54
		3,65	1,88	1,0

*Quoted at 20°C as per South African trade metrology regulations.
LPG based on 60/40 propane/butane mixture.

Parts Per Million	**%**
1 ppm	0,0001
5 ppm	0,0005
10 ppm	0,001
50 ppm	0,005
100 ppm	0,01
500 ppm	0,05
1 000 ppm	0,1
10 000 ppm	1,0

The Cryogenic Thermometer



General Conversion and Reference Tables

Length		
1 millimetre (mm)	—	0,0393 701 inches
1 centimetre (cm)	10 millimetres	0,393 701 inches, 0,032 208 4 feet
1 decimetre (dm)	10 centimetres	3,937 01 inches
1 metre (m)	10 decimetres (100 cm)	39 370,1 inches, 3,280 843 feet, 1,093 614 yards
1 decametre (dam)	10 metres	10,936 14 yards
1 hectometre (hm)	10 decametres (100 m)	109,361 4 yards
1 kilometre (km)	10 hectometres (1 000 m)	3 280,843 feet, 1 093,614 yards, 0,621 371 miles

Area		
1 square millimetre (mm^2)	—	0,001 550 square inches
1 square centimetre (cm^2)	100 square millimetres	0,155 square inches, 0,001 076 39 square feet
1 square decimetre (dm^2)	100 square centimetres	15,50 square inches
1 square metre (m^2)	100 square decimetres (10 000 cm^2)	10,763 915 square feet, 1,195 99 square yards
1 are	100 square metres (1 square decametre)	119,599 square yards
1 hectare (ha)	100 ares (10 000 square metres)	11 959,9 square yards, 2,471 05 acres
1 square kilometre (km^2)	100 hectares (1 000 000 square metres)	0,386 102 square miles

Volume (cubic)		
1 cubic millimetre (mm^3)	—	0,000 061 024 cubic inches
1 cubic centimetre (cm^3)	1 000 cubic millimetres	0,061 024 cubic inches
1 cubic decametre (dm^3)	1 000 cubic centimetres (1 litre)	61,024 cubic inches
1 cubic metre (m^3)	1 000 cubic decimetres (1 000 litre)	35,317 76 cubic feet, 1,307 95 cubic yards

Volume (fluid)		
1 millimetre (ml)	—	0,035 195 fluid oz
1 centilitre (cl)	10 millilitres	0,351 95 fluid oz
1 decilitre (dl)	10 centilitres	3,519 5 fluid oz, 0,175 975 pints
1 litre (ℓ)	10 decilitres	1,759 75 pints, 0,219 969 gallons, 0,264 18 US gallons
1 decalitre (dal)	10 litres	2,199 69 gallons
1 hectolitre (hl)	10 decalitres (100 litres)	21,996 9 gallons
1 kilolitre (kl)	1 000 litres (1 m^3)	219,969 gallons

Mass		
1 milligram (mg)	(1 000 micrograms) mg	0,015 432 36 grains
1 centigram (cg)	10 milligrams	0,154 323 6 grains
1 decigram (dg)	10 centigrams	1,543 236 grains
1 gram (g)	10 decigrams (1 000 milligrams)	15,432 36 grains, 0.035 274 avoir oz
1 decagram (dag)	10 grams	0,352 74 avoir oz
1 hectogram (hg)	10 decagrams	3,527 4 avoir oz, 15 432,358 grains
1 kilogram (kg)	10 hectograms (1 000 grams)	2,204 622 6 litres, 2,204 622 6 lbs
1 tonne (t)	1 000 kilograms	19,684 1 cwts, 0,984 207 tonne, 1 102 311 short tonnes (2,000 lb tonnes)

Celsius to Fahrenheit

°C	°F
300	572
290	554
280	536
270	518
260	500
250	482
240	464
230	446
220	428
210	410
200	392
190	374
180	356
170	338
160	320
150	302
140	284
130	266
120	248
110	230
100	212
99	210,2
98	208,4
97	206,6
96	204,8
95	203,0
94	201,2
93	199,4

°C	°F
92	197,6
91	195,6
90	194,0
89	192,2
88	190,4
87	188,6
86	186,8
85	185,0
84	183,2
83	181,4
82	179,6
81	177,8
80	176,0
79	174,2
78	172,4
77	170,6
76	168,8
75	167,0
74	165,2
73	163,4
72	161,6
71	159,8
70	158,0
69	156,2
68	154,4
67	152,6
66	150,8
65	149,0

°C	°F
64	147,2
63	145,2
62	143,6
61	141,8
60	140,0
59	138,2
58	136,4
57	134,6
56	132,8
55	131,0
54	129,2
53	127,4
52	125,6
51	123,8
50	122,0
49	120,2
48	118,4
47	116,6
46	114,8
45	113,0
44	111,2
43	109,4
42	107,6
41	105,8
40	104,0
39	102,2
38	100,4
37	98,6

°C	°F
36	96,8
35	95,0
34	93,2
33	91,4
32	89,6
31	87,8
30	86,0
29	84,2
28	82,4
27	80,6
26	78,8
25	77,0
24	75,2
23	73,4
22	71,6
21	69,8
20	68,0
19	66,2
18	64,4
17	62,6
16	60,8
15	59,0
14	57,2
13	55,4
12	53,6
11	51,8
10	50,0
9	48,2

°C	°F
8	46,4
7	44,6
6	42,8
5	41,0
4	39,2
3	37,4
2	35,6
1	33,8
0	32,0
-1	30,2
-2	28,4
-3	26,6
-4	24,8
-5	23,0
-6	21,2
-7	19,4
-8	17,6
-9	15,8
-10	14,0
-11	12,2
-12	10,4
-13	8,6
-14	6,8
-15	5,0
-16	3,2
-17	1,4
-18	-0,4
-19	-2,2

°C	°F
-20	-4,0
-21	-5,8
-22	-7,6
-23	-9,4
-24	-11,2
-25	-13,0
-26	-14,8
-27	-16,6
-28	-18,4
-29	-20,2
-30	-22,0
-31	-23,8
-32	-25,6
-33	-27,4
-34	-29,2
-35	-31,0
-36	-32,8
-37	-34,6
-38	-36,4
-39	-38,2
-40	-40,0
-45	-49,0
-50	-58,0
-55	-67,0

Force

Pounds Force (lbf)	Newtons (N)
1	4,448 22
2	8,896 44
3	13,344 67
4	17,792 89
5	22,241 11
6	26,689 33
7	31,137 55
8	35,585 78
9	40,034 00
10	44,482 22

Newtons (N)	Pounds Force (lbf)
1	0,224 809
2	0,449 618
3	0,674 427
4	0,899 236
5	1,124 045
6	1,348 854
7	1,573 663
8	1,798 472
9	2,023 281
10	2,248 090

Tons Force (tonf)	Kilonewtons (kN)
1	9,964 02
2	19,928 04
3	29,892 06
4	39,856 08
5	49,820 10
6	59,784 12
7	69,748 14
8	79,712 16
9	89,676 18
10	99,640 20

Kilonewtons (kN)	Tons Force (tonf)
1	0,100 361
2	0,200 722
3	0,301 083
4	0,401 444
5	0,501 805
6	0,602 166
7	0,702 527
8	0,802 888
9	0,903 249
10	1,003 610

Note: 1 MPa and 1 N/mm² are the same.

Cylinder Safety Precautions

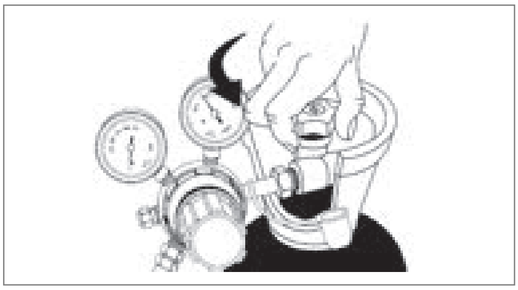
There are no higher priorities than the health and safety of our employees, customers, suppliers and the community, and the protection of the environment.

Cylinder Safety

1. Before attaching a regulator to a cylinder, the cylinder valve should be wiped with an oil-free cloth. Then rapidly open and close the cylinder valve to blow out any dust or dirt. This also ensures that empty cylinders are not being connected. Direct valve outlet away from people in the vicinity and keep well clear of the gas being vented.

   NB: Never vent toxic and/or flammable gases.

2. Be sure to select the correct regulator for the gas you are using. Connect the regulator to the cylinder valve using the correct spanner. Do not use excessive force but make certain that the joint is gas tight. Ensure the regulator thread connections are in a good condition before connecting.



3. Attach and tighten the hose connection to the regulator outlet and check that the torch or other equipment to be used is properly connected at the other end of the hose. Open the cylinder valve 1½ turns slowly and set the regulator delivery pressure. Check for leaks using the recommended leak detection spray or solution.

4. Close the cylinder valve and release the pressure from the torches, hoses and regulators when the equipment is not in use, is being moved or if the cylinders are empty.

Ten Steps to Cylinder Safety

1	Read labels and Material Safety Data Sheet (MSDS) before use.
2	Store upright and use in well ventilated, secure areas away from pedestrian or vehicle thoroughfare.
3	Guard cylinders against being knocked violently or being allowed to fall.
4	Wear safety shoes, glasses and gloves when handling and connecting cylinders.
5	Always move cylinders securely with an appropriate trolley. Take care not to open the valve when moving a cylinder.
6	Keep in a cool, well ventilated area, away from heat sources, sources of ignition and combustible materials, especially flammable gases.
7	Keep full and empty cylinders separate.
8	Keep ammonia-based leak detection solutions, oil and grease away from cylinders and valves.
9	Never use force when opening or closing valves, or tamper with the cylinder or valve.
10	Don't repaint or disguise markings and damage. If damaged, return cylinders to Afrox immediately.

Cylinder Valve Safety

When working with cylinders or operating cylinder valves, ensure that you wear appropriate protective clothing – leather gloves, safety boots and safety glasses.

When moving cylinders, ensure that the valve is not accidentally opened in transit.

Before operating a cylinder valve:

- Ensure that the system you are connecting the cylinder into is suitable for the gas and pressure involved.
- Ensure that any accessories (such as hoses attached to the cylinder valve, or the system being connected to) are securely connected. A hose, for example, can potentially whip around dangerously if it is accidentally pressurised when not restrained at both ends.
- Stand to the side of the cylinder so that neither you nor anyone else is in line with the back of the cylinder valve.

When operating the cylinder valve:

- Open it by hand by turning the valve hand-wheel anti-clockwise. Use only reasonable force.
- Ensure that no gas is leaking from the cylinder valve connection or the system to which the cylinder is connected. DO NOT use ammonia-based leak detection fluid as this can damage the valve. Approved leak detection fluid can be obtained from an Afrox Gas & Gear.
- When finished with the cylinder, close the cylinder valve by hand by turning the valve hand-wheel in a clockwise direction. Use only reasonable force. Do not use mechanical aids to close the valve.

Remember NEVER tamper with the valve. If you suspect the valve is damaged, DO NOT use it. Report the issue to Afrox and arrange for the cylinder to be returned to Afrox.

Leak Detection Fluids for Compressed Gas Applications

Why use a leak detection fluid?

For safety and economic considerations, it is good practice to frequently check your own gas systems and cylinders for leaks.

You can do this by either applying a leak detection fluid to the valve and other potential leakage points, or by spraying a leak detection fluid onto the required areas on the cylinder/valve.

Why is the correct choice of leak detection fluid important?

Selecting an incorrect leak detection fluid can lead to:

- Weakening of brass cylinder valves or brass components; and
- Risk of flames or an explosion.

What should I consider when choosing a leak detection fluid?

- **DO** select leak detection fluids that are compatible with brass and oxygen.
- **DO** carefully use the pre-formulated or correctly diluted leak detection fluid.
- **DO NOT** use leak detection fluids that contain ammonia or halides (e.g. chlorides).
- **DO NOT** use naked flames to check for leaks.

What does Afrox recommend?

Afrox recommends purpose-designed leak detection solutions specially formulated for the purpose.

Leak detection fluid products

- Safetest W012045 leaktest detection spray.

Handling Gas Cylinders — General Safety

- **DO** use mechanical aids (ramps, trolleys, forklifts, scissor lifts) in preference to direct manual handling of cylinders.
- **DO** remove any connected equipment (e.g. regulator) AND refit any supplied valve protection cap and/or valve outlet gas tight cap/plug prior to moving cylinders.
- **DO** ensure cylinders are positively secured to mechanical lifting/handling devices prior to movement.
- **DO** familiarise yourself with and observe appropriate safe lifting techniques/postures prior to manually handling heavy or large gas cylinders.
- **DO** assess the load weight and dimensions before attempting any lift.
- **DO** use suitable personal protective equipment (PPE) – wear safety footwear and leather gloves to protect against falling/slipping cylinders crushing hands or feet during moving.
- **DO** ensure a positive hand grip prior to commencing a manual lift.
- **DO** ensure that loads are equally shared when attempting two-person lifts.
- **DO** note environmental conditions prior to handling cylinders – wet, hot or cold cylinders may diminish the quality of hand grip and footing may be compromised.
- **DO NOT** bear-hug cylinders to effect a lift.
- **DO NOT** lift or lower cylinders where the operator's hands are above shoulder height or below mid-thigh height.
- **DO NOT** edge-roll cylinders up or down steps of 250 mm or higher.
- **DO NOT** edge-roll cylinders over discontinuous or soft surfaces.
- **DO NOT** attempt to catch or restrain a falling cylinder.
- **DO NOT** attempt to handle cylinders if you are fatigued, physically compromised or under the adverse influence of medication or alcohol.
- **DO NOT** drop cylinders as a method of transfer – this may seriously damage the cylinder or its valve, resulting in their failure and product release.

Consider this before handling your cylinders...

"Think before you lift"

"Don't bear-hug cylinders"

"Team lifts share the load"

Transporting Gas Products Safely Including Cryogenic Receptacles

Transporting cylinders in enclosed vehicles

Use of enclosed vehicles for cylinder transportation is NOT RECOMMENDED by Afrox.

Customers who choose to transport cylinders in enclosed vehicles do so at their own risk.

Please ensure you are aware of the dangers:

- A lack of ventilation can cause asphyxiation.
- A cylinder in the boot of a car can leak and cause an explosion.
- Fold-down back seats are not designed to prevent cylinders from penetrating into the passenger compartment and could injure passengers in a frontal crash.
- Cylinders cannot be adequately restrained when placed on passenger seats, in the boot, or against the cargo barrier of station wagons or hatch-backs, and can become projectiles in an accident.

Afrox offers a cylinder delivery service (additional charges may apply) if the customer does not have suitable transportation.

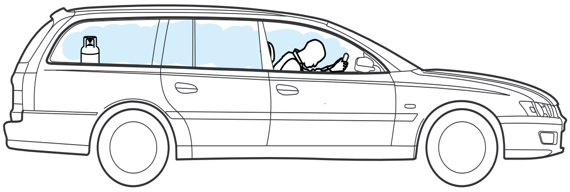
However, if the customer insists on transporting the cylinders in an enclosed vehicle, they should:

- Ensure that at least one window is open at all times and the ventilation fan is on high speed when transporting the cylinders.
- Avoid transporting cylinders in the passenger compartment.
- Ensure that the cylinders are unloaded as soon as possible after arrival at the destination (ventilation decreases considerably when the vehicle is stopped or parked).
- Ensure that the cylinders are not stored or left unattended in the vehicle overnight or for long periods (more than one hour).

Transporting cryogenic receptacles

When transporting liquid nitrogen dewars or dry ice by private car or station wagon:

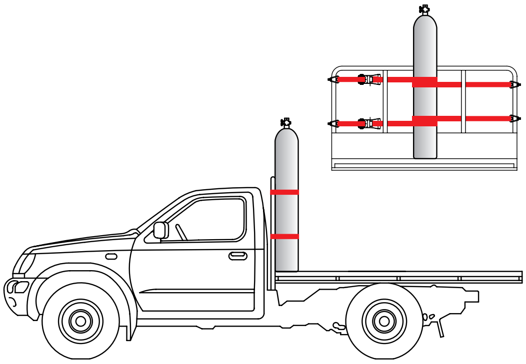
- Do not transport cryogenic receptacles with inert gases, or containers with dry ice, in the passenger compartment.
- Be aware that liquid nitrogen and dry ice are asphyxiants and, if stored or transported in an enclosed vehicle, can rapidly displace the available oxygen inside the vehicle, causing occupants to lose consciousness or can lead to death.



- Be aware that, in the event of an accident, the occupants may have liquid nitrogen spilt on them, causing severe burns to the skin.
- Check the suitability of the container for transport and storage of liquid nitrogen. The only suitable container is a liquid nitrogen flask designed for the purpose. No alternatives can be used. For example, a thermos flask is not suitable for carrying liquid nitrogen.

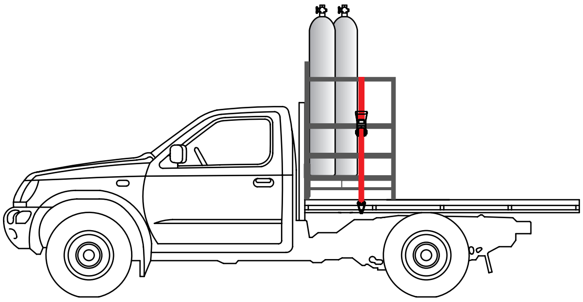
Transporting cylinders upright

- Liquefied gases and acetylene cylinders must be transported in an upright position.
- Cylinders should be restrained, with a lashing strap rated 1 tonne, to the vehicle body or contained within a purpose-built frame.
- If transported upright against a headboard:
  - The total weight of the cylinders should not exceed 250 kg
  - At least two horizontal straps should be applied.

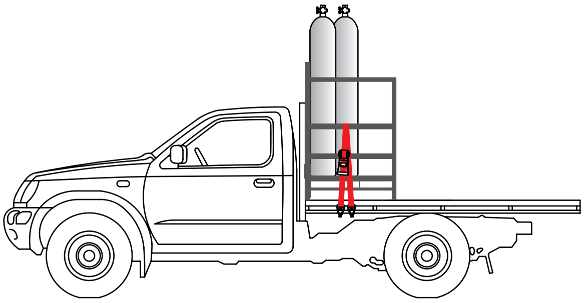


Two lashing straps, each rated at 1 tonne, should be used to restrain the cylinders in an upright position

Transporting cylinders in a pallet



Pallet must be placed against the headboard



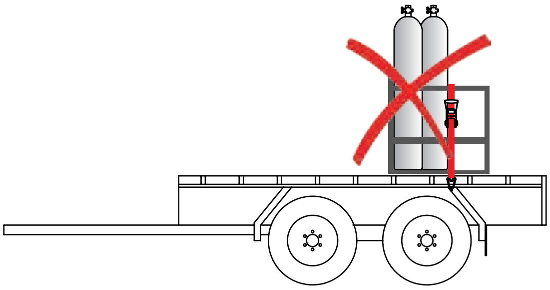
At least one tie-down strap must be used

- A maximum of three loose cylinders will be supplied to customers. It is recommended that greater numbers be supplied strapped in Afrox cylinder pallets (service charges may apply).
- If transported in a pallet in a utility or light truck:
  - The pallet should be placed against a headboard with the open end facing rearwards
  - At least one tie-down strap rated to 2 tonnes should be applied, or two when looped around the pallet rail.

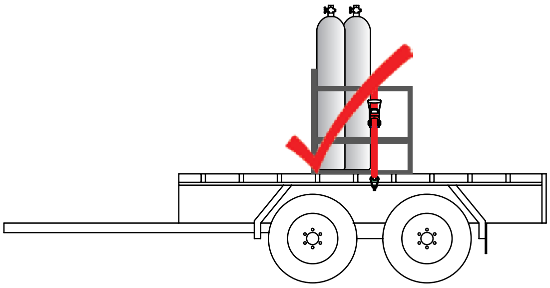
Transporting cylinders in a pallet on a trailer

If cylinders are transported in a pallet on a trailer:

- The pallet should be placed with the open end facing rearwards.
- The pallet should be positioned so that there is a downward force on the tow coupling.
- At least one tie-down strap should be applied rearward of the middle of the pallet, to prevent it tipping forward.



The pallet must be positioned to enable downward force on the tow coupling

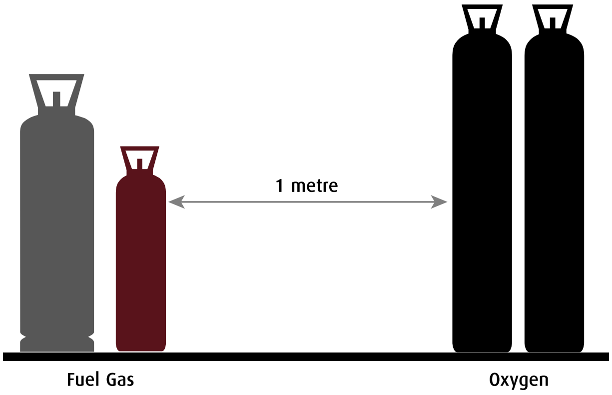


Use at least one tie-down strap as shown

Storing Your Cylinders Safely

All cylinders should be considered and treated as full, regardless of their content. This means:

- Keep cylinders away from heat sources (e.g. flames or heaters).
- Do not store cylinders near combustible materials or flammable liquids.
- Keep flammable gases away from sources of ignition.
- Keep cylinders in well drained areas, out of water pools or ponds.
- The storage area should be kept well ventilated and clean at all times.
- Do not store in confined spaces.
- Avoid below-ground storage where possible. Where impractical, consider enclosed space risks.
- There should be good access to the storage area for delivery vehicles. The ground surface should be level and firm (preferably concrete).
- The storage area should be designed to prevent unauthorised entry, to protect untrained people from hazards and to guard cylinders from theft.
- Different types of gases must be stored separately, in accordance with SANS 10263-2 (The storage and handling of gases in cylinders).
- Stores must clearly show signage in accordance with National Dangerous Goods regulations. This includes Class Diamonds, HAZCHEM, no smoking and naked flame warning signs.
- Full and empty cylinders should be kept separate.
- Toxic and corrosive gases should be stored separately, away from all other gases.
- Liquefied flammable gases and acetylene cylinders must be stored upright, to keep the safety devices in the vapour phase, on a firm, level floor (ideally concrete). This is also preferable for most other gas cylinders.
- Store cylinders away from heavy traffic and emergency exits.
- Rotate stock of full cylinders, and use cylinders on a ‘first in, first out’ basis.
- Never repaint or obscure a cylinder label, even if the cylinder is rusty, dirty or damaged. This can result in unsafe situations.
- Never apply any unauthorised labels or markings to cylinders, unless advised by Afrox to identify faulty cylinders.
- Avoid storing cylinders below 0°C. Some mixtures may separate below this temperature.
- Regularly check for leaks and faults.
- Keep ammonia-based leak detection solutions, oil and grease away from cylinders and valves.
- Never use force when opening or closing valves.



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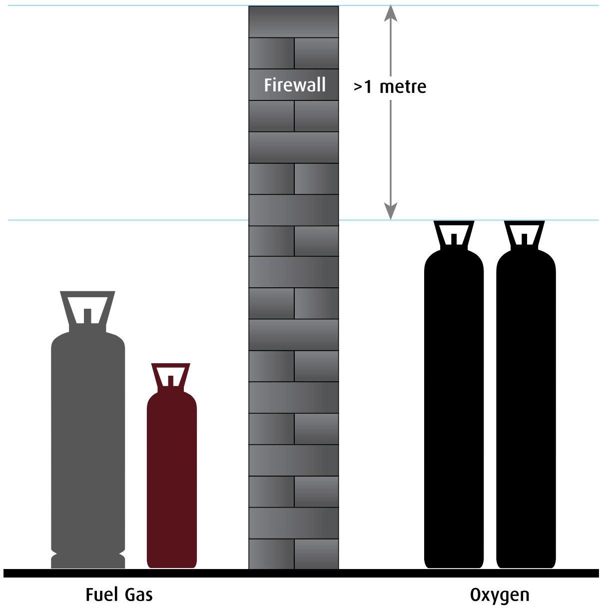


Storage of Fuel Gases

Within the storage area, oxygen should be stored at least one metre from fuel gases cylinders. The use of a firewall may provide the required separation.

Note: Wall must be a minimum of one metre higher than the tallest cylinder.

Afrox Cylinder Identification

1	Gas name and grade
2	Dangerous Goods Classification
3	Contents of cylinder at standard temperature and pressure (20°C @ 101,3 kPa)
4	Hazard phrase*
5	Precautionary phrase*
6	United Nations numbering system for safe handling, transport and storage
7	Afrox gas item code
8	All hours emergency call number

*Always refer to Material Safety Data Sheet (MSDS)

Useful References

- Afrox Material Safety Data Sheets (MSDS), which are available at www.afrox.com or from your local Afrox office.

The following relevant statutory information and South African Standards are available from relevant Government and Standards offices:

- Occupational Health and Safety Act and Regulations 85/1993
- SANS 10019: Transportable containers for compressed, dissolved and liquefied gases - Basic design, manufacture, use and maintenance
- SANS 10232: Dangerous Goods - Initial Emergency Response Guide
- SANS 10087 parts 1 - 8: The storage and handling of LPG
- SANS 10263-2: The storage and handling of gases in cylinders
- SANS 10234: Global harmonised system of classification and labelling of chemicals

Plan For Emergencies

In case of emergency:

Call Afrox on **0860 020202**

- If a cylinder is damaged, contact Afrox immediately.
- People who have a responsibility for storing or using gas cylinders should be trained appropriately, should be made aware of the dangers and should be familiar with any emergency procedures.
- Storage area layouts and emergency procedures should be carefully planned.

Packing Data

The cylinders and valves supplied by Afrox are all manufactured to recognised South African and international standards.

Afrox-made industrial gases and industrial gas mixtures are supplied with cylinder outlet connections that comply with the requirements of SANS 10019.

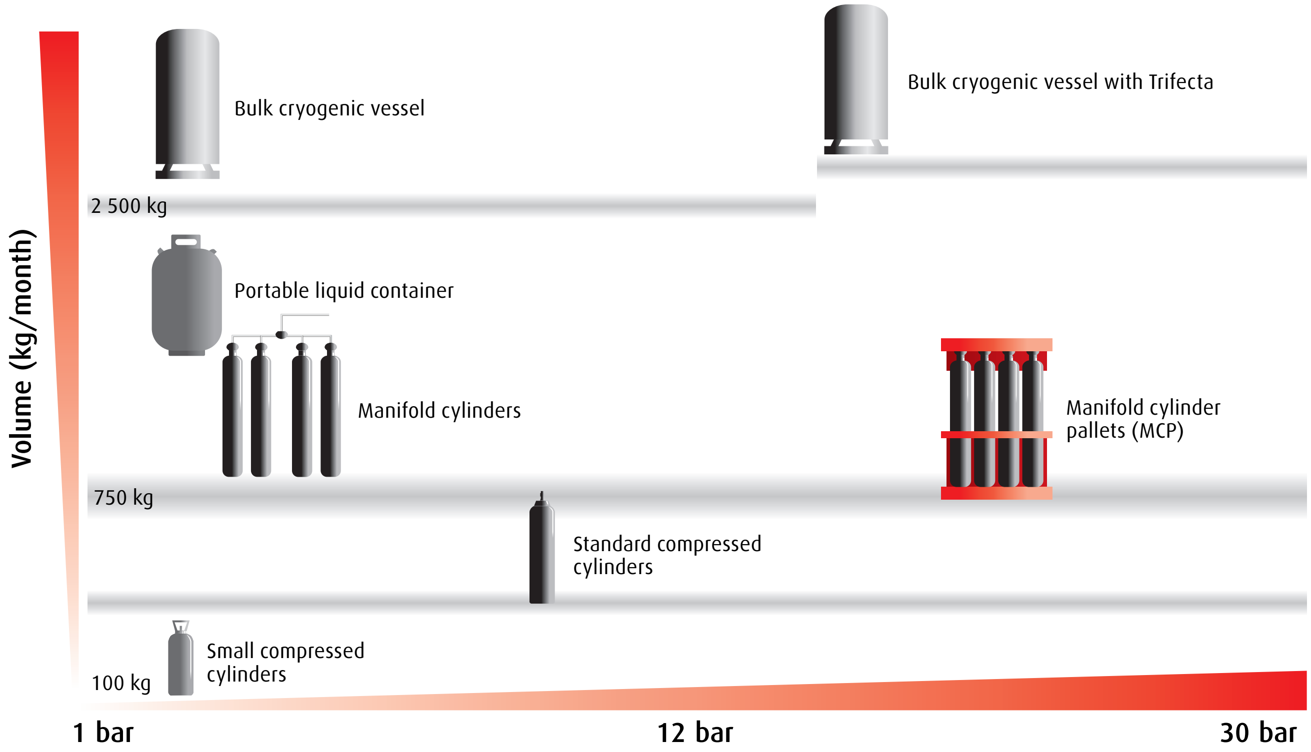
Cylinder sizes and valve connections for all industrial gas cylinders provided by Afrox are detailed in this section. You should also note that the regulators recommended throughout this manual come equipped with the correct valve connection for their intended service.

Note: Some imported and/or industrial grade gas cylinders may have other connections not listed in this catalogue. Please contact Afrox on 0860 020202 for further details.

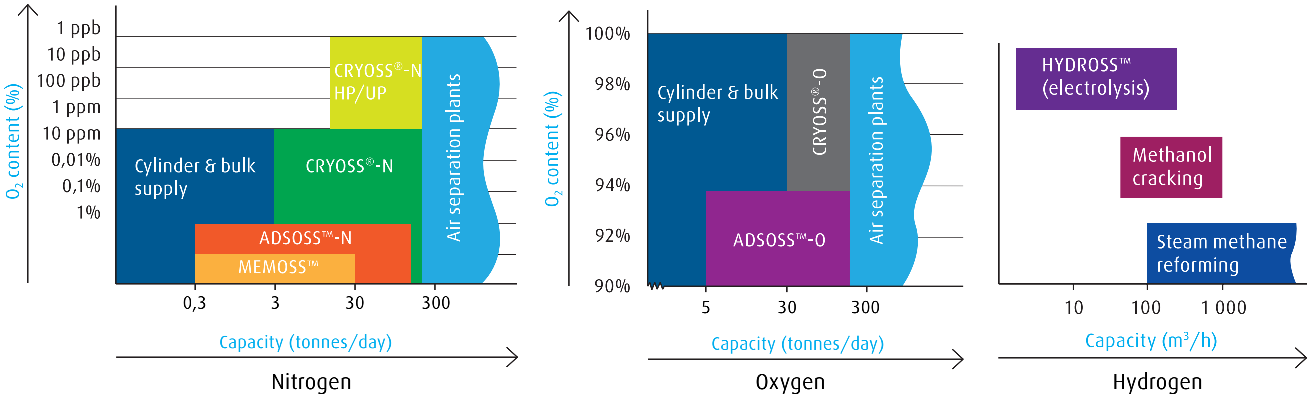
Supply Options

Optimising your business efficiencies

Your gas supply can influence your productivity. Frequent handling and changeover of cylinders can increase non-productive time, reduce your efficiency and ultimately increase your operational costs. To optimise your efficiency, you need to match your demand with your gas supply. Afrox offers a full range of gas products and services that help to make your business more efficient and productive.



ECOVAR® – On-site Gas Supply Options



Compressed cylinders

Afrox offers a wide range of single high pressure cylinders suitable for small volumes of gas. Available in many sizes and pressures, Afrox cylinders offer a high degree of versatility and flexibility.

Cylinder manifolds

Two or more compressed cylinders can be manifolded together in banks to provide a larger supply source. A manifold usually consists of two independent sets of controls to permit alternate or simultaneous operation of the two cylinder banks.

Manifolded cylinder pallets (MCPs)

Manifolded cylinder pallets or packs consist of a number of cylinders connected together with a single or dual outlet. The MCP package can comprise both pure and mixed gases, providing an uninterrupted supply of gas that can easily be transported by a forklift.

Portable cryogenic containers (PCCs)

Afrox offers a range of portable liquid containers suitable for small volumes of liquid.

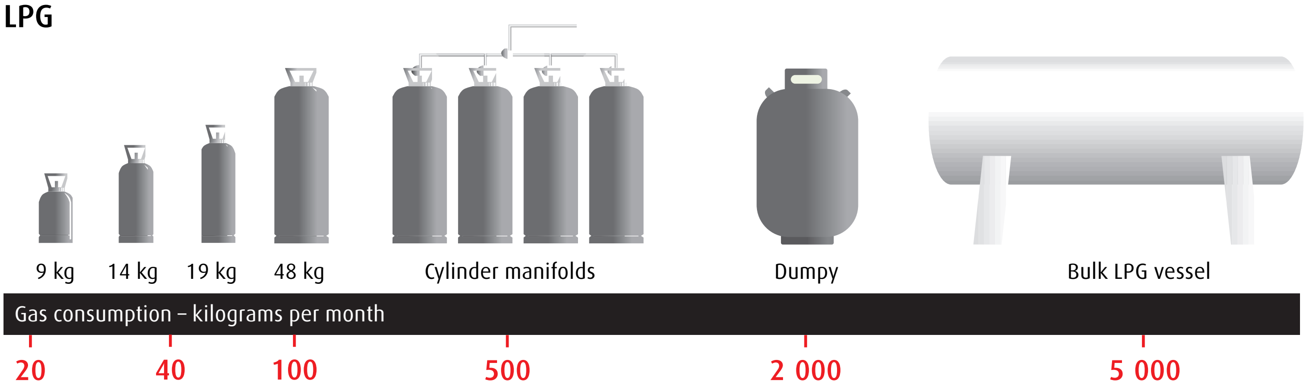
Bulk supply

For customers with high volume requirements and operations suited to piped supplies of gas, a bulk cryogenic storage vessel installed on-site offers the most efficient, convenient solution.

Afrox telemetry

The Afrox telemetry monitoring system constantly gauges the volume in your storage vessel. Afrox will automatically deliver gas as required.

LPG



Nominal Dimensions of LPG Vessels - Horizontal						
Size	**4,5 m³**	**9 m³**	**22,5 m³**	**45 m³**	**70 m³**	**90 m³**
Net Liquid Capacity (ℓ)*	3 600	7 200	18 000	3 600	56 000	72 000
Net Mass Capacity (kg) approx*	1 969	3 938	9 846	19 692	30 632	39 384
Approximate Height (mm)	1 450	1 900	2 270	2 700	On Rec	On Rec
Approximate Width (mm)	1 060	1 450	2 060	2 450	On Rec	On Rec
Approximate Length (mm)	5 600	5 620	7 400	10 300	On Rec	On Rec
Plinth Area (long/wide) (m²)	7,6/3,1	7,7/3,5	9,5/4,2	On Rec	On Rec	On Rec
Net Weight (kg) approx	2 200	3 300	6 500	12 500	On Rec	On Rec
Max Working Pressure	1 725 kPa	1 725 kPa	1 725 kPa	1 725 kPa	1 725 kPa	1 725 kPa
Anticipated Working Pressure	600/800 kPa	600/800 kPa	600/800 kPa	600/800 kPa	600/800 kPa	600/800 kPa

Nominal Dimensions of LPG Vessels - Vertical				
Size	**2,25 m³**	**4,5 m³**	**9 m³**	**22,5 m³**
Net Liquid Gas Capacity (ℓ)*	1 800	3 600	7 200	18 000
Net Mass Capacity (kg) approx*	985	1 969	3 938	9 846
Approximate Height (mm)	3 820	4 210	7 480	7 700
Approximate Width (mm)	1 070	1 380	1 380	2 110
Plinth Area (m²)	12,5	12,5	12,5	16
Net Weight (kg) approx	2 100	2 900	4 400	8 600
Max Working Pressure	1 725 kPa	1 725 kPa	1 725 kPa	1 725 kPa
Anticipated Working Pressure	600/800 kPa	600/800 kPa	600/800 kPa	600/800 kPa

*Note: Net mass based on 60/40 propane/butane mixture with liquid density 0,547
Net liquid capacity (ℓ) based on filling to 80% of total volume

Individual Cylinder Tracking

Afrox has launched a pioneering tracking system that will enable us to operate the most effective and fully integrated cylinder tracking system available in the market today; ensuring that we are better positioned to serve the needs of our customers.

All Afrox Industrial , Special, Hospitality and Medical cylinders are tracked on this system. Refrigerants and LPG cylinders are excluded.

How does cylinder tracking work?

- All Afrox gas cylinders (Industrial, Special and Medical gas cylinders) now carry a unique barcode, which is scanned during delivery using a state-of-the-art handheld device.
- All tracked cylinders supplied by Afrox have their barcode scanned at each stage of delivery and return to Afrox.
- Customers are required to acknowledge receipt and collection of cylinders by providing our delivery drivers with an electronic signature on a handheld device.
- The Delivery Advice Note is created after all cylinders have been scanned.
- The Delivery Advice Note lists the serial numbers of all tracked gas cylinders supplied and returned, providing detailed information to help you manage cylinder stocks.
- Every transaction will be recorded and uploaded to our fully integrated Cylinder Tracking Management System.
- Every cylinder supplied by us will be scanned and automatically allocated to the customer's account.
- Every cylinder returned to or collected by us will be scanned and automatically removed from your account.

What benefits does cylinder tracking offer to our customers?

- Peace of mind through increased levels of traceability of tracked gas cylinders.
- Improved invoice accuracy and cylinder management, making it easier to do business with Afrox.
- Greater reliability and accuracy of stock holdings to help you improve internal cost management.
- Improved handling of gas cylinder enquiries, saving time and effort.

An important change to how you may currently manage your cylinders

It is important to be aware that if you have swapped, or inadvertently changed cylinders with another Afrox customer, any returned cylinders will be deducted from the original customer account, not from the returning account.

However, if cylinders are moved within a customer's own organisation, this does not impact the overall cylinder holdings, as the system automatically updates the account accordingly.

Additional benefits in doing business with Afrox

Safety First

- No need to worry about testing your cylinders and valves – we do it for you.
- We look after cylinder repair and replacements.
- With us, you can work according to the highest safety standards.

Zero Investment

- We invest in cylinders for you – meaning no cylinder purchasing or deposit costs.
- You don't need to hold extra cylinders during maintenance.
- We free up your time so you can get on with the job at hand.

Flexible solutions

- You are free to select and swap between gas types and cylinder sizes.
- You can choose to pick up from any of our retail outlets or agents or have your cylinders delivered.
- Pricing is flexible, adapting to your consumption.

Latest Technologies

- We invest in new cylinder packages for you.
- You have access to state-of-the-art technologies such as lightweight cylinders and high-tech valves.
- We constantly innovate new technologies to add value to your business.

Reliable Partner

- Get access to our broad product range.
- Benefit from our large scope of services.
- We offer extensive technical and safety support.
- You have the convenience of a dense network of retail outlets and agents with one-stop shopping at selected stores.

INDUSTRIAL GASES

3

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View the **AFROX INDUSTRIAL GAS EQUIPMENT** video on YouTube™

COMPRESSED GASES

Industrial gases are supplied in a range of different cylinders depending on the properties of the gas. Some are supplied at high pressures, while others are only available at low pressures.

The properties of an industrial gas dictate the way in which it is supplied to the customer.

Gases such as oxygen, nitrogen, argon and hydrogen can be readily compressed into a cylinder at pressures up to 200 bar.

Acetylene, because of its properties, needs to be stored in a cylinder containing a 'porous mass' in which the gas is held in a carrier solvent.

Industrial gas cylinders come in a range of sizes which are normally categorised by the water capacity of the container. Which size is most suitable for you will depend on a range of factors including consumption and flow rate.

Each cylinder is fitted with a cylinder valve tailored to suit the gas and pressure requirements.

The outlet thread is determined by national standards to ensure that only regulators compatible with these requirements can be fitted.

For applications requiring higher capacities, Afrox also supplies a range of Manifolded Cylinder Pallets, which are multiple cylinders connected together and palletised.

Afrox Industrial Gas Cylinder Colour Identification

Atmospheric Gases

Air
Dry
- 3,9 kg cylinder
  13-KB
- 8,5 kg dry
  13-RC

Nitrogen
Technical
- 2,2 kg cylinder
  42-IE
- 4,4 kg cylinder
  42-JE
- 11,0 kg cylinder
  42-SE
- 15 x 11,0 kg MCP
  42-ME15
- 120,0 kg PCC
  41-PA
- PCC 35 Bar
  41-PC
- Dewar PVT kg
  P42

High Purity
- 2,2 kg cylinder
  98-IE
- 11,0 kg cylinder
  98-SE
- 15 x 11,0 kg MCP
  98-ME15

Laser Gas
- 15 x 11,0 kg MCP
  98-ME15-LAS

Oxygen
Technical
- 11,5 kg cylinder
  1-QD
- 15 x 12,3 kg MCP
  1-MR15
- PortaPak®
  1,43 kg cylinder
  3-GD
- 180 kg PCC
  554-PA

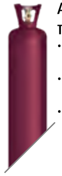
Laser Gas
- 15 x 11,5 kg MCP
  317-MR15

Argon
Technical
- 17,4 kg cylinder
  10-SE
- 220 kg PCC
  556-PA

High Purity
- 17,4 kg cylinder
  11-SE
- 15 x 17,4 kg MCP
  11-ME15

PortaTIG®
- 1,9 kg cylinder
  10-GD1

Fuel Gases



Acetylene
Technical
- 8 kg cylinder
  15-DE
- 12 x 8 kg MCP
  15-MD12
- PortaPak®
  0,9 kg cylinder
  16-DA

Hydrogen
Technical
- 0,74 kg cylinder
  54-SH
- 15 x 0,74 kg MCP
  54-MH15

Other Gases

Carbon Dioxide
Technical
- 31,3 kg cylinder
  40-RC
- 180 kg PCC
  573-PA

Wet
- 31,3 kg cylinder
  40-RC-W

Notes

1. Designated cylinder colours comply with SANS 10019
2. Numbers in grey are Afrox's item numbers

Shielding Gases

Argoshield® Light
- 3,6 kg cylinder
  24-IE
- 17,8 kg cylinder
  24-SE-LIG
- 15 x 17,8 kg cylinder
  24-ME15-LIG

Argoshield® Universal
- 18,5 kg cylinder
  28-SE

Argoshield® Heavy
- 19,6 kg cylinder
  25-SE

Argoshield® 5
- 8,4 kg cylinder
  24-KE
- 17,8 kg cylinder
  24-SE

Portashield®
- 1,8 kg cylinder
  27-GD

Alushield®
- 8,4 kg cylinder
  94-SE

Copashield®
- 4,8 kg cylinder
  395-SE

Fluxshield®
- 20,5 kg cylinder
  26-SE

Stainshield®
- 17,4 kg cylinder
  27-SE

Stainshield® Plus
- 17,6 kg cylinder
  30-SE

Stainshield® Heavy
- 10,4 kg cylinder
  99-SE

Stainshield® TIG
- 16,7 kg cylinder
  87-SE

Stainshield® TIG Plus
- 12,3 kg cylinder
  000187-SE-C

TIGshield®
- 3,5 kg cylinder
  87-IE

RoboShield®
- 19,7 kg cylinder
  20-SE

The gas contents of Afrox cylinders are identified by the labels affixed to the cylinders. A cylinder without a label should not be used, and should be returned to the supplier. An important part of the label is the class diamond, which represents the characteristic of the gas, as illustrated. A label with multiple class diamonds indicates multiple associated hazards.

Class Diamonds

Class 2.2 / 5.1
Oxidising Gas
Yellow / Black lettering

Class 2.1
Flammable Gas
Red / Black lettering

Class 2.3
Toxic Gas
White / Black lettering

Class 2.2
Non-Flammable, Non-Toxic Gas
Green / Black lettering

Porta Cylinder Range

The Porta cylinder range comprises small cylinders ideal for DIY and light fabrication. The Porta range consists of oxygen, acetylene, argon and CO_2 cylinders ideal for gas, GMAW (MIG), TIG welding, cutting and heating processes. The cylinders may only be filled by Afrox. The customer shall be liable to pay a non-refundable maintenance fee for each new Afrox-owned cylinder that they take without returning an empty comparable cylinder (gas price excluded). There is no rental applicable on the PortaPak® range.

PortaPak® Oxygen (Shell - W005740) (Refill: 3-GD)
- 5,8 ℓ steel cylinder
- Contains 1,43 kg of oxygen
- Black body and valve guard
- Valve - PortaPak® right hand female

PortaPak® Acetylene (DA) (Shell - W005782) (Refill: 16-DA)
- 6 ℓ steel cylinder with porous mass
- Contains 0,9 kg of DA
- Maroon body and valve guard
- Valve - PortaPak® left hand female

Portashield® (Ash 5) (Shell - W005170) (Refill: 27-GD)
- 5,8 ℓ steel cylinder
- Contains 1,9 kg mix of argon, CO_2 and 0_2
- Silver body and valve guard
- Valve - 5/8" BSPF valve (same as large cylinder)

PortaTIG® (Argon) (Shell - W005177) (Refill: 10-GD1)
- 5,8 ℓ steel cylinder
- Contains 1,9 kg of argon
- Peacock blue body and valve guard
- Valve - 5/8" BSPF valve (same as large cylinder)

THE PORTA CYLINDER RANGE

IDEAL FOR DIY & LIGHT FABRICATION

PORTATIG® VALVES
PortaTIG® cylinder valves are identical to larger similar cylinders, eliminating the need for an additional regulator, ensuring easy change-over when needed.

PORTATIG® VALVES
Oxygen and acetylene PortaPak® cylinders have unique valves specifically made to fit the existing PortaPak® regulator.

PORTASHIELD® VALVES
Portashield® cylinder valves are identical to larger similar cylinders, eliminating the need for an additional regulator, ensuring easy change-over when needed.

A SHIELDING GAS SPECIFICALLY MADE AVAILABLE FOR TIG WELDING

OXYGEN & ACETYLENE IDEAL FOR WELDING AND CUTTING OF VARIOUS THICKNESS OF STEEL

AN ARGON-BASED MIXTURE USED AS A SHIELDING GAS FOR GMAW (MIG) WELDING

Atmospheric Gases

Air

Air, the earth's natural atmosphere, is a non-flammable, colourless and odourless mixture of gases in which nitrogen (78%) and oxygen (21%) predominate. The balance of less than 1% is composed of the rare gases helium, neon, argon, krypton and xenon. Supplied in high pressure in metal cylinders.

Hazards

- High pressure gas in cylinders
- A source of oxygen and will support combustion.

Classifications (Air Dry)	
Gas Components	**Purity**
Air Dry	Moisture <10 vpm
Nitrogen	78%
Oxygen	21%
Argon	0,9%
Carbon Dioxide	0,03%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
AIR DRY CYL 3,9 kg	3,9	23,6	139	5/8" BSPF right hand female	13-KB
AIR DRY CYL 8,5 kg	8,5	47,2	153	5/8" BSPF right hand female	13-RC
AIR Tec 8,5 kg	8,5	47,2	153	5/8" BSPF right hand female	12-RC

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	28,96
Specific volume at 21,1˚C and 101,325 kPa	830,3 ℓ/kg
Boiling point at 101,325 kPa	194,35˚C
Critical temperature	-140,6˚C
Relative density (air = 1) at 1 atm	1,0
Density, gas at 101,325 kPa and 0˚C	1,205 kg/m^3

Uses and Features

- Industrial compressed air is employed as a source for burning and various industrial oxidation processes
- Other common uses include the operation of pneumatic tools, starting diesel engines and 'pigging' pipelines.

Precautions in Use

- Use only approved pressure rated equipment
- Never allow oil or grease on a cylinder or valve
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Dry air is non-corrosive and so any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Nitrogen (N_2)

Nitrogen is a colourless, odourless, non-toxic, almost totally inert gas comprising approximately 79% by volume of air. It is non-flammable and will not support combustion. Nitrogen is supplied in cylinders as a high pressure gas, or in insulated containers as a liquid.

Hazards

- High pressure compressed gas
- Asphyxiant in high concentrations.

Classifications (Nitrogen Technical)	
Gas	**Purity**
Nitrogen Technical	99,5%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
NIT TEC CYL 11,0 KG	11,0	50,0	200	3/4" BSPF right hand female	42-SE
NIT TEC CYL 4,4 KG	4,4	20,0	200	3/4" BSPF right hand female	42-JE
NIT TEC CYL 2,2 KG	2,2	10,0	200	3/4" BSPF right hand female	42-IE
NIT TEC MCP 15 X 11,0 KG	165,0	MCP	200	3/4" BSPF right hand female	42-ME15
NIT TEC PCC	120	120	180	3/4" BSPF right hand female	41-PA

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Classifications (Nitrogen High Purity)	
Gas	**Purity**
Nitrogen High Purity	99,997%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
NIT HP CYL 11,0 KG	11,0	50,0	200	3/4" BSPF right hand female	98-SE
NIT HP CYL 2,2 KG	2,2	10,0	200	3/4" BSPF right hand female	98-IE
NIT HP MCP 15 X 11,0 KG	165,0	MCP	200	3/4" BSPF right hand female	98-ME15
NIT LASER GAS MCP 15 X 11,0 KG	165,0	MCP	200	3/4" BSPF right hand female	98-ME15-LAS

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	28,0134
Specific volume at 20˚C and 101,325 kPa	861,5 ℓ/kg
Boiling point at 101,325 kPa	-195,8˚C
Critical temperature	146,9˚C
Relative density (air = 1) at 1 atm and 25˚C	0,967
Density, gas at 101,325 kPa and 25˚C	1,1455 kg/m^3
Flammability	N/A

Uses and Features

- Among the many uses for gaseous nitrogen are flow testing, gauge calibration, plastic forming, aerosol propellant, powering air tools, mechanical agitation in photo processing, metal de-gassing, pipeline testing, pressure testing cables and the handling and transfer of flammable liquids
- To prevent the undesirable presence of oxygen, nitrogen is valuable in furnaces, metal plating and tinning, chemical processing, food packing, wine making, paint and varnish manufacture, tube manufacture, packaging and preserving rubber products and optics
- Dry nitrogen gas is used as a purging medium in drying refrigeration systems, catalytic towers in refineries, chemical processing, electronic tube and light bulb manufacture
- Wherever moisture may not be tolerated, dry nitrogen is the preferred grade
- Nitrogen is also used for the inert packaging of foods, sparging wines, pressurisation of head spaces in liquid containers and conveyance of beverages in pressurised pipe systems
- Carrier gas in chromatography, calibration gas and scientific research.

Precautions in Use

- Wear leather gloves, safety gloves and safety shoes when handling cylinders
- Use only approved pressure rated equipment
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Symptoms and Treatment

Symptoms may include loss of mobility/consciousness since the victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self-contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stops.

Material Compatibility

- Nitrogen is non-corrosive and the vast majority of materials are compatible provided equipment is designed to withstand process pressure.

Oxygen (O_2)

A colourless, odourless and tasteless gas. Supplied in high pressure steel cylinders.

Oxygen as a gas is slightly heavier than air, but will dispense fairly rapidly in a well ventilated area. However, it can remain for long periods in cavities, trenches, pits and vessels. Oxygen will also remain for considerable periods in clothing or similar porous materials.

Hazards

- High pressure compressed gas
- Vigorously supports combustion of many materials which will not normally burn in air.

Classifications (Oxygen Technical)

Gas	Purity
Oxygen Technical	99,5%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
OXY TEC CYL 11,5 KG	11,5	46,6	175	5/8" BSPF right hand female	1-QD
OXY TEC CYL PORTAPAK®	1,43	5,8	175	11/16" x 20 TPI W female	3-GD
OXY TEC MCP 15 X 12,3 KG	184,5	MCP	175	5/8" BSPF right hand female	1-MR15
OXY LASER GAS MCP 15 X 11,5 KG	172,5	MCP	175	5/8" BSPF right hand female	317-MR15

Higher grades and purities of this product are available from Afrox Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	32,0
Specific volume at 21,1˚C and 101,325 kPa	755,4 ℓ/kg
Boiling point at 101,325 kPa	-183,0˚C
Critical temperature	-118,6˚C
Relative density (air = 1) at 1 atm and 25˚C	1,105
Density, gas at 101,325 kPa and 25˚C	1,309 kg/m³
Flammability	Does not burn, but vigorously supports combustion

Fire Hazards

Although non-flammable, oxygen is an active element which supports combustion and combines – directly and indirectly – with all elements except the rare gases neon, helium, argon, krypton, xenon and radon.

The ignition temperature of most material is lowered considerably in the presence of oxygen gas, particularly at high pressure. Fire or an explosion can occur when an igniter, combustion material and an oxidant combine.

Any heat source hotter than 50°C must be regarded as a possible igniter of fires in the presence of gaseous oxygen or oxygen-rich atmospheres.

Igniters

- Naked lights
- Burning cigarettes or pipes
- Cigarettes or pipes that have been visibly extinguished, but are still hot
- Sparks caused by static or live electrical discharge
- Sparks or heat caused by hard materials striking each other
- Sparks and molten metal, or heat from the plate, during and after welding and cutting
- Frictional heat caused by moving machine components
- Sudden gas compression effects can occur when a valve in an oxygen line is closed too quickly
- Heat from a soldering iron
- Heat from open electric fires or electrical motors
- Acetylides
- Exothermic chemical reactions.

Most of these heat sources are readily recognisable and common sense urges that they be avoided. However, it is important for personnel to be made aware of the less obvious causes of ignition. For example, cigarettes that have been extinguished but are still hot are likely to re-ignite in an oxygen-rich atmosphere.

Uses and Features

- In combination with a fuel gas such as acetylene, hydrogen or LPG, it is used in welding, cutting, brazing, hardening, scarfing, flame cleaning and heating
- Oxygen is used in the manufacture of steel, glass, ethylene oxide, methanol, acrolein, titanium dioxide, vinyl acetate and synthesis gas
- Oxygen can be considered for use in any chemical reaction where air is used to give faster reaction time and higher yields. A typical use would be in the treatment of refuse and effluent
- Ultra and high purity oxygen is used in laboratories, in process control operations and in metal analysis instruments and oxidation in semiconductor production
- Oxygen is widely used in medical treatment of respiratory disorders, anaesthetic and hyperbaric chambers.

Precautions in Use

- Use only equipment which is approved for the temperature range and has been degreased for oxygen service
- Wear leather gloves, safety glasses and safety shoes when handling cylinders
- Fit and maintain flashback arrestors when used with acetylene and LPG equipment
- Only experienced and properly instructed people should use this product
- Do not use oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Only oxygen-compatible materials may be used with oxygen and these must be fully degreased. Copper, brass and high quality stainless steel are the most commonly used metals. Most lubricants are NOT compatible. Oil and grease can cause ignition.

Principles of Oxygen Safety

To prevent accidents, the following principles should be applied:

- Personnel should be conversant with the contents of this document and should be competent to operate the oxygen equipment they use
- Where practical, designs should incorporate fail-safe features to protect personnel and property
- All personnel concerned with the operation of equipment and handling of products should be actively aware of the potential hazards and alert to all aspects of safety.

Argon (Ar)

Argon is the third most abundant of the mixture of gases in the air, the concentration being approximately 0,94% by volume. It is inert, non-toxic, colourless, odourless and tasteless. Supplied in high pressure metal cylinders and manifolded cylinder packs.

Hazards

- Compressed high pressure gas in cylinders
- Asphyxiant in high concentrations.

Classifications (Argon Technical)	
Gas	**Purity**
Argon Technical	99,9%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ARGON TEC CYL 17,4 KG	17,4	50,0	200	5/8" BSPF right hand female	10-SE
PortaTIG®	1,9	5,8	200	5/8" BSPF right hand female	10-GD1
Argon tec PCC	200	180	200	5/8" BSPF right hand female	556-PA

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Gas (Argon High Purity)	Purity
Argon High Purity	99,998%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ARGON HP CYL 17,4 KG	17,4	50,0	200	5/8" BSPF right hand female	11-SE
ARGON HP MCP 15 X 17,4 KG	261	MCP	200	5/8" BSPF right hand female	11-ME15

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	39,948
Specific volume at 21,1˚C and 101,325 kPa	603,7 ℓ/kg
Boiling point at 101,325 kPa	-185,9˚C
Critical temperature	-122,4˚C
Relative density (air = 1) at 1 atm	1,380
Absolute density, gas at 101,325 kPa and 0˚C	1,784 kg/m^3
Flammability	N/A

Uses and Features

- Argon is used in plasma jet torches
- The high temperature preparation, refining and fabrication of many materials must be carried out in an argon atmosphere
- Argon is used as a shielding gas for GTAW applications and for GMAW of aluminium
- Argon is used for purging applications when an inert atmosphere is required.

Precautions in Use

- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Only properly instructed people should handle this gas
- Never allow oil or grease on a cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Argon is non-corrosive and so any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Other Gases

Carbon Dioxide (CO_2)

An odourless, colourless, non-toxic, non-flammable gas.
Supplied as a high pressure liquefiable gas in metal cylinders.

Hazards

- High pressure liquefiable gas
- Sudden expansion will produce low temperatures
- Asphyxiant in high concentration.

Classifications (Carbon Dioxide Technical)	
Gas	**Purity**
Carbon Dioxide Technical	99,0%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20ºC (Bar)	Valve Outlet Connection	Item Number
CO_2 TEC CYL 31,3 KG	31,3	47,2	153	0,860" x 14TPI Right hand male	40-RC
CO_2 TEC CYL 31,3 KG WET	31,3	47,2	153	0,860" x 14TPI Right hand male	40-RC-W
CO_2 TEC PCC	175	175			573-PA

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	44,011
Specific volume at 20˚C and 101,325 kPa	547 ℓ/kg
Critical temperature	31˚C
Relative density (air = 1) at 1 atm	1,53
Density, gas at 101,325 kPa and 0˚C	1,977 kg/m^3
Flammability	N/A

Store and Handling

- Gas cylinders must be stored in a cool, well-ventilated, dry location
- When cylinders are stored or used inside, ventilation, either natural or forced, should be used
- Because carbon dioxide is heavier than air, it tends to accumulate in low areas, and should not therefore be stored or used in sub-surface spaces such as basements
- The cylinders normally used for carbon dioxide have a gas withdrawal system. However, those that have a yellow stripe along the wall are of the liquid withdrawal type and are fitted with an educator tube. These must not be connected directly to gas systems
- Protective gloves should be used when operating cylinder valves and equipment connected to a liquid withdrawal cylinder
- Many applications for carbon dioxide require the dispensing of carbon dioxide gas only, in which case adequate ventilation must be available at point of use
- A periodic test, as well as a commissioning test, must be carried out to ensure that the level of carbon dioxide in the work area is below 5 000 ppm by volume in air.

Health Hazards

- Carbon dioxide gas will displace oxygen from the breathing atmosphere which may lead to suffocation
- Carbon dioxide helps regulate the body's breathing function. It is normally present in the air at a concentration of 300 ppm by volume. Increasing this level will cause both breathing and heart rate to accelerate, and concentration of the order of 10% can cause respiratory paralysis and can only be endured for a few minutes.

Uses and Features

- Welding grade CO_2 is a general purpose shielding gas for steel sections and plate. Used primarily for short arc welding of mild steels with all diameters of solid steel MIG wire and flux cored gas shielded wires
- Industrial grade CO_2 is used as an inert atmosphere for many industrial applications, e.g. prevention of oxidation, conveying flammable materials
- Some applications for compressed CO_2 include: beer dispensing, post-mix soft drink dispensing, shielded arc welding, sparging, foundry sand mould curing, fire fighting (fire extinguishers), gas atmosphere for preservation of packaged foods, animal immobilisation.

Precautions in Use

- Use only approved pressure rated equipment
- Wear safety glasses, use leather/plastic protective gloves, wear overalls when handling cylinders
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Refer to MSDS for more information.

Material Compatibility

- Dry carbon dioxide is non-corrosive, hence common materials are acceptable, e.g. steel, iron, copper, brass, plastic
- Moist carbon dioxide is slightly corrosive, hence carbonic acid resistant materials are required.

SHIELDING GASES

Shielding gases is a general term for a range of products used in the joining and cutting of predominantly metallic materials. They protect the molten metal in the weld from oxygen and nitrogen in the atmosphere.

Unprotected molten metal can be weakened by oxygen and nitrogen, causing a range of problems including weld failure, defects in the weld metal and decreased corrosion resistance.

The choice of shielding gas is determined by the material, the process being used and the performance and properties required by the customer. Shielding gases can be individual gases or mixtures.

Argon and argon-based mixtures predominate the joining of metals. Shielding gases are used with arc welding and cutting processes such as MIG, TIG and PAC. They can strongly influence the properties, weld metal and even the shape and size of the weld bead.

Shielding Gases

Key	
Recommended	🟢
Also Suitable	⚫

	Carbon & Alloy Steel					Austenitic Stainless Steel				
	MIG	TIG	Cored Wire	PAC	Purging	MIG	TIG	Cored Wire	PAC	Purging
Argoshield® Light	🟢									
Argoshield® Universal	🟢		⚫					⚫		
Argoshield® Heavy	🟢		⚫					⚫		
Alushield®		⚫			⚫		⚫			⚫
Copashield®		⚫			⚫		⚫			⚫
Portashield®	🟢									
Stainshield® Heavy						🟢				
Stainshield® TIG Plus							🟢			⚫
Stainshield® TIG							🟢			⚫
TIGshield®		🟢			🟢		⚫			🟢
Stainshield® Plus						⚫				
Stainshield®	⚫					⚫				
Fluxshield®	⚫		🟢					🟢		
Carbon Dioxide	⚫		⚫	⚫				⚫	⚫	
Nitrogen				⚫	⚫				⚫	⚫

	Ferric & Martensitic Stainless Steel					Duplex Stainless Steel				
	MIG	TIG	Cored Wire	PAC	Purging	MIG	TIG	Cored Wire	PAC	Purging
Argoshield® Light										
Argoshield® Universal			⚫					⚫		
Argoshield® Heavy			⚫					⚫		
Alushield®		⚫			⚫		⚫			⚫
Copashield®		⚫			⚫		⚫			⚫
Portashield®										
Stainshield® Heavy	🟢					🟢				
Stainshield® TIG Plus		🟢			⚫					
Stainshield® TIG										
TIGshield®		🟢			🟢		🟢			🟢
Stainshield® Plus	⚫					⚫				
Stainshield®	⚫					⚫				
Fluxshield®			🟢					🟢		
Carbon Dioxide			⚫	⚫				⚫	⚫	
Nitrogen				⚫	⚫				⚫	⚫

	Aluminium				Copper				Cast Iron			
	MIG	TIG	PAC	Purging	MIG	TIG	PAC	Purging	MIG	TIG	PAC	Purging
Argoshield® Light												
Argoshield® Universal												
Argoshield® Heavy												
Alushield®	🟢	🟢		⚫	🟢	🟢		⚫		⚫		⚫
Copashield®	🟢	🟢		⚫	🟢	🟢		⚫		⚫		⚫
Portashield®												
Stainshield® Heavy												
Stainshield® TIG Plus												
Stainshield® TIG												
TIGshield®	⚫	⚫		🟢	⚫	⚫		🟢		🟢		🟢
Stainshield® Plus												
Stainshield®												
Fluxshield®												
Carbon Dioxide			⚫				⚫				⚫	
Nitrogen			⚫				⚫				⚫	⚫

	Nickel Alloys (not Montels)				Nickel or Copper - Montels				Titanium & Magnesium			
	MIG	TIG	PAC	Purging	MIG	TIG	PAC	Purging	MIG	TIG	PAC	Purging
Argoshield® Light												
Argoshield® Universal												
Argoshield® Heavy												
Alushield®		⚫		⚫	🟢	🟢		⚫	🟢	🟢		⚫
Copashield®		⚫		⚫	🟢	🟢		⚫	🟢	🟢		⚫
Portashield®												
Stainshield® Heavy	🟢											
Stainshield® TIG Plus		🟢		⚫								
Stainshield® TIG		🟢		⚫								
TIGshield®		⚫		🟢	⚫	⚫		🟢	⚫	⚫		🟢
Stainshield® Plus	⚫											
Stainshield®	⚫											
Fluxshield®												
Carbon Dioxide			⚫									
Nitrogen			⚫	⚫			⚫				⚫	

Argoshield® Light

Argoshield® Light has been formulated specifically for welders using the GMAW process on carbon steel typically less than 4 mm thick. This gas mixture, which can be used in all positions, produces low heat input and narrow weld beads, so reducing distortion and burn-through. Together with its excellent arc stability and high speed capability for welding thin sheet, Argoshield® Light is easy to use, provides a quality weld and minimises overall cost.

Afrox MSDS: MS090 (Ar/CO_2/O_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders
- Use only approved pressure rated equipment.

Classifications
Gas Components
Argon
Carbon Dioxide
Oxygen

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ARGOSHIELD® LIGHT CYL 17,8 KG	17,8	50,0	200	5/8" BSPF right hand female	24-SE-LIG
ARGOSHIELD® LIGHT CYL 3,6 KG	3,6	10,0	200	5/8" BSPF right hand female	24-IE
ARGOSHIELD® LIGHT MCP 15 x 17,8 KG	267	MCP	200	5/8" BSPF right hand female	24-ME15-LIG

Applications

- Duct and sheet metal engineering industries
- Automotive components manufacture
- Vehicle repair
- Cabinets/steel furniture manufacture
- Domestic appliance manufacture
- Light gauge storage tanks.

Features	Benefits
Excellent arc stability	Minimal spatter
Low distortion	Easy to use. Minimises post weld treatment
Low oxidation potential	Good appearance and quality finish
Wide operating envelope	Allows high productivity. Easy to use
Low levels of nitrogen and moisture	Low porosity and other defects
High levels of accuracy and quality control during production	Reproducible weld quality from cylinder to cylinder

Precautions in Use

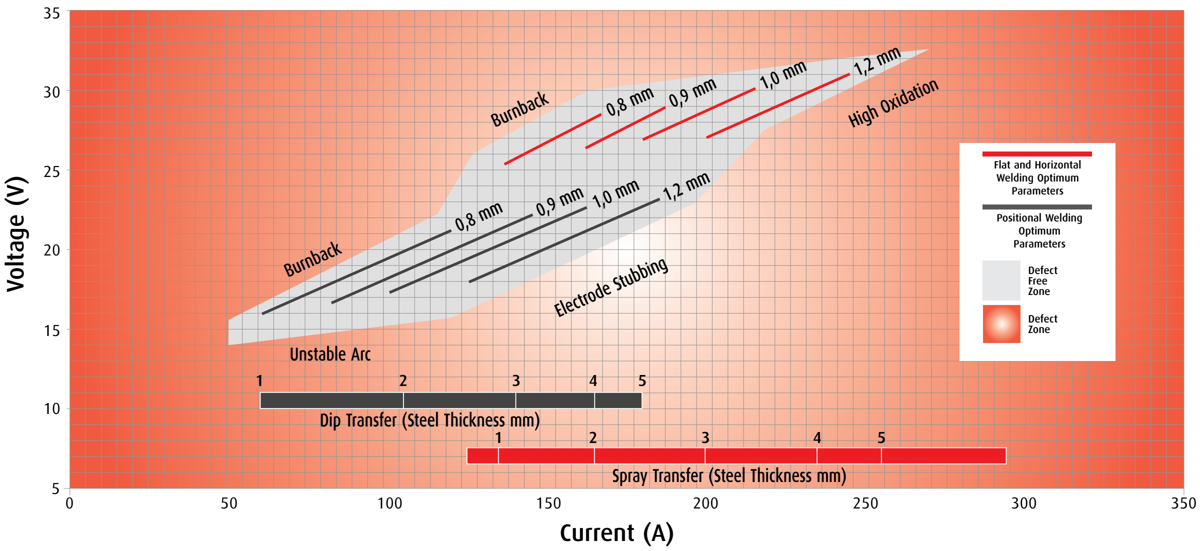
- Asphyxiant in high concentrations
- Compressed high pressure gas in cylinders
- Use only approved pressure rated equipment
- Do not allow oil or grease on cylinder or valve
- Open cylinder valves slowly
- Close cylinder valves when not in use
- Cylinders should be secured from falling over.

Material Compatibility

- Argoshield® Light is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 0,8 mm, 0,9 mm, 1,0 mm and 1,2 mm diameter wires.



Electrode stick out, contact tip-to-work distance 18 mm for spray, 15 mm for dip, gas flow rate 15 ℓ/min

Argoshield® Universal

Argoshield® Universal has been formulated for general fabrication of carbon steel over the typical thickness range 5-12 mm. This gas mixture is easy to use, giving good weld performance across a wide range of applications and welding parameters. It can be used in any position, for single- and multi-pass welds in dip, spray, pulsed or synergic mode. Combined with its excellent arc stability, low spatter and broad weld profile, these advantages make Argoshield® Universal an excellent choice for quality and economy in general engineering applications.

Afrox MSDS: MS090 (Ar/CO_2/O_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Carbon Dioxide
Oxygen

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ARGOSHIELD® UNIVERSAL CYL 18,5 KG	18,5	50,0	200	5/8" BSPF right hand female	28-SE
Argoshield Universal MCP	15 x 18,5	50,0	200	5/8" BSPF right hand female	28-ME 15

Applications

- General fabrication
- General industrial products
- Light to medium-plate fabrication
- Structural steelworks
- Bridgework
- Pipe and tube joining
- Vehicle manufacture/heavy trucks.

Features	Benefits
Excellent arc stability	Low spatter
Low distortion	Minimal post weld straightening
Low oxidation potential	Smooth weld bead
Used in dip, pulsed and spray metal transfer modes	Higher productivity
Low levels of nitrogen and moisture	Low porosity and other defects
High levels of accuracy and quality control during production	Reproducible weld quality from cylinder to cylinder

Precautions in Use

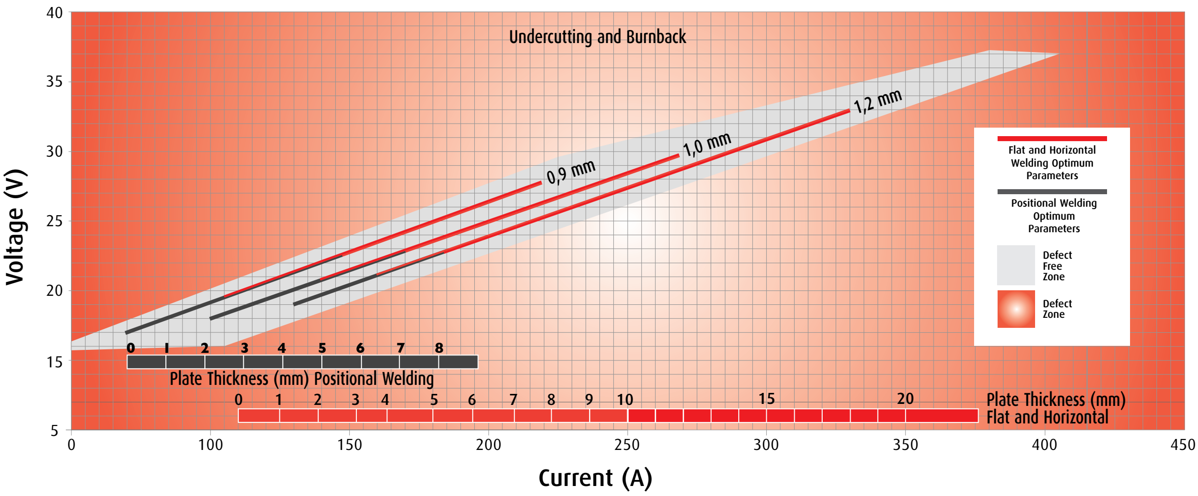
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Argoshield® Universal is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 0,9 mm, 1,0 mm and 1,2 mm diameter wires.



Electrode stick out, contact tip-to-work distance 19-25 mm for spray, 6-13 mm for dip, gas flow rate 15-20 ℓ/min

Argoshield® Heavy

Argoshield® Heavy has been formulated for welders using the GMAW process on constructional steelworks typically greater than 10 mm thick. Its higher carbon dioxide content gives welds in carbon steel good rounded penetration profiles that are deep and wide. This produces consistently reliable strong welds, which can be used for bridges, buildings, boilers, plant and machinery. Argoshield® Heavy is ideal for multi-pass welds in spray mode on heavy sections, allowing fast welding speeds which reduce costs. It also has the advantage of tolerating contaminants such as dirt, oil, grease and rust and poor joint fit-up.

Afrox MSDS: MS090 (Ar/CO_2/O_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Carbon Dioxide
Oxygen

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ARGOSHIELD® HEAVY CYL 19,6 KG	19,6	50,0	200	5/8" BSPF right hand female	25-SE

Applications

- Heavy engineering
- Heavy structural steel
- Boiler manufacture
- Shipbuilding and repair
- Heavy vehicle manufacture
- Thick-walled pipes and pressure vessels
- Pad-eyes and lifting lugs
- Earth-moving equipment.

Features	Benefits
Good arc stability	Easy to use. Low spatter
Low oxidation potential	Reduced spatter. Good weld appearance. Low weld clean-up
Used in dip, pulsed and spray metal transfer modes	Good appearance and finish
	Minimises distortion and maximises productivity
Low levels of nitrogen and moisture	Low porosity and other defects
	Reduced porosity, increased toughness
High levels of accuracy and quality control during production	Suitable for automated applications
	Reproducible weld quality from cylinder to cylinder

Precautions in Use

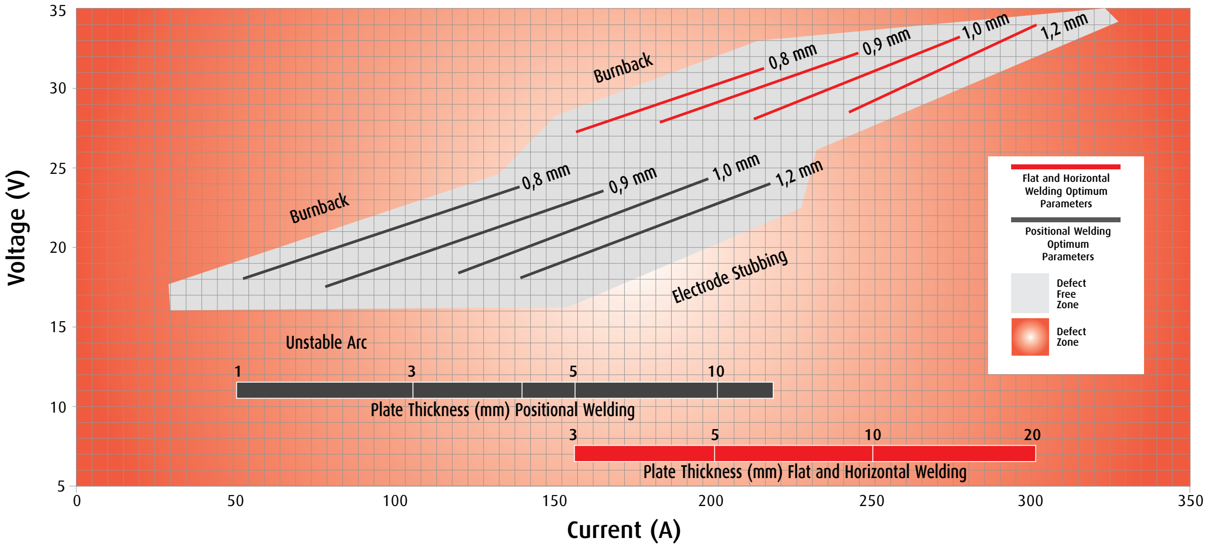
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Argoshield® Heavy is inert and non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 0,8 mm, 0,9 mm, 1,0 mm and 1,2 mm diameter wires.



Electrode stick out, contact tip-to-work distance 18 mm for spray,
15 mm for dip, gas flow rate 16 ℓ/min

Argoshield® 5

Argoshield® 5 has been formulated specifically for welders using the GMAW process on carbon steel typically less than 4 mm thick. This gas mixture, which can be used in all positions, produces low heat input and narrow weld beads, thereby reducing distortion and burn-through. Together with its excellent arc stability and high speed capability for welding thin sheet, Argoshield® 5 is easy to use, provides a quality weld and minimises overall cost.

Afrox MSDS: MS090 ($Ar/CO_2/O_2$)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Carbon Dioxide
Oxygen

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20ºC (Bar)	Valve Outlet Connection	Item Number
ARGOSHIELD® 5 CYL 17,8 KG	17,8	50,0	200	5/8" BSPF right hand female	24-SE
ARGOSHIELD® 5 CYL 8,4 KG	8,4	23,6	200	5/8" BSPF right hand female	24-KE
PORTASHIELD® CYL 1,8 KG	1,8	5,8	200	5/8" BSPF right hand female	27-GD

Applications

- Duct and sheet metal engineering industries
- Automotive components manufacture
- Vehicle repair
- Cabinets/steel furniture manufacture
- Domestic appliance manufacture
- Light gauge storage tanks.

Features	Benefits
Excellent arc stability	Minimal spatter
Low distortion	Easy to use, minimal post weld straightening
Low oxidation potential	Good appearance and quality finish
Wide operating envelope	Allows high productivity, excellent welder appeal
Low levels of nitrogen and moisture	Low porosity and other defects, high toughness
High levels of accuracy and quality control during production	Reproducible weld quality from cylinder to cylinder

Precautions in Use

- Asphyxiant in high concentrations
- Compressed high pressure gas in cylinders
- Use only approved pressure rated equipment
- Do not allow oil or grease on cylinder or valve
- Open cylinder and MCP valves slowly
- Close cylinder and MCP valves when not in use
- Cylinders should be secured from falling over.

Material Compatibility

- Argoshield® 5 is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Alushield®

Alushield® is a gas mixture of argon and helium for GMAW and GTAW welding of aluminium and its alloys. It is a versatile, high specification gas suitable for welding over a range of thicknesses, giving consistently good penetration and bead shape. The mixture is chemically inert providing a stable, steady and controllable arc. Alushield® can also be used on automated welding processes and by allowing faster welding speeds with lower defect rates, can significantly reduce fabrication costs.

Helium content provides a higher arc energy to combat the high thermal conductivity of these alloys, increasing penetration and minimising the need for preheating.

Afrox MSDS: MS075 (Ar/He)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Helium

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ALUSHIELD® CYL 8,4 KG	8,4	50,0	200	5/8" BSPF right hand female	94-SE

Applications

- Ship and marine superstructures
- Pressure vessels
- Chemical and petrochemical plant
- Pipework.

Features	Benefits
Excellent arc stability	Little/no spatter
Low oxidation potential	Strong weld
Uses less wire	Reduces wire wastage of high value wires
Used in dip, pulsed and spray metal transfer modes	Easy to use
Fast, high arc energy	Low production costs
High heat input	Low defect levels
High purity argon/helium mixture	Reduced repair
	Reduced clean-up
	Can be used on machines and robots

Precautions in Use

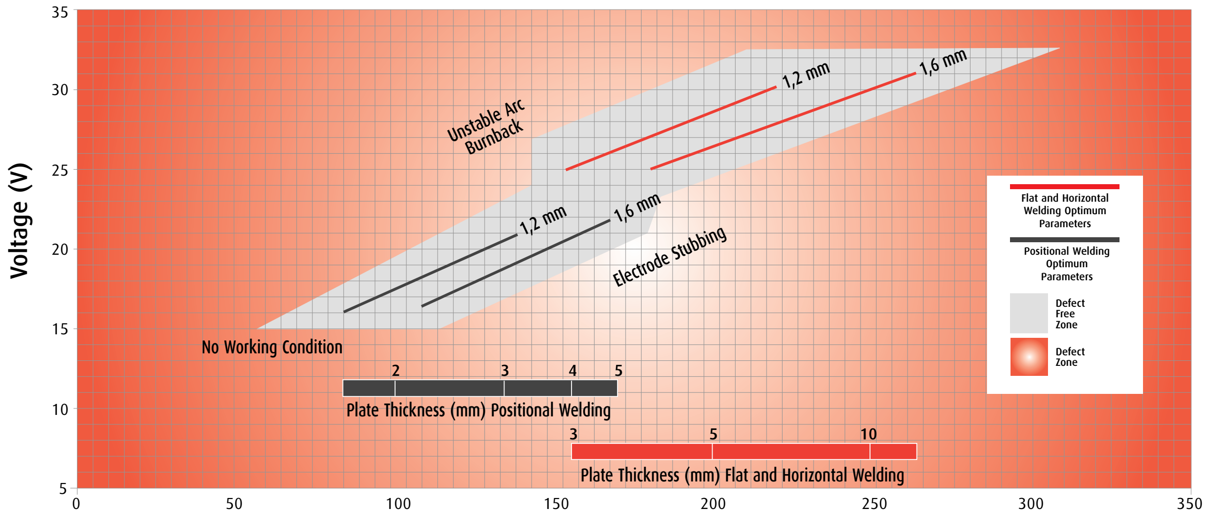
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Alushield® is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 1,2 mm and 1,6 mm diameter wires.



Electrode stick out, contact tip-to-work distance 19-25 mm for spray, 8-13 mm for dip. Gas flow rate 15-18 ℓ/min

Copashield®

Copper and copper-based alloys are typically characterised by a high thermal conductivity and high heat capacity. The high helium content of Copashield® provides a very intense arc which allows these materials to be welded more readily than by using other gases. In many cases, preheating can be eliminated by the high arc energy available. Copashield® is suitable for both GMAW and GTAW welding. Copashield® can also be used on aluminium and aluminium alloys above 6 mm and is ideal because it is a fast welding gas with hotter arc, with low porosity at high productivity levels.

Afrox MSDS: MS075 (Ar/He)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Helium

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
COPASHIELD® CYL 4,8 KG	4,8	50,0	200	5/8" BSPF right hand female	395-SE

Applications

- Copper-lined steel pressure vessels
- Bus-bar manufacture
- Spirit distillation vessels
- Arc furnace electrode holders
- Heat exchangers
- Petrochemical equipment
- Calorifiers.

Features	Benefits
Helium achieves hotter arc	Reduced preheat requirement – none required below 6 mm*
Good wetting characteristics	Excellent penetration
Good weld penetration profile	Increased strength
Low spatter	Smooth and flat weld surface profiles, less wire used
Ultra-high purity gas mixture	Reduced fusion defects
	Reduced clean-up time

*Above 6 mm preheat from 350-550°C

Precautions in Use

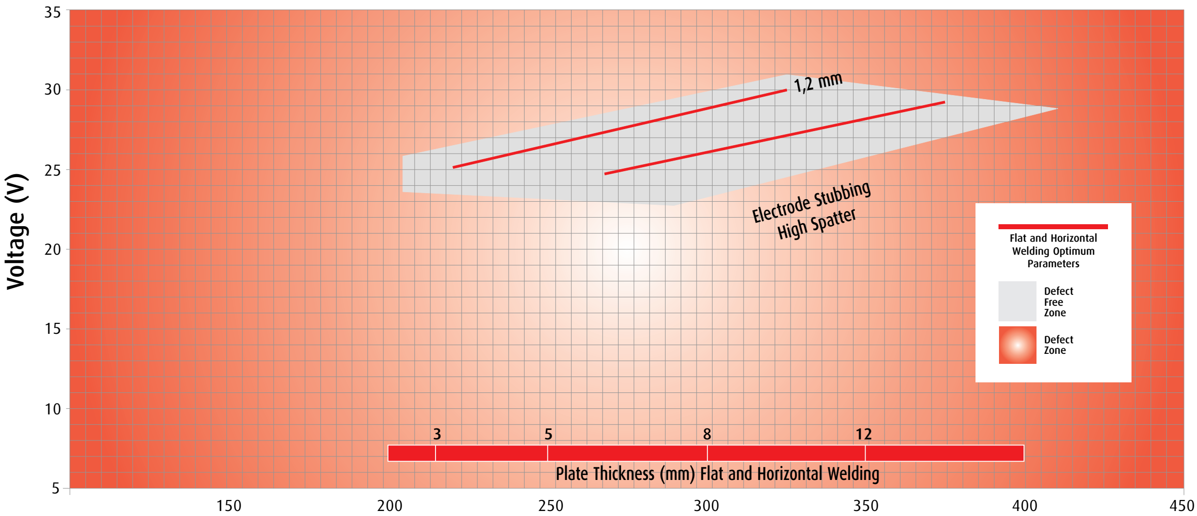
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Copashield® is non-corrosive and so any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 1,2 mm and 1,6 mm diameter wires.



Electrode stick out, contact tip-to-work distance 15 mm for spray.
Gas flow rate 18 ℓ/min

Fluxshield®

Fluxshield® is an argon/carbon dioxide-based shielding gas specifically designed for high quality single- and multi-pass welding of mild, low alloy and stainless steels using the flux cored and metal cored wire processes. It can be used in all positions either manually or semi-automated, depending on the wire type. Fluxshield® exhibits excellent arc stability, generates good penetration profiles, a very smooth weld appearance with low spatter levels and promotes excellent slag detachability. Fluxshield® is also tolerant of poor fit-up and less than ideal joint cleanliness.

Afrox MSDS: MS062 (Ar/CO_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Carbon Dioxide

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
FLUXSHIELD® CYL 20,5 KG	20,5	50,0	200	5/8" BSPF right hand female	26-SE

Applications

- General plate fabrications
- Structural steel and bridgework
- Heavy engineering type fabrications
- Pressure vessels, piping and tank manufacture
- Offshore drilling rigs and shipbuilding
- Fabrications previously limited to SMAW using AWS-E7018 electrodes, with stringent mechanical strength requirements, i.e. for low temperature impact toughness, high yield and UTS requirements
- Ideal for HSLA, mild, structural and stainless steels.

Features	Benefits
Superior/excellent mechanical properties	High integrity welds exceeding the minimum requirements of AWS-5.18, AWS-A5.20, AWS-5.29 and ASME SFA5.20
Low weld metal hydrogen levels (<5 ml per 100 g of weld metal)	Low risk of hydrogen cracking
Excellent arc stability, very smooth arc	Excellent weldability and welder appeal with excellent weld bead appearance
Deep penetrating capability	Excellent fusion at the weld root
Ultra-high purity gas mixture	Consistent X-ray quality welds
Fast freezing slag	Allows welding in all positions
Low spatter and easy slag removal	Minimum post weld cleaning required
High weld metal deposition rates	High productivity and improved process economics over GMAW

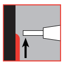
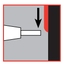
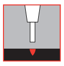
Precautions in Use

- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder and MCP valve slowly
- Close cylinder and MCP valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Fluxshield® is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Welding Parameters for Mild Steel Flux Cored Wire E7 It-1*

	Welding Position	Wire Diameter (mm)	Current		Optimum Settings		Wire Feed Speed (m/min)	Deposited Metal (kg/h)
			Amps (A)	Volts (V)	Amps (A)	Volts (V)		
	**Vertical-up**	1,2	130 - 200	19 - 25	175 - 185	23 - 25	3,3 - 6,3	1,4 - 2,9
	**Vertical-down**	1,6	170 - 250	19 - 26	200 - 220	22 - 24	2,5 - 7,3	1,1 - 2,7
	**Flat/ downhand welding**	1,2	150 - 300	21 - 33	300	33	3,3 - 12,7	1,4 - 4,5
		1,6	200 - 400	22 - 34	350	34	3,7 - 10,8	1,6 - 6,8
	**Horizontal fillet welding**	1,2 - 1,6	150 - 400	21 - 34	350	34	3,7 - 10,8	1,6 - 6,8

Electrode stick out, contact tip-to-work distance 20 mm. DCEP (direct current electrode positive).
Gas flow rate 15-20 ℓ/min

Stainshield®

Stainshield® is a general formulation gas for welders using the GMAW process on all stainless steels. It offers an economical solution, suitable for many applications on a wide range of metal thicknesses. Stainshield® is particularly suitable where minimal oxidation of the weld is required and where there is a risk of carbon contamination of the product. Stainshield® performs well across a range of applications providing good arc stability in dip, pulse and spray transfer modes.

Afrox MSDS: MS084 (Ar/O_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Oxygen

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
STAINSHIELD® CYL 17,4 KG	17,4	50,0	200	5/8" BSPF right hand female	27-SE

Applications

- All stainless steels
- Tubing and pipework
- Tanks and vessels.

Features	Benefits
High weld quality	Proven technology
Good penetration	Low porosity and other defects
No carbon pick-up	Maintains corrosion resistance
Low levels of nitrogen and moisture	Versatile – can be used across a range of thicknesses
High levels of accuracy and quality control during production	Low spatter
	Reproducible weld quality from cylinder to cylinder

Precautions in Use

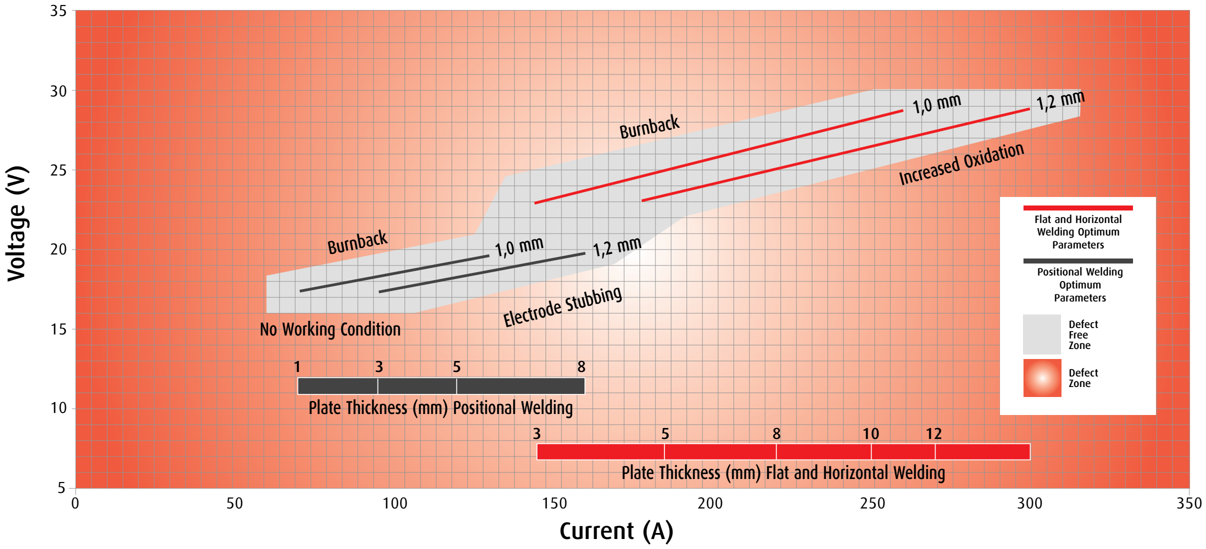
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Stainshield® is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 1,0 mm and 1,2 mm diameter wires.



Electrode stick out, contact tip-to-work distance 19-25 mm for spray, 8-13 mm for dip, gas flow rate 15-18 ℓ/min

Stainshield® Plus

Stainshield® Plus has been formulated specifically for welders using the GMAW process on all stainless steels, particularly 3CR12. It provides a strong weld and is suitable across a wide range of metal thicknesses, particularly where the final appearance of the weld is important to the product. Its low oxidation potential, stable arc and fluid weld pool produce a decorative finish to the weld.

Afrox MSDS: MS062 (Ar/CO_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon
Carbon Dioxide

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
STAINSHIELD® PLUS CYL 17,6 KG	17,6	50,0	200	5/8" BSPF right hand female	30-SE

Applications

- All stainless steels
- Tubing and pipework
- Tanks and vessels
- Catering equipment
- Components for the petrochemical industry.

Features	Benefits
Good arc stability	Reduced spatter
Low oxidation potential	Low defect levels, good weld appearance
Wide operating envelope	Good weld appeal, versatile
Uses less wire	Minimises waste of expensive wire
Low distortion	Reduced post weld treatment
Fast	Can also be used on machines and robots
Improved fusion characteristics	Good positional welding, X-ray quality welds
Very stable dip transfer	Excellent on thin sheet, e.g. tanks

Precautions in Use

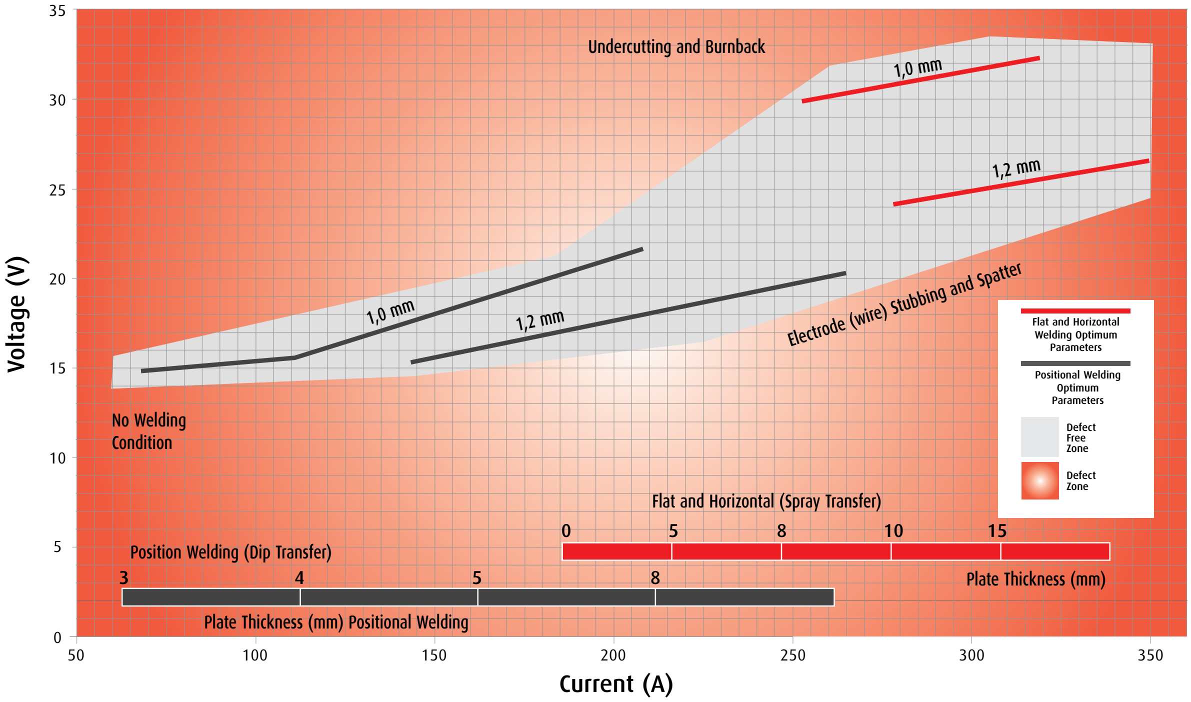
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Stainshield® Plus is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 1,0 mm and 1,2 mm diameter wires.



Electrode stick out, contact tip-to-work distance 19-25 mm for spray, 8-13 mm for dip, gas flow rate 15-18 ℓ/min

Stainshield® Heavy

Stainshield® Heavy is an argon-rich three component of argon-helium-CO_2 mixture developed primarily for the MIG welding of stainless steels above 10 mm thick, but it also has applications in the MIG welding of other metals. It is slightly oxidising, making it ideal for use with metals or processes that can tolerate the presence of oxidising gases.

The addition of helium to the shielding gas increases the amount of energy transferred into the weld, producing smooth, even and defect-free welds. Stainshield® Heavy has been developed to greatly improve welding speed, increase deposition rates and, in some cases, reduce preheat requirements.

Afrox MSDS: MS092 (Ar/CO_2/He)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Carbon Dioxide
Helium
Argon

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20ºC (Bar)	Valve Outlet Connection	Item Number
STAINSHIELD® HEAVY CYL 10,4 KG	10,4	50,0	200	5/8” BSPF right hand female	99-SE

Applications

- All stainless steels
- Tubing and pipework
- Tanks and vessels
- Catering equipment
- Components for the petrochemical industry
- Ship repair industry.

Features	Benefits
For materials thicker than 8 mm	Low spatter levels
Very good fusion characteristics	Low defect levels
Very good arc stability	Increased weld speed
Low fusion defects	Excellent porosity control

Precautions in Use

- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Stainshield® Heavy is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Stainshield® TIG Plus

Argon-helium shielding gas mixtures are two component mixtures of argon and helium developed primarily for MIG and TIG welding of non-ferrous metals of between 3-10 mm.

Argon-helium-rich shielding gases input more heat into the weld than pure argon, but the addition of argon improves the arc stability. These gases will help a skilled welder to produce smooth, even and defect-free welds. They are also suitable for TIG welding of copper, copper alloys and nickel alloys where high heat input is required.

Mixtures with a high helium content have the ability to transfer heat more effectively to the weld pool. This makes them ideal for welding thick metals that have to be preheated before welding. Preheat can be reduced or, in some cases, dispensed with altogether.

Afrox MSDS: MS075 (Ar/He)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Helium
Argon

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
STAINSHIELD® TIG PLUS CYL 12,3 KG	12,3	50,0	200	5/8” BSPF right hand female	000187-SE-C

Applications

- Automatic and orbital welding
- Pipework
- Electronics
- Petrochemical
- Power generation
- Tubing and seams.

Features	Benefits
High welding speeds	No burn-through
Fluid weld pool	Suited for manual processes
Versatile	Versatile for all grades of stainless steel
Reduced surface tension beads	Slightly flatter weld

Precautions in Use

- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Stainshield® TIG Plus is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

TIGshield®

TIGshield® is an argon shielding gas developed primarily for TIG welding. Welding with argon produces a relatively cold arc suitable for welding thin section materials. As it has a low ionisation potential and is a completely inert gas, it easily forms a welding arc without reacting with the metal components being welded.

When welding thicker material, other gases are added to the argon base to produce a hotter welding arc and to improve fusion characteristics when MIG welding, if the metallurgy of the material permits it.

Argon, a colourless, odourless and tasteless gaseous element, is heavier than air.

Afrox MSDS: SG/MSDS 2

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders.

Classifications
Gas Components
Argon

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20ºC (Bar)	Valve Outlet Connection	Item Number
TIGSHIELD® CYL 3,5 KG	3,5	10,0	200	5/8" BSPF right hand female	87-IE

Applications

- All types of stainless steels 0-3 mm
- 95% of TIG applications up to 3 mm for stainless steel; 5 mm for carbon steel
- Excellent purging gas
- Thin applications.

Features	Benefits
General purpose shielding gas for all grades of stainless steel, mild steel and aluminium	Ideally suited for thin sections
Can be used as a purge gas	Easy striking arc

Precautions in Use

- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- Argon is non-corrosive and so any common metal is acceptable, provided the equipment is designed to withstand process pressure.

RoboShield®

RoboShield® has been formulated for robotic and mechanised applications in the automotive industry resulting in strong, spatter-free welding at high production rates. It is also highly suitable for welders using the GMAW process on constructional steelworks typically greater than 12 mm thick. Its higher carbon dioxide content gives welds in carbon steel good rounded penetration profiles that are deep and wide. This produces consistently reliable strong welds, which can be used for bridges, buildings, boilers, plant and machinery. RoboShield® is ideal for multi-pass welds in spray mode on heavy sections, allowing fast welding speeds which reduce costs. It also has the advantage of tolerating contaminants such as dirt, oil, grease and rust and poor joint fit-up.

Afrox MSDS: MS090 (Ar/CO_2)

Hazards

- Asphyxiant in high concentrations
- Compressed – high pressure gas mixture in cylinders
- Use only approved pressure rated equipment.

Classifications
Gas Components
Argon
Carbon Dioxide

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20°C (Bar)	Valve Outlet Connection	Item Number
ROBOSHIELD®	19,7	50	200	5/8” BSPF right hand female	20-SE

Applications

- Mechanised and robotic high speed welding
- General plate fabrications
- Structural steel and bridgework
- Heavy engineering type fabrications
- Pressure vessels, piping and tank manufacture
- Offshore drilling rigs and shipbuilding
- Carbon steels and low alloy steels.

Features	Benefits
Formulated for robotic welding	Resulting in high speed, clean spatter free welding
Superior/excellent mechanical properties	High integrity welds exceeding the minimum requirements of AWS-A5.18, AWS-A5.20, AWS-A5.29 and AWS-A5.36
Low weld metal hydrogen levels (<5 ml per 100 g of weld metal)	Low risk of hydrogen cracking
Excellent arc stability, very smooth arc	Excellent weldability and welder appeal with excellent weld bead appearance
Deep penetrating capability	Excellent fusion at the weld root
Ultra-high purity gas mixture	Consistent X-ray quality welds
High weld metal deposition rates	High productivity and improved process economics over GMAW
Suitable for manual GMAW of solid wires	Low spatter

Precautions in Use

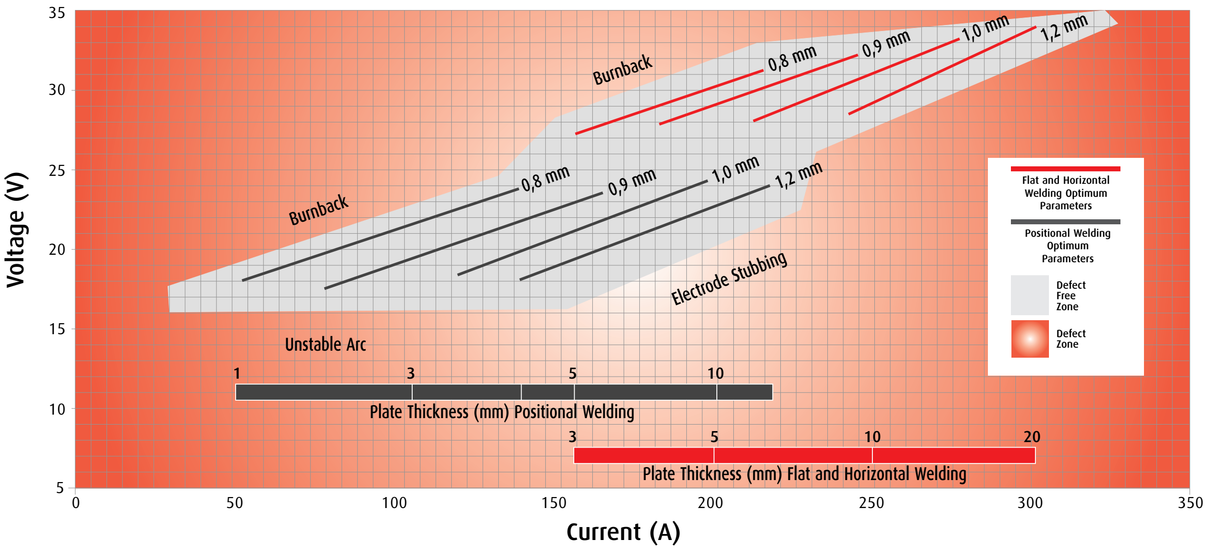
- Use only approved pressure rated equipment
- Use only in well ventilated areas
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Do not allow oil or grease on cylinder or valve
- Cylinders should be secured from falling over
- Refer to MSDS for more information.

Material Compatibility

- RoboShield® is non-corrosive, therefore any common metal is acceptable, provided the equipment is designed to withstand process pressure.

Current/Voltage Envelope

Operating limits for 0,8 mm, 0,9 mm, 1,0 mm and 1,2 mm diameter wires.



Electrode stick out, contact tip-to-work distance 18 mm for spray,
15 mm for dip, gas flow rate 16 ℓ/min

Fuel Gases

Dissolved Acetylene (C_2H_2)

Acetylene is a highly flammable colourless gas of distinct odour. The high solubility of acetylene in acetone (300:1 by volume at 1 100 kPa) enables it to be supplied dissolved in acetone. Acetylene cylinders are filled with porous material which carries the acetone.

Hazards

- An asphyxiant with anaesthetic properties
- Forms an explosive mixture with air
- Can form explosive acetylides with unalloyed copper, silver, mercury, brass containing more than 66% copper, and brazing materials containing copper and silver
- Can spontaneously decompose within equipment and pipework under certain flow, temperature and pressure conditions.

Classifications	
Gas	**Purity**
Acetylene Technical	98,0%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20ºC (Bar)	Valve Outlet Connection	Item Number
ACET TEC CYL 8,0 KG 12/10/5/2/ R 006	8,0	50,0	-	5/8" BSPF left hand female	15-DE
ACET TEC CYL PORTAPAK® 12/10/5/2/ R 006	0,9	5,6	-	11/16" x 20 TPI W left hand female	16-DA
ACET TEC MCP 12 X 8,0 KG 12/10/5/2/ R 006	96,0	MCP	-	5/8" BSPF left hand female	15-MD12

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless gas, ethereal when pure. Garlic when commercial
Molecular weight	26,038
Specific volume at 15,6˚C and 101,325 kPa	900,8 ℓ/kg
Boiling point at 170 kPa	-75˚C
Critical temperature	35,2˚C
Relative density (air = 1) at 101,325 kPa	0,908
Density, gas at 101,325 kPa and 0˚C	1,1747 kg/m³
Flammable limits in air (by volume)	2,0 - 82%

Uses and Features

- Acetylene is the best and most versatile fuel gas for welding, straightening, bending, forming, hardening, cutting or tempering. It is the hottest flame temperature when compared to MAPP gas, propylene and propane and natural gas (2,910˚C, 2,895˚C, 2,800˚C and 2,780˚C respectively)
- Acetylene is used as a fuel gas for oxy-acetylene welding, cutting, general localised heating, flame hardening, flame cleaning to remove rust from steel, spalling concrete and other processes requiring a high temperature flame (3,160˚C when combusted in oxygen)
- Specially purified instrument grade acetylene which has such impurities (arsine, phosphine, ammonia and hydrogen sulphide) removed is used in atomic absorption, analytical instrumentation and navigational beacons.

Precautions in Use

- Fit and maintain flashback arrestors in equipment
- Keep hot work and sparks away from cylinder relief devices and hoses. Do not work directly above cylinders
- Use only approved equipment
- Do not use at pressure greater than 150 kPa
- Open cylinder valve slowly
- Close cylinder valve when not in use
- Cylinders should be secured from falling over
- Excessive flow rates may remove acetone from the cylinder
- Use personal protective equipment.

Material Compatibility

- Steel, stainless steel, aluminium and wrought iron are recommended for use with acetylene. Joints may be welded, threaded or flanged. The use of cast iron fittings is not permissible. Unalloyed copper, silver and mercury, brasses containing more than 66% copper and brazing materials containing copper and silver should never be used in direct contact with acetylene due to the possible formation of explosive acetylides. Ensure hoses and pipelines are compatible with acetone.

Hydrogen (H_2)

Hydrogen is a colourless, odourless, flammable gas. It is supplied as a permanent gas at high pressure in metal cylinders.

Hydrogen is the lightest substance known to man, and is non-toxic, although it does not support life. It also burns, having a flammability range of 4-75% in air. Hydrogen is useful to industry for three main reasons: it is reactive, it burns and it has a very low boiling point.

Hazards

- High pressure compressed gas
- Forms explosive mixtures in air
- Asphyxiant in high concentrations
- Only gas that becomes warm when expanded
- Risk of static electricity sparking.

Classifications	
Gas	**Purity**
Hydrogen Technical	99,5%

Material Description	Mass (kg)	Cylinder Capacity (ℓ)	Pressure @ 20ºC (Bar)	Valve Outlet Connection	Item Number
H_2 TEC CYL 0,74 KG	0,74	50,0	200	5/8" BSPF left hand female	54-SH
H_2 TEC MCP 15 X 0,74 KG	11,1	MCP	200	5/8" BSPF left hand female	54-MH15

Higher grades and purities of this product are available from Afrox
Specifications are included in the 'Special Products & Chemicals' section

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	2,016
Specific volume at 21,1˚C and 101,325 kPa	11967,4 ℓ/kg
Boiling point at 101,325 kPa	-252,8˚C
Critical temperature	-239,9˚C
Relative density (air = 1) at 101,325 kPa and 25˚C	0,0695
Density, gas at 101,325 kPa and 25˚C	0,08235 kg/m³
Flammable limits in air (by volume)	4,0 - 75%

Uses and Features

- Hydrogen finds wide use in the metallurgy field because of its ability to reduce metal oxides and prevent oxidation in the heat treating of certain metals and alloys (reducing atmospheres)
- Hydrogen is also extensively used in the manufacture of chemicals, plastics and in petroleum refining
- Hydrogen is widely used for the hydrogenation of vegetable and animal oils and fats
- Purified hydrogen is used in gas chromatography as a detector fuel and in semiconductor manufacturing
- Not suitable for inflation of balloons.

Precautions in Use

- Use only approved ancillary equipment which is flameproof. Consult our Customer Engineering Services Department for assistance
- High pressure leaks can auto-ignite
- Caution – burns with an almost invisible flame. Use leak-detecting solutions for minor leaks
- Store away from oxidising sources
- Use only in a well ventilated area
- Wear safety glasses, use leather/plastic safety gloves, wear overalls and safety shoes when handling cylinders
- Always use a regulator to connect to system
- Always open and close cylinder valve slowly
- Refer to MSDS for more information.

Material Compatibility

- Hydrogen is non-corrosive, therefore any common metals are acceptable provided the equipment is designed to withstand process pressure and temperature. Hydrogen embrittlement can occur under certain circumstances and needs to be allowed for in-design.

Leak Detection

Leak of hydrogen in lines and equipment may be detected with soapy water (1% Nukleen in water). Leaks will be indicated by bubble formation.

BULK GASES

Large volumes of gas are supplied by bulk deliveries, either as a cryogenic liquid or a high pressure gas into storage on customer sites.

Bulk deliveries of oxygen, nitrogen, argon, hydrogen and carbon dioxide are supplied as liquid because they require much less storage capacity than gas.

The liquid is delivered by our dedicated fleet of cryogenic tankers into vacuum insulated bulk storage vessels that we usually own and maintain on customers' premises. The stored liquid is controlled at the required pressure by means of an automated regulation system.

If the customer process requires gas, the liquid is vaporised and delivered as a gas along the supply pipe. If the process requires liquid, it is delivered directly from the storage vessel through a cryogenic vacuum insulated pipeline.

Bulk Liquid Supply

Oxygen (O_2), Liquid

A pale blue liquid which rapidly evaporates to a colourless, odourless and tasteless gas.

Hazards

- Contact with combustible material may cause fire
- Causes burns
- Extremely cold cryogenic liquid.

Classifications		
Gas	**Purity**	**Valve Outlet Connections**
Oxygen Technical	99,5%	Liquid withdrawal 3/4" BSP R/H male with 45° inverted flare Gas withdrawal 5/8" BSP R/H female with 60° inverted flare

Higher grades and purities of this product are available from Afrox on request

Supply

Details of a wide range of storage vessels and ancillary equipment are available from Afrox on request.

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	32,0
Specific volume at 21,1˚C and 101,325 kPa	755,4 ℓ/kg
Boiling point at 101,325 kPa	-183,0˚C
Critical temperature	-118,6˚C
Relative density of gas (air = 1) at 1 atm and 25˚C	1,105
Density, liquid at boiling point	1,309 kg/m^3
Flammability	Does not burn, but supports combustion

Uses and Features

- In combination with a fuel gas such as acetylene, hydrogen or LPG, it is used in welding, cutting, hardening, scarfing, flame cleaning and heating
- Oxygen is used in the manufacture of steel, glass, methanol, titanium dioxide, vinyl acetate and synthesis gas
- Oxygen can be considered for use in any chemical reaction where air is used to give faster reaction time and higher yields
- Can be used for laser gas and metallurgy applications.

Precautions in Use

- Use only approved degreased temperature and pressure rated equipment
- Wear face shield, use leather protective gloves, wear overalls when handling PLCs or liquid oxygen systems
- Refer to MSDS for more information.

Material Compatibility

- Only oxygen-compatible materials may be used with liquid oxygen and these must be fully degreased. Copper, aluminium and stainless steels are the most commonly used metals. Most lubricants are NOT compatible. Oil and grease can cause ignition. Equipment to handle liquid oxygen must be constructed from suitable materials for the temperatures encountered.

Nitrogen (N_2), Liquid

A colourless, odourless, non-toxic liquid.

Hazards

- Extremely cold, cryogenic liquid
- Asphyxiant in high concentrations.

Classifications

Gas	Purity	Valve Outlet Connections
Nitrogen Technical	99,5%	Liquid withdrawal 1/2" BSP R/H male with 45° inverted flare Gas withdrawal 3/4" BSP R/H female with 60° inverted flare

Higher grades and purities of this product are available from Afrox on request

Supply

Details of a wide range of storage vessels and ancillary equipment are available from Afrox on request.

Physical Data

Appearance/odour	Colourless, odourless and non-toxic liquid
Molecular weight	28,0134
Specific volume at 21,1˚C and 101,325 kPa	861,5 ℓ/kg
Boiling point at 101,325 kPa	-195,8˚C
Critical temperature	146,9˚C
Relative density (air = 1) at 101,325 kPa and 25˚C	0,967
Density, liquid at boiling point	803,6 kg/m^3
Flammability	Inert

Uses and Features

- To prevent the undesirable presence of oxygen, nitrogen is valuable in furnaces, metal plating and tinning, chemical processing, food packing, wine making, paint and varnish manufacture, tube manufacture and packaging and preserving rubber products
- Dry nitrogen is used for in-transit refrigeration, artificial insemination, biological freezing, tissue preservation, cryosurgery, laboratory low temperature tests, dermatology, low temperature component testing, environmental testing, shrink fitting, grinding of plastics, quick freezing of foods, metal grinding and rubber de-flashing
- Among the many uses for gaseous nitrogen are flow testing, gauge calibration, plastic forming, aerosol propellant, powering air tools, metal de-gassing, pipeline testing, pressure testing cables and generators, recoil systems, hydraulic systems (cushions), inflating aircraft tyres and the handling and transfer of flammable liquids
- Gaseous nitrogen is also used for the inert packaging of foods, sparging wines, pressurisation of head spaces in liquid containers and conveyance of beverages in pressurised pipe systems
- Shrink fitting and pipe freezing
- Carrier gas in chromatography.

Precautions in Use

- Use only approved degreased temperature and pressure rated equipment
- Do not trap liquid between closed valves
- Wear leather gloves, face shield and safety shoes when handling low temperature products
- Keep self-contained full face positive pressure breathing apparatus nearby
- Refer to MSDS for more information.

Material Compatibility

- Nitrogen is non-corrosive and so any common metal is acceptable provided equipment is designed to withstand process pressure and temperature. Equipment to handle liquid nitrogen must be constructed of suitable materials for the low temperatures encountered.

Argon (Ar), Liquid

Non-toxic, colourless, odourless and tasteless liquid.

Hazards

- Extremely cold, cryogenic liquid
- Asphyxiant in high concentrations.

Classifications		
Gas	**Purity**	**Valve Outlet Connections**
Argon Industrial	97,5%	Liquid withdrawal 3/8" BSP R/H male with 45° inverted flare Gas withdrawal 5/8" BSP R/H female with 60° inverted flare
Argon Technical	99,99%	

Higher grades and purities of this product are available from Afrox on request

Supply

Details of a wide range of storage vessels and ancillary equipment are available from Afrox on request.

Physical Data	
Appearance/odour	Colourless and odourless
Molecular weight	39,948
Specific volume at 21,1˚C and 101,325 kPa	603,7 ml/g
Boiling point at 101,325 kPa	-185,9˚C
Critical temperature	-122,29˚C
Relative density (air = 1) at 1 atm and 0˚C	1,380
Absolute density of gas at 101,325 kPa and 0˚C	1,7841 kg/m^3
Flammability	N/A

Uses and Features

- Liquid argon is used in GMAW process of aluminium and the GTAW process of most metals including steel, stainless steel, nickel and copper
- Plasma jet torches, utilising an argon-hydrogen mixture, are used for cutting operations and for coating metals with refractory materials. The high temperature preparation, refining and fabrication of many materials must be carried out in an argon (or helium) atmosphere. Most of the high-purity single crystals used for semi-conducting devices are grown in an argon atmosphere. In doping semiconductors with controlled amounts of impurities, the latter are frequently introduced in a stream of argon.

Precautions in Use

- Use only approved temperature and pressure rated equipment
- Do not trap liquid between closed valves
- Wear face shield, use leather protective gloves and overalls when handling low temperature equipment
- Keep self-contained full face positive pressure breathing apparatus nearby, in the event of accidental spillage
- Use only in well ventilated areas
- Refer to MSDS for more information.

Material Compatibility

- Liquid argon is non-corrosive and so many common metals are acceptable, provided equipment is designed to withstand process pressure and temperature. At cryogenic temperatures, the risk of materials becoming brittle has to be given expert consideration. Please refer to Afrox for advice relative to your specific application.

Carbon Dioxide (CO_2), Liquid

A colourless, odourless, non-flammable gas that is denser than air. Supplied as liquid from tanker to bulk storage vessel.

Hazards

- Low temperature liquid, rapid release to atmosphere will produce solid carbon dioxide (dry ice) and low temperature gas
- High pressure liquefied gas
- Asphyxiant in high concentration.

Classifications

Gas	Purity	Valve Outlet Connections
Carbon Dioxide Technical	99,95%	Liquid withdrawal 5/8" BSP R/H male Gas withdrawal 0,860" 14 TPI Witworth male

Supply

Details of a wide range of storage vessels and ancillary equipment are available from Afrox on request.

Physical Data	
Appearance/odour	Colourless, odourless and non-toxic liquid
Molecular weight	44,011
Critical temperature	31,0˚C
Relative density (air = 1) at 101,325 kPa and 0˚C	1,53
Density, liquid at boiling point 156,0 kg/m³	-122,29˚C
Flammability	N/A

Uses and Features

- Carbon dioxide uses include: soft drink carbonisation, food freezing and chilling, purging and inerting, snow shooting for in-transit refrigeration, and potable water treatment
- Carbon dioxide is also used as a chemical reactant, pH buffer, grain storage fumigation, greenhouse atmosphere enrichment, oil well stimulation and clean-out, tobacco processing, propellant in aerosol packaging, solvent for extraction of organic chemicals.

Precautions in Use

- Use only approved pressure and temperature rated equipment
- Workers should use gloves and may require additional protective clothing (apron, face shield) which is resistant to low temperatures to prevent freeze burns and frostbite, if more than momentary contact with solid CO_2 at low temperature is required
- Refer to MSDS for more information.

Material Compatibility

- Dry carbon dioxide is non-corrosive, hence any common material is acceptable, e.g. steel, iron, copper, brass, plastic
- Moist carbon dioxide is slightly corrosive, hence acid resistant materials are required, e.g. stainless steel, certain plastics. Low temperatures require special materials of construction.

On-Site Production (ECOVAR®)

ECOVAR® (ECOnomical and VARiable) - On-site Gas Generation
The ECOVAR® concept from Linde is the solution of choice for a broad range of industries that require continuous, if sometimes fluctuating, amounts of high-quality gases. With our ECOVAR® on-site supply solutions, we ensure a continuous, monitored and flexible gas supply directly at the customer's site. For the on-site production of oxygen, nitrogen and hydrogen, we combine standardised components which are cost-efficiently adapted to specific demands on location.

Nitrogen ECOVAR® Solutions

Range	Capacity Range (TPD)	Purity Range	Spec Power (kWh/Nm^3)*
CRYOSS®-N GAN	120 to 900	10 ppm to 1 ppb O_2	0,22 to 0,24
CRYOSS®-N MiniGAN	6 to 78	up to 0,1 ppm O_2	0,25 to 0,34
ADSOSS™-N A-Series	30 to 150	95 to 99,995% N_2	-
ADSOSS™-N G-Series	6 to 60	95 to 99,9% N_2	0,25 to 0,6
ADSOSS™-N ECOVAR® Mini	0 to 6	95 to 99,995% N_2	-

*based on an outlet pressure of 8 bara

Oxygen ECOVAR® Solutions

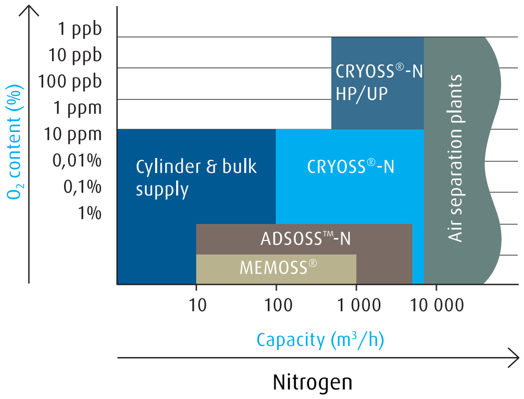
Range	Capacity Range (TPD)	Purity Range	Spec Power (kWh/Nm^3)*
CRYOSS®-O	35 to 300	90 to 99,5% O_2	0,4 to 0,5
ADSOSS™-O Modular VPSA	70 to 195	90 to 93% O_2	0,34 to 0,36
ADSOSS™-O Containerised VPSA	7 to 60	91 to 99,5% O_2	0,37 to 0,39
ADSOSS™-O PSA	5 to 20	91 to 93% O_2	0,7 to 0,8

*based on an outlet pressure of 1,2 bara

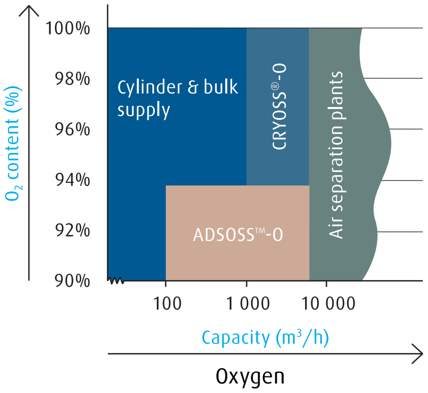
Hydrogen ECOVAR® Solutions

Range	Capacity Range (kg/day)	Purity Range	Spec Power
HYDROSS™-S Steam Reforming	535 to 2 100	95 to 99,999% H_2	0,4 Nm^3 natural gas / Nm^3 H_2
HYDROSS™-E Electrolyser	20 to 128	up to 2 ppm O_2	5,4 kWh/Nm^3

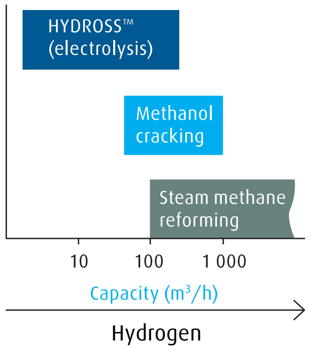
CRYOSS® = Cryogenic On-Site Supply
ADSOSS™ = Adsorption On-Site Supply
HYDROSS™ = Hydrogen On-Site Supply
VPSA = Vacuum Pressure Swing Adsorption
PSA = Pressure Swing Adsorption
TPD = Tonnes Per Day



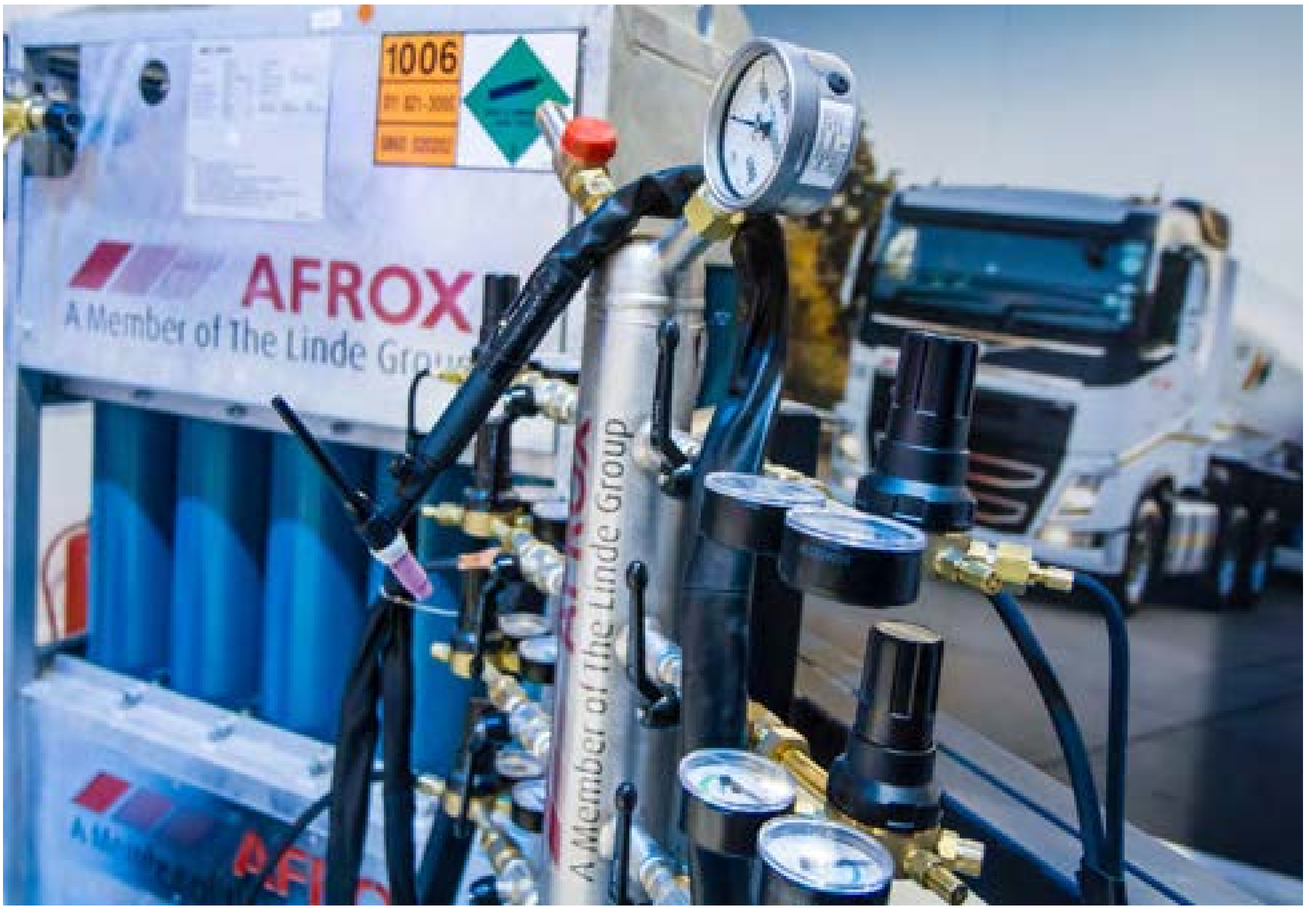
Nitrogen



Oxygen



Hydrogen



HEALTHCARE

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MEDICAL GASES

Afrox is a member of The Linde Group and Afrox Healthcare forms part of the Linde's Global Healthcare strategic business unit. Afrox Healthcare is a leading supplier of medical gases and related services in the southern African region. Linde has established a global medical gases headquarters that aims to serve the medical community worldwide. With these strategic alliances, Afrox Healthcare is able to access and adopt best practices and Afrox Healthcare customers are able to enjoy local service, whilst also benefiting from valuable advice on best clinical practices across a wide range of medical gas applications.

Afrox supplies products and services to hospitals in the public and private sectors, to dentists, private doctors and veterinarians, as well as to homecare patients. One of our important guiding principles as an organisation when dealing with and handling medical gases is that of safety. This remains fundamentally critical for both our employees as well as our customers.

As a company, we recognise the responsibility and significance of ensuring a healthy nation. As such, we contribute to this by offering high quality products and services.

Medical gases are regulated by the Medicines Control Council (MCC) and all Afrox medical gases are in compliance to all applicable MCC regulations. Afrox is the first gases company in South Africa to have achieved registration of all our gases under the Medicines and Related Substances Control Act (101/1965); our customers can be assured that all medical gases purchased from Afrox Healthcare meet the requirements in terms of safety, quality and efficacy. All our gases are manufactured in ISO 9001 certified plants. We reassure our customers that all relevant handling, processing and storage of our products and equipment takes place in accordance with Good Manufacturing Practice (GMP) and the Medical Device Directive 93/42. All Afrox finished medical products and devices are subject to a rigorous quality control process, as guided by Linde safety and quality measures.

AFROX HOSPITALCARE

Overview

Afrox Healthcare provides a full spectrum of high quality medical gases and associated services to hospitals and clinics in both private and public sectors across southern Africa. Our gases are manufactured in ISO 9001 certified plants and are distributed to various healthcare institutions through an extensive gas distribution network in a wide range of modes from cylinders to highly specialised installations.

Medical Air

Medical air is used:

- As a replacement for atmospheric air when the atmosphere is contaminated by noxious fumes, vapours or gases
- In anaesthesia as a carrier for volatile anaesthetic agents
- As a power source for pneumatic equipment
- In ventilators and incubators to provide uncontaminated and controlled air flow.

Medical Carbon Dioxide

Medical carbon dioxide is used:

- To increase the depth of anaesthesia rapidly when volatile agents are being administered. It increases depth of respiration and helps to overcome breath-holding and bronchial spasm
- To facilitate blind intubation in anaesthetic practice
- To facilitate vasodilation, and thus lessen the degree of metabolic acidosis during induction of hypothermia
- To increase the cerebral blood flow in arteriosclerotic patients undergoing surgery
- To stimulate respiration after a period of apnoea
- In chronic respiratory obstruction after it has been relieved
- To prevent hypocapnia during hyperventilation
- For clinical and physiological investigation.

ALPINOX Pin Index Medical Oxygen Regulator with Flow Selector

Pin index oxygen gas regulator is used for homecare, emergency and hospital oxygen therapy.

Key advantages:

- New generation of medical regulator with high flow precision and continuous flow between settings
- Ergonomic, intuitive design is easy to use and ensures safer, more accurate dosing
- Single-stage piston regulator technology ensures a long lifetime
- CE certified according to MDD 93/42/EEC
- Compliant with EN ISO 10524.

Applications:

- Emergency solutions / regulators / cylinder regulator
- Homecare solutions / regulators / cylinder regulator
- In-hospital therapy / flowmeters / cylinder regulators.

Specifications

Gas Type	Oxygen
Inlet Pressure	200 bar 2 900 PSI
Outlet Pressure	4,5 bar 58 PSI
Flow Settings	0-1/2-1-2-3-4-5-6-7-9-12-15, 0-1/4-1/2-1-2-3-4-6-12-15-25 litres/minute
Gauge Face	0-315
Body Material	White coated brass
Seat Material	Nylon
O-ring Material	EPDM

Description	Item Number
Alpinox Medical Oxygen Regulator - Pin Index	W039025

ALPINOX Bull Nose Medical Oxygen Regulator with Flow Selector

Pin index oxygen gas regulator is used for homecare, emergency and hospital oxygen therapy.

Key advantages:

- New generation of medical regulator with high flow precision and continuous flow between settings
- Ergonomic, intuitive design is easy to use and ensures safer, more accurate dosing
- Single-stage piston regulator technology ensures a long lifetime
- CE certified according to MDD 93/42/EEC
- Compliant with EN ISO 10524.

Applications:

- Emergency solutions / regulators / cylinder regulator
- Homecare solutions / regulators / cylinder regulator
- In-hospital therapy / flowmeters / cylinder regulators.

Specifications

Gas Type	Oxygen
Inlet Pressure	200 bar 2 900 PSI
Outlet Pressure	4,5 bar 58 PSI
Flow Settings	0-1/2-1-2-3-4-5-6-7-9-12-15, 0-1/4-1/2-1-2-3-4-6-12-15-25 litres/minute
Gauge Face	0-315
Body Material	White coated brass
Seat Material	Nylon
O-ring Material	EPDM

Description	Item Number
Alpinox Medical Oxygen Regulator - Bullnose	W039024

Medical Nitrous Oxide

Medical nitrous oxide is used:

- For the relief of severe pain, usually in emergency situations, by inhalation with 50% oxygen
- During induction and maintenance of anaesthesia, in controlled situations
- Medical nitrous oxide is a Schedule 4 gas.

Medical Oxygen

Medical oxygen is used:

For virtually all modern anaesthetic techniques as well as pre- and post-operative management. Oxygen provides life support by restoring tissue oxygen levels in a range of conditions, including:

- Cyanosis as a result of cardio-pulmonary disease
- Surgical trauma, chest wounds and rib fractures
- Shock, severe haemorrhage and coronary occlusion
- Carbon monoxide poisoning
- Hyperpyrexia
- Major trauma, such as road accidents and gunshot wounds
- Oxygen plays a vital role in the management of sudden cardiac and respiratory arrest - whether drug induced or traumatic - and in the resuscitation of critically ill patients when circulation is impaired. It is also used in neo-natal resuscitation
- Episodic cluster headaches.

Entonox

Entonox is used:

Exclusively for the relief of pain in a controlled setting by a healthcare professional. Entonox is a ready-to-use medical gas mixture consisting of 50% nitrous oxide and oxygen. The balanced nitrous oxide/oxygen ratio assures good oxygenation and minimises the risk of over-sedation.

During a painful procedure like childbirth, when the emphasis is on delivering relief from pain and discomfort with minimal sedation, Entonox is a commonly used technique. It is fast acting, self-regulated, and disperses rapidly from the body following cessation of inhalation.

Nitrous oxide exhibits classical dose-dependent analgesic effects, reducing the level of pain experienced. Entonox is fast and effective – the onset of pain relief is gained within a minute – any effects wear off rapidly.

The main advantages are:

- Non-invasive, inhaled analgesic
- Rapid onset/offset action
- Not only analgesic but contains sedative and anxiolytic properties
- Entonox can be combined with all other analgesics.

Analgesic Demand valve

Entonox is administered via a demand valve for self-administration where the patient has control of the drug intake.

Description	Item Number
Regulator - Entonox	W342229
Analgesic demand valve for cylinders	W342228
Analgesic demand valve for wall points - 3m	W342235
Analgesic demand valve for wall points - 6m	W342239
Exhalation valve for face mask pack of 25	W342252
Exhalation valve for face mask pack of 100	W342237
Exhalation valve with mouthpiece pack of 25	W342251
Exhalation valve with mouthpiece pack of 100	W342252

Analgesic Demand Valve

The analgesic demand valve is intended for the self-administration of analgesic gas mixture (O_2/N_2O) – Entonox.

Unlike conventional demand valves, the flow through the demand valve increases without a significant increase in resistance to flow. This results in an incredibly low patient effort irrespective of flow rate.

There are a number of medical applications where self-administration of medicinal gases at high flow rates:

- The exhalation valve directs exhaled gas away from the handset, eliminating the risk of cross-contamination
- State-of-the-art electrostatic viral filter allows incredibly low resistance during inhalation
- Unique one-way valve eliminates filter resistance during exhalation
- Ruby to brass valve seat eliminates the resistance to flow due to seat compliance that is suffered by conventional systems
- Unique non-linear valve actually reduces flow resistance as flow increases
- Latex-free, phthalate-free for maximum patient safety.

Benefits of the unique exhalation valve:

- Enables exceptionally high flows with incredibly low inspiratory effort, resulting in an unparalleled user experience
- Directs exhaled gas away from the delivery device, eliminating the risk of handset contamination
- Is a single patient use filter used with demand valves, with no risk of cross-contamination. There is no need for an expensive decontamination process after every patient use
- Incorporates a unique ultra-low resistance one-way valve. This unique valve prevents dilution of medical gas with ambient air during inhalation, only opening during exhalation to channel exhaled breath away from the handset. In contrast with conventional systems, resistance to flow at exhalation due to filter resistance is eliminated
- Is sealed securely to the handset with two snap fit clips, which when lifted, release the exhalation valve quickly and simply for disposal.

Integrated Valve Regulator (IVR) Medical Oxygen

The Integrated Valve Regulator (IVR):

Designed specifically to address the needs of nurses and respiratory therapists for the administration of medical oxygen in portable cylinders. Here's how:

- The IVR is ready to use whenever it is needed; there are no separate parts to find and attach
- The valve, regulator, content gauge and flow controls are integrated into a single piece and covered by a virtually indestructible protective guard
- The live contents gauge is easy to read and always indicates how much oxygen is available
- The unique design of the IVR promotes a safer environment for hospital staff and patients
- No more need to maintain an inventory of working regulators or cylinder spanners.

These features save staff time and money.

Description	Item Number
IVR 2000	101-JE-IVR
IVR 1000	101-FE-IVR
IVR 420	101-BE-IVR

Cylinder Data Sheet

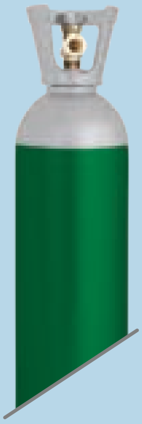
Dimensions exclude the cylinder valve, and are only for guidance, as the actual size/mass depends on the cylinder supplier. In the interest of product improvement, Afrox reserves the right to alter or withdraw products from the market without prior notice.

Gas Type	Contents (kg)	Valve Type	New SAP Item Number	Contents (L gas @ 1 atm. & 20°C)	Cylinder Height (mm)	Cylinder Diameter (mm)	Cylinder Material
Medical Oxygen 	0,25	PI	P101-AD-P125	187	262	90	Aluminium
	0,47	PI	101-CB-PI	352	415	100	Steel
				352	415	100	Steel
	0,49	PI	P101-BD-PI	367	405	102	Aluminium
	0,56	IVR	101-BE-IVR	420	400	100	Steel
	0,94			705	755	100	Steel
		PI	101-EB-PI	705	755	100	Steel
	1,40	IVR	101-FE-IVR	1 050	880	100	Steel
	2,8	IVR	101-JE-IVR	1 380	770	140	Steel
	1,84	PI (Homecare)	101-HB-PI	1 380	770	140	Steel
		PI (Homecare)	101-HH-PI	1 380	470	176	Steel
	4,60	BN	101-KB	3 450	1 197	176	Steel
		PI	101-KB-PI	3 450	1 197	176	Steel
	10,20	BN	101-RC	7 650	1 422	230	Steel

Gas Type	Contents (kg)	Valve Type	New SAP Item Number	Contents (L gas @ I atm. & 20°C)	Cylinder Height (mm)	Cylinder Diameter (mm)	Cylinder Material
Medical Nitrous Oxide 	1,60	PI	141-CB-PI	868	415	100	Steel
				868	415	100	Steel
	6,30	PI	141-HB-PI	3 420	770	140	Steel
		BN	141-HB	3 420	770	140	Steel
	15,70	BN	141-KB	8 525	1 197	176	Steel
	31,30	BN	141-RB	16 995	1 414	230	Steel

Gas Type	Contents (kg)	Valve Type	New SAP Item Number	Contents (L gas @ 1 atm. & 20°C)	Cylinder Height (mm)	Cylinder Diameter (mm)	Cylinder Material
Entonox 	0,79	PI	211-CB-P1	499	415	100	Steel
	3,07	PI	211-HB-P1	1 940	770	140	Steel
	7,70	PI	211-KB-P1	4 866	1 197	176	Steel
	15,40	PI	211-RC-P1	9 733	1 414	230	Steel

Gas Type	Contents (kg)	Valve Type	New SAP Item Number	Contents (L gas @ 1 atm. & 20°C)	Cylinder Height (mm)	Cylinder Diameter (mm)	Cylinder Material
Medical Air 	1,57	PI	191-HB-PI	1 303	770	140	Steel
				1 303	770	140	Steel
	3,90	BN	191-KB	3 237	1 197	176	Steel
	8,70	BN	191-RC	7 221	1 422	230	Steel
	0,78	PI	191-EB-PI				

Gas Type	Contents (kg)	Valve Type	New SAP Item Number	Contents (L gas @ 1 atm. & 20°C)	Cylinder Height (mm)	Cylinder Diameter (mm)	Cylinder Material
Medical Carbon Dioxide 	1,44	PI	201-CB-P1	783	415	100	Steel
	5,60	PI	201-HB-P1	3 046	770	140	Steel
	14,10	MALE	201-KB	7 670	1 197	176	Steel
		MALE WET	201-KB-W	7 670	1 197	176	Steel
	31,50	MALE	201-RC	17 136	1 422	230	Steel
		MALE WET	201-RC-W	17 136	1 422	230	Steel

Customer Service Centre

- Afrox boasts a highly competent Customer Service Centre (CSC) which operates Monday to Friday from 07h30 to 17h30. In order to ensure that our customers' needs are met at all times, a service consultant is always available to answer to your calls after hours, 7 days a week and 365 days a year
- The centre uses an event tracking system enabling and empowering our entire service and sales organisation to meet our healthcare customers' requirements
- Afrox HospitalCare's multi-skilled staff are customer service experts, offering specialised advice on all products and services that Afrox HospitalCare offers
- Throughout the country, customers can place orders, make account and general enquiries by using the shared services number 0860 020202 (Afrox HospitalCare)
- The CSC is equipped with state-of-the-art IT systems to enhance operational efficiency for the nursing services, electronic billing, electronic links for speedy authorisations and other functions. This is an effort by Afrox HospitalCare to ensure that we meet the high service levels required by our customers
- All our customer accounts are managed through the Customer Service Centre.

Why use the Afrox eShop (www.afroxshop.co.za)

- Keep track of orders and invoices
- Check order history
- Re-order from previous invoices (speeding up your order process)
- Create a custom order template (speeding up your order process)
- Manage cylinder holdings
- Manage deliveries
- View latest specials & offers
- Orders are processed in our system immediately
- No order placement queues
- Available 24/7.

HospitalCare Supply & Delivery Offer

Afrox's medical gas and equipment distribution network is unrivalled within southern Africa. Wherever you are, we can supply.

- For the convenience and comfort of our customers, Afrox HospitalCare offers an extensive delivery service countrywide
- All deliveries are scheduled via our world-class Customer Service Centre (CSC) which can be contacted on 0860 020202
- Our CSC or your local Afrox HospitalCare representative is able to offer advice regarding lead times for our customer deliveries; however, these are naturally influenced by the proximity of our customer delivery points to Afrox distribution hubs
- Generally all orders placed and approved with the Afrox CSC will be delivered the following day provided that the purchase order has been placed the previous day before 12 noon. Bulk delivery is determined as per a telemetry system and bulk product can be delivered anytime as agreed upon with the customer
- In general, product will be delivered to a safe and convenient location, given suitable ground conditions within the standard delivery window
- Afrox will provide a customer representative with the proof of delivery (POD) collection note at the time of delivery and/or collection
- For hospitals and other large medical establishments, bulk delivery patterns are established and dependant on demand. A minimum stock of 25% or 2 days supply is generally factored in the delivery planning and scheduling
- Afrox will re-fill bulk gases as per requirements by and agreement with the customer, at any scheduled time or day of the week
- Delivery of gas other than in cylinders shall be effected at the point where it is discharged into the storage equipment at the customer site
- Delivery of gas in cylinders shall be effected at the point where the cylinders are delivered to the customer site as per the Afrox delivery matrix
- Afrox offers the convenience of a cylinder policy that operates on a "full-for-empty" basis. Extra allocations are available, subject to prior arrangement and availability
- Geographical restrictions may apply in locations that are significantly distant from an Afrox filling site.

AFROX HOMECARE

Overview

Afrox Homecare is committed to providing a comprehensive range of products, accessories and related services to chronic obstructive pulmonary disease (COPD) patients in the comfort of their homes. COPD is the most common cause of respiratory insufficiency. Oxygen flow rate and hours of use are prescribed by the patient's medical practitioner and Afrox Homecare ensures compliance to the prescribed regimen. Afrox Homecare actively interacts with all medical aids to assist the patient with obtaining authorisations from their medical aids for oxygen therapy.

At Afrox Homecare we pride ourselves in delivering quality products backed by outstanding services including the Afrox Homecare nursing service.

Catering for CRI (Chronic Respiratory Insufficiency) patients' homecare needs through the supply of:

- Oxygen concentrators (stationary and portable)
- Medical oxygen cylinders
- Portable cylinder oxygen systems
- Oxygen conserving devices
- Value added services.

Customer Service Centre

Tel: 0860 030202

Fax: 011 821 3050

E-mail: homecare@afrox.linde.com

Respiratory Insufficiency - Medical Oxygen Therapy

Definition

Chronic Respiratory Insufficiency (CRI)

Chronic Respiratory Insufficiency (CRI) is the respiratory system's inability to oxygenate the blood. It is reflected in a fall of oxygen (O_2) levels in the blood, sometimes linked to an increase in carbon dioxide (CO_2) levels. These blood gases are analysed from a blood sample taken from an artery in the wrist. Blood oxygenation can be evaluated less accurately, but without a need for a blood sample, by measuring the oxygen saturation in the blood, using a saturometer placed on the end of the finger.

The main sign of respiratory insufficiency is breathlessness during activity (dyspnea). The main consequence of this chronic lack of oxygenation in the body is the development of right cardiac insufficiency, due to the gradual shrinkage of pulmonary blood vessels through which the cardiac pump must force the blood. The result is water retention with oedema of the lower limbs.

The Main Causes of Respiratory Insufficiency

Chronic Obstructive Pulmonary Disease (COPD) is the most common cause of respiratory insufficiency. It is mainly caused by smoking. Smoke inhalation leads to inflammation of the bronchi, then their gradual shrinkage (obstruction). The alveoli can also be damaged by smoke; this is called emphysema.

At first, COPD is revealed by a chronic wet cough, then the passage of air into the bronchi becomes more difficult, which explains the breathlessness, initially on activity, then at rest. In the same way, blood oxygenation initially falls on activity, then at rest.

COPD is a common disease which affects one smoker in five after the age of 40. In France, 2,5-million people suffer from it. Of these, 30 000 are at the stage of chronic respiratory insufficiency and are treated at home with oxygen therapy or assisted ventilation. 90% of cases of COPD are due to smoking. It has been shown that at any stage of the disease, stopping smoking prevents deterioration of respiratory function and, at the same time, increases life expectancy. There are other bronchial diseases, such as asthma or cystic fibrosis.

Other Causes

Other causes of respiratory insufficiency are represented by diseases of the lungs, thoracic wall, or respiratory pump, and these reduce the volume of air which can be taken into the lungs and hence the passage of oxygen into the blood, for example, muscular diseases (myopathies) or lung diseases such as pulmonary fibrosis.

Diagnosis and Monitoring

Respiratory insufficiency is diagnosed and monitored jointly by the pneumologist, the GP and the physiotherapist. In the most serious cases, medical home assistance companies will be called in to administer treatments such as medical oxygen.

The pneumologist will first evaluate the condition of the respiratory tract with a Lung Function Test (LFT) which includes two types of analysis:

- Spirometry: measures respiratory capacity
- A study of blood gases.

Normal values are 75 to 100 mm of mercury for blood oxygen, between 35 and 45 mm of mercury for blood carbon dioxide and between 94 and 100% for oxygen saturation.

These examinations are often completed by a pulmonary X-ray. At the end of this first examination, the diagnosis and severity of respiratory insufficiency will be established and a programme of treatment will be proposed, followed by regular examinations (at least twice a year), to monitor treatment efficacy and progression of the respiratory insufficiency.

Treatment

Preventive Treatment

Preventive treatment includes stopping smoking and having an anti-flu vaccination every year and an anti-pneumococcal vaccination every four years. A change of lifestyle is often recommended: weight loss, a specific diet and regular physical exercise (after the age of 60, everyone should walk for at least 30 to 45 minutes every day).

Treatment with Aerosol Therapy

Treatment with aerosol therapy includes the administration of drugs designed to dilate the bronchi (bronchodilators) and sometimes anti-inflammatory drugs. These drugs are taken in the form of either powder for inhalation or a spray. In some cases, these drugs are taken in the form of aerosols produced by generators.

Respiratory Physiotherapy Sessions

Respiratory physiotherapy sessions are often prescribed to improve drainage of bronchial secretions and activity retraining.

Oxygen Therapy

When blood oxygen levels fall during physical exercise, breathlessness on activity can be improved by administering oxygen from portable medical oxygen reserves.

When resting, blood oxygen levels are below 60 mm Hg. It is essential to administer oxygen therapy for at least 15 hours a day.

Oxygen can be administered using concentrators which produce oxygen-enriched air, or liquid or gas medical oxygen reserves.

Ventilation

In the most severe cases of respiratory insufficiency, it is sometimes necessary to resort to mechanically assisted ventilation.

Homecare Products

At Afrox Homecare, we pride ourselves in delivering quality products backed by outstanding service.

Oxygen Concentrator

- Ideal solution for patients requiring oxygen in the comfort of their homes
- Oxygen is always available, no refilling required
- Concentrator is quiet and aesthetically appealing.

Oxygen Devices

- The oxymatic conserving device can extend the average usage time of an oxygen cylinder by five times.

Medical Oxygen Cylinders

- Used for intermittent oxygen usage
- Backup system (power failures are a reality).

Oxygen Concentrators (Stationary)

Oxygen concentrators are electrically operated devices that concentrate the oxygen content of normal room air to approximately 90% at flow rates up to 5 ℓ/min. Concentrators are convenient, cost effective, do not require refills and are aesthetically attractive. Of all the delivery systems used by oxygen-dependent patients, oxygen concentrators are the most common and usually the most economical method to provide oxygen therapy at home. An oxygen concentrator uses sieve-bed technology to extract oxygen from the surrounding air. This oxygen is then delivered to the patient using a plastic tube connected to a nasal cannula or face mask. The advantages of a concentrator over other forms of oxygen supply are:

- Concentrators provide a continuous supply of oxygen, while requiring very low maintenance
- The concentrator stays in the room in which it is placed and the person using the device can use a longer length of oxygen tubing (15 m of tubing is provided free of charge) to move around the house without having to move the concentrator
- A concentrator can be combined with a medical oxygen cylinder as a backup in case of power outages
- Concentrators are highly cost-efficient.

Because concentrators operate solely on electricity, it is critical that they are always supplied with a backup cylinder to ensure uninterrupted oxygen supply, even during power failure.

Description	Item Number
Everflo Concentrator (Rental)	W342109
VisionAire Concentrator (Rental)	W342242

Oxygen Concentrator (High Flow Oxygen Concentrator)

Airsep New Life Intensity high flow concentrator combines high pressure with high flow to create the premium 10 ℓ/min oxygen concentrator. It is uniquely designed to meet oxygen patients' high flow needs while providing the essential outlet pressure to drive special respiratory accessories, including large-volume jet nebulisers, venti-masks, and medication nebulisers. The high pressure from the concentrator also easily powers long oxygen tubing runs.

The 10 ℓ/min oxygen concentrator simplifies a tracheostomy setup by eliminating the need for a separate external compressor. Administer humidified oxygen to a trach by connecting a jet neb bottle directly to Intensity's O_2 outlet. The unit can reduce both equipment needs and overall power consumption through the delivery of oxygen to two patients simultaneously up to combined total flow of 10 ℓ/min with one unit.

Description	Item Number
AirSep High Flow Concentrator	W342920

Oxygen Concentrator (Portable Oxygen Concentrator)

The Inogen One® G5™ offers the most oxygen per kilogram for a portable oxygen concentrator on the market today. With flow settings from 1-6, the Inogen One® G5™ is designed to dramatically increase independence for most supplemental oxygen users 24/7. Advanced diagnostics take the guesswork out of patient support, as the Inogen One® G5™ is bluetooth enabled and compatible with Inogen Connect, the free mobile app. It can be charged at home or on the go - giving patients the freedom of Oxygen. Anytime. Anywhere®.

Description	Item Number
Inogen One® G5™ Concentrator 8 Cell Battery	W342060
Inogen One® G5™ Concentrator 16 Cell Battery	W342061
Inogen One® G5™ 8 Cell Battery - Lithium Ion Battery* Up to 6,5 hours run time	W342062
Inogen One® G5™ 16 Cell Battery Lithium Ion** Up to 13 hours run time	W342063
Inogen One® G5™ AC Power Supply*	W342065
Inogen One® G5™ DC Power Cable*	W342066
Inogen One® G5™ Carry Bag*	W342067
Inogen One® G5™ Backpack**	W342068

*Included with system **Accessory sold separately

Oxygen Vitapak System

Travelling with medical oxygen can be difficult. Oxygen Vitapak System is designed to take care of all medical oxygen needs throughout the journey, freeing patients from worry and the need to make arrangements with different authorities in different countries or regions.

With Oxygen Vitapak System, Afrox Homecare combines our expertise in technology and logistics to create a truly life-enhancing service for oxygen-dependent patients. We work in cooperation with international partners, coordinating the delivery of medical oxygen at every step of the journey. Patients have the freedom to plan an extensive itinerary, safe in the knowledge that their vital supply of oxygen will be there, when and where they need it.

This system consists of a small portable cylinder, an Oxymatic® unit, a carry pouch and a nasal cannula. The Oxymatic® oxygen conserver extends the life of the oxygen cylinder by as much as seven times. Oxygen cylinders, used in combination with the Oxymatic® unit, provide a cost-effective solution to the patient. Small lightweight cylinders fit neatly into a backpack, permitting valuable freedom of movement away from the patient's home oxygen source for reasonably long periods of time, thus allowing the patient to get out into the community, to shop, visit friends or family, or get to their doctor for a checkup. The availability of mobile oxygen has a direct impact on patients' quality of life.

Conserving device

Oxygen, Vitapak

Description	Item Number
Oxymatic® Device with Carry Bag (Purchase)	W342144
Oxymatic® Device with Carry Bag (Rental)	W340576
Oxygen, Vitapak, 0,25 kg Medical Oxygen Cylinder	101-ad-pi25

Medical Oxygen Cylinders

Afrox medical oxygen cylinders are registered as medicines with the South African Medicines Control Council under the Medicines and Related Substances Control Act (101 of 1965). This means that the manufacturing process has to comply with Good Manufacturing Practice, ensuring that Afrox medical oxygen is fit for its intended use, is safe, is of appropriate quality, and performs as expected so as not to place patients at risk.

Cylinders are widely available in many different sizes, flexible in their use, provide high purity oxygen of 99,5% and can deliver flow rates in excess of 5 ℓ/min, which making them suitable for nebulisation.

For short burst oxygen therapies, or where high flow rates are prescribed, cylinders are used as the main source of medicinal oxygen.

For homecare, medical oxygen cylinders are primarily used as a backup for oxygen concentrators, in case of power failures, for example.

Lightweight cylinders increase patient mobility, paired with an oxygen-conserving device and a backpack to increase ease-of-use. The oxygen-conserving device usually enables a cylinder to last approximately 5 times as long as a stand-alone cylinder.

Nebuliser Mini-Plus

- The Mini-Plus is a compressor nebuliser designed for easy portability, especially for people on the move.
- Chronic respiratory problems are unpredictable and it is important for people to have their treatment devices close at hand.
- The compact size, lightweight and convenient carrying handle of the Mini-Plus facilitate portability and allow each person to keep their Mini-Plus accessible at all times.

Features and Benefits

- Reliable piston-driven motor
- Compact size
- Tubing holder design.

Free Accessories

Mouthpiece set

Size: 14 cm (w) x 18,8 cm (d) x 10 cm (h)

Weight: 1,6 kg

Description	Item Number
Nebuliser Mini-Plus	W342912

Finger Monitor SB100

Fingertip SpO2 incorporates the electronics and sensor into one unit that provides a cost-effective solution for spot-checks and short-term monitoring. Fingertip SpO2 is not influenced by a patient's motion; therefore, it gives patients the freedom of having their physical checkup taken anywhere and anytime they want including having it incorporated into an athletic activity.

Features and Benefits

- Delivers accurate pulse rate and blood saturation in seconds
- One-touch keypad for easy operation
- Big and bright LED display
- Compact and light for mobility
- Two AAA alkaline batteries for easy power supply
- Automatic power-off after 10 seconds in idling.

Size: 63,5 mm (h) x 34 mm (w) x 36 mm (d)

Weight: 37 g

Description	Item Number
Finger Monitor SB100	W342913

Vac Pump Vac Pro

The VAC-series pump is Afrox Homecare's new portable suction unit and has been designed by Apex to combine function with aesthetic appeal and meet the needs of today's hygiene and infection control requirements. The VacMaxi suction unit is a powerful, fast and effective aspirator ideal for use in high vacuum, high flow applications.

Features and Benefits

- Lightweight for easy portable use
- Integrated canister holder
- Ergonomic easy to carry handle
- Easy to adjust pressure regulator
- Smooth ABS hygienic finish, easy to clean
- Detachable power cord for quickly change.

Size: 352 mm (l) x 206 mm (w) x 192 mm (d)

Weight: 2,8 kg

Description	Item Number
Vac Pump Vac Pro	W342914

Regulators and Other Accessories

Afrox provides a wide range of medical regulators to use with medical gas cylinders.

ALPINOX Pin Index Medical Oxygen Regulator with Flow Selector

Pin index oxygen gas regulator is used for homecare, emergency and hospital oxygen therapy.

Key advantages:

- New generation of medical regulator with high flow precision and continuous flow between settings
- Ergonomic, intuitive design is easy to use and ensures safer, more accurate dosing
- Single-stage piston regulator technology ensures a long lifetime
- CE certified according to MDD 93/42/EEC
- Compliant with EN ISO 10524.

Applications:

- Emergency solutions / regulators / cylinder regulator
- Homecare solutions / regulators / cylinder regulator
- In-hospital therapy / flowmeters / cylinder regulators.

Specifications

Gas Type	Oxygen
Inlet Pressure	200 bar 2 900 PSI
Outlet Pressure	4,5 bar 58 PSI
Flow Settings	0-1/2-1-2-3-4-5-6-7-9-12-15, 0-1/4-1/2-1-2-3-4-6-12-15-25 litres/minute
Gauge Face	0-315
Body Material	White coated brass
Seat Material	Nylon
O-ring Material	EPDM

Description	Item Number
Alpinox Medical Oxygen Regulator - Pin Index	W039025

ALPINOX Bull Nose Medical Oxygen Regulator with Flow Selector

Pin index oxygen gas regulator is used for homecare, emergency and hospital oxygen therapy.

Key advantages:

- New generation of medical regulator with high flow precision and continuous flow between settings
- Ergonomic, intuitive design is easy to use and ensures safer, more accurate dosing
- Single-stage piston regulator technology ensures a long lifetime
- CE certified according to MDD 93/42/EEC
- Compliant with EN ISO 10524.

Applications:

- Emergency solutions / regulators / cylinder regulator
- Homecare solutions / regulators / cylinder regulator
- In-hospital therapy / flowmeters / cylinder regulators.

Specifications

Gas Type	Oxygen
Inlet Pressure	200 bar 2 900 PSI
Outlet Pressure	4,5 bar 58 PSI
Flow Settings	0-1/2-1-2-3-4-5-6-7-9-12-15, 0-1/4-1/2-1-2-3-4-6-12-15-25 litres/minute
Gauge Face	0-315
Body Material	White coated brass
Seat Material	Nylon
O-ring Material	EPDM

Description	Item Number
Alpinox Medical Oxygen Regulator - Bullnose	W039024

MINIOX Medical Gas Regulator

Compact cylinder regulator is used for homecare, hospital and emergency oxygen therapy.

Key advantages:

- Precise gas flow and pressure control for safe and accurage oxygen therapy
- More accurate flow control reduces gas wastage and reduces operating costs
- Complies with national standards
- Available in single outlet, double outlet or flowmeter configurations
- Compact, economical design

Applications:

- Emergency solutions / regulators / cylinder regulator
- Homecare solutions / regulators / cylinder regulator
- In-hospital therapy / flowmeters / cylinder regulators.

Specifications Dimensional Drawing Ordering Codes

Gas Type	Oxygen, Air, N_2O
Filter Material	Sintered bronze 20 µm
O-ring Material	EPDM
Diaphragm Material	EPDM
Seat Material	PA 6.6
Body Material	Chrome-plated brass
Upper Operating Temperature Limit	60 Celsius 140 Fahrenheit
Lower Operating Temperature Limit	-20 Celsius -4 Fahrenheit
Flow Rate	0-18 slpm
Outlet Connection	National standards
Inlet Connection	National standards
Outlet Pressure	3,5 bar 43,5 PSI
Inlet Pressure	200 bar 2 900 PSI
Weight	0,640 grams

Description	Inlet Connection	Item Number
BPR Medical Oxygen Regulator PI	Pin Index	W039015
BPR Medical Air Regulator PI	Pin Index	W039017
Rotarex Medical Oxygen Regulator PI	Pin Index	W039022
Alpinox Medical Oxygen Regulator PI	Pin Index	W039025

Accessories and Consumables

Afrox Homecare offers a range of accessories and consumables for the delivery of medical gases in homecare, including regulators, cannulae and face masks.

Description	Item Number
Oxygen Humidifier Bottle	W342031
Adult Oxygen Face Mask	W342036
Adult Oxygen Nasal Cannula	W342037
Nipple & Nut Connector	W342038
Twist & Pull Connector	W342044
Oxygen 15 m Tubing	W342046
Paediatric Nasal Cannula	W342032
Paediatric Oxygen Mask	W342034
Paediatric Nebuliser Mask	W342135
Paediatric Flowmeter	W342136
Nebuliser (Medicine Aerosol Therapy)	W342049

Homecare Services

Customer Service

- Operating hours:
  - Monday to Friday, 07h00 to 17h30 - for all queries, new account application, orders, etc.
  - After hours and weekend - the Customer Service Centre is available to support existing customers only with urgent orders, technical queries and other urgent queries. No new account applications will be attended to during this time
- Contact details:
  - Phone number: 0860 03 02 02
  - Fax number: (011) 821 3050
  - Email address: homecare@afrox.linde.com
- Medical aid authorisation and claims submission facilitated on customer's behalf.

Home Nursing Visits

- Patients will be visited by a qualified nurse periodically as per agreed terms
- The nurse visits are aimed at ensuring that the oxygen equipment works according to specifications, as well as to check up on the patients' general well-being.

Delivery

- Generally, all homecare orders placed and approved with Customer Services Centre (CSC) will be delivered the following day provided that the purchase order has been placed the previous day before 17h30
- Afrox Homecare offers an extensive delivery service country-wide at a reasonable fee
- Emergency (same day or weekend) deliveries can be arranged based on transport availability at an additional cost
- Initial delivery of Afrox Homecare equipment (concentrator, cylinder, etc.) is free of charge anywhere in South Africa
- Education and assistance on how to use the concentrator and cylinders provided.

Prescribing Information

Scheduling Status

Not scheduled

Proprietary Name

Afrox Compressed Medical Oxygen

Composition

Oxygen	99,5% min

Maximum Impurities

Carbon dioxide	300 vpm
Carbon monoxide	5 vpm
Moisture	60 vpm
Nitrogen & argon	0,5%

Pharmacological Classification

A34 Other. Medical Gases

Pharmacological Action

Oxygen is present in the atmosphere at 21%.

The basal oxygen consumption in man is about 250 ml/min for a body surface of 1,8 m^2. It is reduced by about 10% during anaesthesia and natural sleep, and by about 50% for a 10°C fall in body temperature.

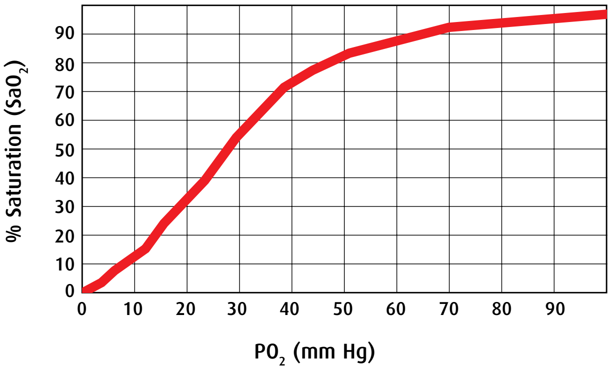
Pharmacokinetic particulars

The uptake of oxygen by the blood in the lungs, and discharge to the tissues is determined by the oxygen dissociation curve. The characteristic sigmoid shape ensures that, at tensions between 5 kPa (40 mm Hg), and 2 kPa (15 mm Hg), the oxygen carried in the blood from the lungs can be readily given up to the tissues.

The uptake from the lungs is rapid because blood flow through the capillaries, where exchange takes place, occurs in about 0,5 seconds. The uptake of oxygen is favoured by the simultaneous loss of carbon dioxide which is then excreted in the expired air. Conversely, the entry of carbon dioxide into the blood from the tissues facilitates oxygen transfer to the cells.

At rest, mixed venous blood returning to the lungs contains 13-14 ml of oxygen per 100 ml, but with severe exercise, the oxygen content may fall to 3-4 ml. In very active tissue, almost complete extraction occurs.

Oxyhaemoglobin dissociation curve



Indications

Oxygen is used for the prevention and treatment of hypoxia.

Contra-Indications

(i) There are no absolute contra-indications to the use of oxygen but the inspired concentration should be limited in the case of premature infants and those patients with chronic bronchitis and emphysema. (See Side Effects and Special Precautions).

(ii) Oxygen supports combustion and smoking should be prohibited when oxygen is in use, and no naked flame should be allowed.

Warnings

(i) Special care is needed when oxygen is administered and careful monitoring is required:

- To chronic respiratory failure patients
- In hyperbaric chambers in the management of conditions such as carbon monoxide poisoning, anaerobic infections and acute ischaemic disease. Convulsions and other central nervous system effects may occur at 2 atmospheres or more, after a few hours' exposure to pure oxygen. At higher pressures, more rapid onset of central nervous system effects may occur.

(ii) Too high an oxygen tension in the treatment of an acute exacerbation of chronic respiratory failure may arise, for instance, as a result of pulmonary infection in an elderly patient with bronchitis and emphysema. In such a patient the arterial PO_2 may be of the order of 35 mm, and the PCO_2 about 75 mm, with the stimulus to ventilation being primarily hypoxic. If high tensions of oxygen are administered, the hypoxic drive is removed, ventilation is reduced and the PCO_2 may rise sufficiently high to produce coma. Under these conditions, the hypoxaemia can be reduced by quite small increments in the concentration of inspired oxygen. This should never exceed 35% at the beginning of treatment; an initial concentration of 25% will produce considerable improvement, subsequent increments being permissible provided the PCO_2 does not rise further.

Dosage and Directions for Use

Recommended doses and dosage schedules:

(i) Distinguish between adults, children and the elderly and between different clinical indications.

(ii) There is no distinction generally between the use of oxygen in any age group.

(iii) The fundamental indication is the presence of hypoxia due to an unknown cause.

(iv) Modern oxygen usage requires separate devices for administering the gas in high and in low concentrations. The lowest concentration should not fall below that present in ambient air (20,9%).

(v) The concentration should be increased to a level that provides a satisfactory oxygen partial pressure in arterial blood.

Routes of administration:

Oxygen is usually administered through the lungs by inhalation. The major exception is when a metered supply is fed into the oxygenator of an extracorporeal circulation of a cardio-pulmonary by-pass system.

These devices have been classified as follows:

Fixed Performance Systems (patient independent)

- High flow – venti masks
- Low flow – anaesthetic circuits.

In all these systems, the oxygen concentration is pre-determined by the clinician.

Variable Performance Systems (patient dependent)

- Without re-breathing – catheters and cannulae
- With re-breathing through a face mask.

These systems only function by means of the patient who creates the inspired mixture by the act of breathing.

Various patients and device factors influence the result.

Side Effects and Special Precautions

(i) Oxygen toxicity depends on both the inspired pressure (a function of concentration and barometric pressure), and the duration of exposure, the safe duration decreasing as the pressure increases.

At lower pressures of up to 2 atmospheres absolute, pulmonary toxicity occurs before central nervous system toxicity. At higher pressures the reverse applies. Symptoms of pulmonary toxicity include a decrease in vital capacity, cough and substernal distress.

Symptoms of central nervous system toxicity include nausea, mood changes, vertigo, twitching, convulsions and loss of consciousness.

(ii) High concentrations of oxygen should be avoided in patients whose respiration is dependent upon hypoxia drive, otherwise carbon dioxide retention and respiratory depression may ensue.

(iii) Any fire or spark is highly dangerous in the presence of increased oxygen concentrations, especially when oxygen is used under pressure. Cylinders containing oxygen should be fitted with an approved regulator by which the rate of flow can be controlled. It is important that the regulator be free from oil or grease, otherwise a violent explosion may occur.

(iv) Care should be taken in the handling and use of medical oxygen gas cylinders.

Other Undesirable Effects (Frequency and Seriousness)

Oxygen toxicity can occur as manifested by:

(i) Retinopathy of prematurity has been associated in some premature infants with excessvie oxygen therapy.

(ii) Central nervous system toxicity including dizziness, convulsion and loss of consciousness after only 2-3 hours of exposure to pure oxygen at 2 or more atmospheres, e.g. sports and deep sea diving.

(iii) Retrosternal soreness associated with coughing and breathing difficulties, made worse by smoking and exposure to cold air after breathing pure oxygen at atmospheric pressure for several hours.

Identification

- All cylinders containing compressed medical oxygen shall be colour-coded in accordance with SABS 06-1957
- The cylinder shall have a black body, with the shoulder being painted white. The symbol ‘O_2’ shall be stencilled in white on the side of the body.

Presentation

- All cylinders having a water capacity of more than 10 ℓ shall have valve protection guards fitted, the only exceptions being cylinders manufactured before 1985, as they have no provision for the fitting of guards
- Chevron labels, stating the name ‘Oxygen’ and the masses/volumes of the contents, shall be fitted to the shoulders of the cylinders in line with the valve outlet socket
- A ‘Tickopress’ label stating the expiry date, the name of the filling site, and carrying the sequential number shall be affixed to the shoulder of the cylinder
- A heat-shrink seal shall be fitted to the valve of the cylinder confirming that the cylinder has been properly filled and has passed the leak-test.

Storage Instructions

- Never permit oil, grease, or any other readily combustible substance to come into contact with high pressure oxygen
- Full and empty cylinders should be segregated
- Use a ‘first-in – first-out’ inventory system to prevent full cylinders being stored for excessive periods of time
- Keep out of reach of children.

Registration Number

290037

Name and Business Address of the Applicant

African Oxygen Limited
23 Webber Street
Selby
Johannesburg
2001

Prescribing Information

Scheduling Status

Not scheduled

Proprietary Name

Afrox Compressed Medical Air

Composition

Oxygen	20,5 -	21,5%
Nitrogen & Inerts	78,5% -	79,5%

Maximum Impurities

Carbon Dioxide	500 vpm
Carbon Monoxide	10 vpm
Moisture	25 vpm
Odour	Nil

Pharmacological Classification

A34 OTHER. MEDICAL GASES

Indications

Air is used :-

- As a replacement for atmospheric air when the atmosphere is contaminated by noxious fumes, vapours or gases
- In anaesthesia as a carrier for volatile anaesthetic agents
- As a power-source for pneumatic equipment
- In ventilators and incubators to provide uncontaminated and controlled air flows.

Contra-Indications

Compressed air is contra-indicated where oxygen or other gaseous combinations would be indicated. (Airways obstruction, pneumonia, and a myriad of cardio-respiratory conditions.

Warnings

- Compressed air should never be given if it contains less than 21% oxygen
- Care should be taken in the handling and use of medical air cylinders.

Dosage and Directions for Use

- Distinguish between adults, children and the elderley, and between different clinical conditions. The clinical indication would not be whether to use air for use in breathing apparatus, anaesthetic equipment or incubators, but whether to change the formulation of air, e.g. to add more oxygen, depending on the clinical condition
- For breathing purposes, air is administered by various means, commonly by self-contained, or compressed air line breathing apparatus
- In anaesthesia, air is administered via a cylinder and valve assembly through a face mask or endotracheal tube.

Side Effects and Special Precautions

- Oxygen toxicity depends on both the inspired pressure (a function of concentration and barometric pressure), and the duration of exposure, the safe duration decreasing as the pressure increases.

  At lower pressures of up to 2 atmospheres absolute, pulmonary toxicity occurs before central nervous system toxicity. At higher pressures the reverse applies. Symptoms of pulmonary toxicity include a decrease in vital capacity, cough and substernal distress.

  Symptoms of central nervous system toxicity include nausea, mood changes, vertigo, twitching, convulsions and loss of consciousness
- Retinopathy of prematurity has been associated in some premature infants with excessive oxygen therapy
- Facilities or practices in which medical air is breathed in a high pressure environment should be prepared to deal with illnesses associated with decompression (Bends or Caisson disease).

Known Symptoms of Overdosage and Particulars of its Treatment

- Treatment is symptomatic and supportive
- See "Side Effects and Special Precautions."

Identification

All cylinders containing compressed medical air shall be colour-coded in accordance with SABS 06-1957.

The cylinder shall have a French grey body, with the shoulder being painted with white and black quadrants. The word "Air" shall be stencilled in black on the cylinder.

Presentation

All cylinders having a water capacity of more than 10 litres shall have valve protection guards fitted, the only exceptions being cylinders manufactured before 1985, as they have no provision for the fitting of guards.

Chevron labels, stating the name "Air" and the masses/volumes of the contents, shall be fitted to the shoulders of the cylinders in line with the valve outlet socket.

A "Tickopress" label stating the expiry date, the name of the filling site, and carrying the sequential number, shall be affixed to the shoulder of the cylinder.

A heat-shrink seal shall be fitted to the valve of the cylinder confirming that the cylinder has been properly filled and has passed the leak-test.

Storage Instructions

Never permit oil, grease, or any other readily combustible substance to come into contact with high pressure air.

Full and empty cylinders should be segregated.

Use a "first-in - first-out" inventory system to prevent full cylinders being stored for excessive periods of time.

Keep out of reach of children.

Prescribing Information

Scheduling Status

Not scheduled

Proprietary Name

Afrox Medical Carbon Dioxide

Composition

Constituent		Purity Minimum	Active or Inactive	Purpose if Inactive
Chemical Name	Approved Name	99,0%	Active	N/A
Carbon Dioxide	Medical Carbon Dioxide			

Pharmacological Classification

A34 OTHER. MEDICAL GASES

Pharmacological Action

The effect of inhaling carbon dioxide, or of its accumulation in the body through ventilation defects, varies with the tension achieved in the blood, the duration and condition of the exposure, and the susceptibility of the individual concerned.

Indications

- Increase the depth of anaesthesia rapidly when volatile agents are being administered. It increases depth of respiration and helps to overcome breath-holding and bronchial spasm
- Facilitates blind intubation in anaesthetic practice
- Facilitates vasodilation, and thus lessen the degree of metabolic acidosis during induction of hypothermia
- Increases the cerebral blood flow in arteriosclerotic patients undergoing surgery
- Stimulates respiration after a period of apnoea
- In chronic respiratory obstruction after it has been relieved
- Prevents hypocapnia during hyperventilation
- For clinical and physiological investigations.

Contra-Indications

- The use of carbon dioxide is not recommended in pregnancy, and the safety in lactation has not been established.

Warnings

- Carbon dioxide is stored in high pressure gas cylinders as a liquid under pressure. Rapid opening of the valve can cause the discharged gas to re-liquefy. This liquid can cause cold burns if in contact with the skin. Cylinders should only be used in the vertical position with the valve uppermost
- Care is needed in the handling and use of Medical carbon dioxide gas cylinders.

Dosage and Directions for Use

Carbon dioxide should only be given under the direct supervision of a clinician. Except under special circumstances (e.g. physiological investigations), the inspired concentration should not exceed 5%. However, 100% carbon dioxide may be insufflated into the abdominal cavity to distend it, to allow the investigation and treatment of intra-abdominal disease, particularly of a gynaecological nature.

Routes of Administration

The major exception is when a metered supply is fed into the oxygenator of an extracorporeal circulation of a cardio-pulmonary by-pass system.

Side Effects and Special Precautions

- Above a concentration of 6%, carbon dioxide gives rise to headache, dizziness, mental confusion, palpitations, hypertension, dyspnoea, increased depth of rate of respiration, and depression of the central nervous system
- Concentrations of about 30% may produce convulsions. Higher concentrations are depressants; inhalation of 50% carbon dioxide is reported to produce central effects similar to anaesthetics
- The inhalation of high concentrations may produce respiratory acidosis
- Abrupt withdrawal of carbon dioxide after prolonged inhalation commonly produces pallor, hypertension, dizziness, severe headache and nausea or vomiting.

Known Symptoms of Overdosage and Particulars of its Treatment

- Overdose of carbon dioxide stimulates breathing. If excessive this may cause extreme respiratory difficulty, raise the blood pressure and lead to nausea and vomiting, and occasionally unconsciousness
- Treatment is symptomatic and supportive.

Identification

All cylinders containing medical carbon dioxide shall be colour-coded in accordance with SABS 06-1957.

The cylinder shall have a green body with a French grey shoulder. The symbol “CO_2” and the name “CARBON DIOXIDE” shall be stencilled in black on the shoulder and body of the cylinder respectively.

Presentation

All cylinders having a water capacity of more than 10 litres shall have valve protection guards fitted, the only exceptions being cylinders manufactured before 1985, as they have no provision for the fitting of guards.

Chevron labels, stating the name "Medical carbon dioxide" and the masses/volumes of the contents, shall be fitted to the shoulders of the cylinders in line with the valve outlet socket.

A "Tickopress" label stating the expiry date, the name of the filling site, and carrying the sequential number, shall be affixed to the shoulder of the cylinder.

A heat-shrink seal shall be fitted to the valve of the cylinder confirming that the cylinder has been properly filled and has passed the leak-test.

Storage Instructions

Medical carbon dioxide cylinders should be stored:

- Under cover, kept dry and clean
- Away from stocks of material and not subjected to extremes of heat
- Stored separately from industrial and other non-medical cylinders
- Full and empty cylinders stored separately.
- Keep out of reach of children.

Prescribing Information

Scheduling Status

Schedule: 4

Proprietary Name

Afrox Medical Nitrous Oxide

Composition

Nitrous Oxide	99,0% min

Maximum Impurities

Carbon Dioxide	100 vpm
Carbon Monoxide	10 vpm
Moisture	50 vpm
Nitrogen Oxides	2 vpm
Oxygen & Nitrogen	1,0%

Pharmacological Classification

A34 OTHER. MEDICAL GASES

Pharmacological Action

- Nitrous oxide is eliminated unchanged from the body mostly by the lungs
- Induction with nitrous oxide is relatively rapid, but a concentration of about 70% is needed to produce unconsciousness at sea level. At higher altitudes, unconsciousness will not be produced in healthy robust patients
- Nitrous oxide is a low potency inhalation anaesthetic and not readily soluble. High concentrations, not greater than 70%, are used for induction of anaesthesia and recovery occurs quickly.

Indications

Nitrous oxide is used:-

- For the relief of severe pain, usually in emergency situations, by inhalation with 50% oxygen
- Only during induction and maintenance of anaesthesia, in controlled situations.

Contra-Indications

- Nitrous oxide should not be used with any condition where air is entrapped within a body and where its expansion might be dangerous e.g.

- Artificial, traumatic or spontaneous pneumothorax
- Air embolism
- Decompression sickness
- Following a recent dive
- Following air encephelography
- Severe bullous emphysema
- Use during myringoplasty
- Gross abdominal distension

- The safety in pregnancy and lactation has not been established
- Nitrous oxide should not be used as an analgesic anaesthetic agent for more than 24 hours without monitoring of peripheral blood for features of megaloblastic anaemia and leukopenia.

Warnings

- Administration of nitrous oxide, more frequently than every 4 days, should be accompanied by routine blood cell counts for evidence of megaloblastic change in red cells and hypersegmentation of neutrophils
- Nitrous oxide should never be given with less than 21% oxygen. A minimum of 30% oxygen should be used during anaesthesia. At high altitudes and in the presence of disorders affecting oxygenation, higher concentrations of oxygen will be needed
- Scavenging of waste nitrous oxide gas should be used to reduce operating theatre and equivalent treatment room levels to a level below 200 ppm of ambient nitrous oxide
- At the end of a nitrous oxide/oxygen anaesthesia, withdrawal of the mask leads to an outpouring of nitrous oxide from the lungs and consequent dilution of oxygen in incoming air. This results in "diffusion hypoxia" and is counteracted by giving 100% oxygen for a few minutes when the flow of nitrous oxide is stopped
- EFFECTS ON ABILITY TO DRIVE AND TO USE MACHINES Nitrous oxide is rapidly eliminated but driving, use of machinery and other psycho-motor activities should not be undertaken until 12 hours have elapsed after nitrous oxide anaesthesia
- Care should be taken in the handling and use of nitrous oxide gas cylinders.

Dosage and Directions for Use

- Distinguish between adults, children and the elderly and between different clinical indications
- For the production of general anaesthesia nitrous oxide is administered by inhalation through a suitable anaesthetic apparatus in concentrations up to 70% with oxygen as the balance
- In neonates and elderly patients, an increased susceptibility to anaesthesia may be observed
- There are no essential differences between the adult and child.

Routes of Administration

Nitrous oxide is administered through a face mask or tracheal tube by means of an anaesthetic apparatus. The gas is breathed in by the patient and absorbed through the lungs.

Side Effects and Special Precautions

- Anaesthetic agents should be used with caution in patients with cardiac, respiratory, renal, or hepatic impairment
- Hypoxic anaesthesia is dangerous, and nitrous oxide should always be administered with oxygen
- Nitrous oxide diffuses into gas-filled body cavities, and care is essential when using it in patients at risk from such diffusion, such as those with abdominal distension, pneumothorax, or similar cavities in the peritoneum or pericardium.

Other Undesirable Effects (Frequency & Seriousness)

- The use of nitrous oxide causes inactivation of vitamin B12 which is a co-factor of methionine synthase. Folate metabolism is consequently interfered with and DNA synthesis is impaired following prolonged nitrous oxide administration. These disturbances result in megaloblastic marrow changes. Exceptionally heavy occupational exposure and addiction have resulted in myeloneuropathy and subacute combined degeneration
- In patients with normal bone marrow, stores of mature granulocytes will normally be adequate to prevent leucopenia during exposure for up to 3 days : in patients exposed to nitrous oxide for longer periods of time, leucopenia will develop, and exposure for 4 days or longer can result in agranulocytosis
- Repeat exposure to nitrous oxide at intervals of less than 3 days will have a cumulative effect on DNA synthesis, and megaloblastic marrow changes have been reported following multiple short-term exposures
- Depletion of methionine has been implicated in the neurological deficit seen in chronic abusers of nitrous oxide
- Oxygen should be administered during emergence from prolonged anaesthesia with nitrous oxide to prevent diffusion, hypoxia where the alveolar oxygen is diminished
- Nitrous oxide is known to have an ozone depleting potential.
  It is a "greenhouse gas" and may contribute to global warming.

Known Symptoms of Overdosage and Particulars of its Treatment

- Inapplicable, unwitting or deliberate inhalation of nitrous oxide will result in unconsciousness, passing through stages of increasing light-headedness and intoxication, and, if the victim were to be within a confined space, death from anoxia could result. The treatment is removal to fresh air, and if necessary, the use of an oxygen resuscitator.

Identification

All cylinders containing compressed nitrous oxide shall be colour-coded in accordance with SABS 06-1957.

The cylinder shall have a French Blue shoulder and body, with the symbol "N_20" and the name "NITROUS OXIDE" stencilled in white on the shoulder and body of the cylinder respectively.

Presentation

All cylinders having a water capacity of more than 10 litres shall have valve protection guards fitted, the only exceptions being cylinders manufactured before 1985, as they have no provision for the fitting of guards.

Chevron labels, stating the name "Nitrous Oxide" and the masses/volumes of the contents, shall be fitted to the shoulders of the cylinders in line with the valve outlet socket.

A "Tickopress" label stating the expiry date, the name of the filling site, and carrying the sequential number, shall be affixed to the shoulder of the cylinder.

A heat-shrink seal shall be fitted to the valve of the cylinder confirming that the cylinder has been properly filled and has passed the leak-test.

Storage Instructions

Never permit oil, grease, or any other readily combustible substance to come into contact with high pressure nitrous oxide.

Full and empty cylinders should be segregated.

Use a "first-in - first-out" inventory system to prevent full cylinders being stored for excessive periods of time.

Keep out of reach of children.

Prescribing Information

Scheduling Status

Schedule: 4

Proprietary Name

Entonox

Composition

Oxygen	48% min
Nitrous oxide	52% max

Maximum Impurities

Moisture	50 vpm

Only oxygen and nitrous oxide that conform to their individual specifications shall be used for the filling of Entonox cylinders.

Pharmacological Classification

A34 OTHER. MEDICAL GASES

Pharmacological Action

- Nitrous oxide is eliminated unchanged from the body mostly by the lungs
- Induction with nitrous oxide is relatively rapid, but a concentration of about 70% is needed to produce unconsciousness at sea level. At higher altitudes, unconsciousness will not be produced in healthy robust patients

Indications

Entonox is used exclusively for the relief of pain in a controlled setting by trained personnel.

Contra-Indications

- Entonox should not be used in any condition where air is entrapped within a body and where its expansion might be dangerous, e.g.
  - Artificial, traumatic or spontaneous pneumothorax
  - Air embolism
  - Decompression sickness
  - Following a recent dive
  - Following air encephelography
  - Severe bullous emphysema
  - Use during myringoplasty
  - Gross abdominal distension
- The safety in pregnancy and lactation has not been established.
- Entonox should not be used for more than twenty-four hours without monitoring blood for features of megaloblastic anaemia and leukopenia.

Warnings

- Administration of Entonox more frequently than every 4 days should be accompanied by routine blood cell counts for evidence of megaloblastic change in red cells and hypersegmentation of neutrophils
- Thorough ventilation or scavenging of waste gases should reduce operating theatre and equivalent treatment room levels of ambient nitrous oxide to a level below 200 ppm. Entonox is non-flammable but strongly supports combustion (including some materials which do not normally burn in air). It is highly dangerous when in contact with oils, greases, tarry substances and many plastics
- A slight, but quantified impairment in driving ability was found up to 30 minutes following 15 minutes inhalation of nitrous oxide/oxygen mixtures
- Care should be taken in the handling and use of Entonox gas cylinders.

Dosage and Directions for Use

- Distinguish between adults, children and the elderly and between different clinical indications
- Doses are self-regulated in nearly all cases by the use of a face mask connected through a demand valve to the Entonox cylinder
- Entonox may be administered by personnel trained in its use (obstetric units, accident units and accident ambulances).

Routes of Administration

Entonox is administered through a face mask. The mask is connected to an Entonox supply through a demand valve system. The valve is operated by the act of inhalation of the patient and closes down when the patient ceases to inhale.

In nearly all cases, Entonox is self-administered, but it may be administered by attendant medical personnel. Since pain is usually relieved by a concentration of 25% nitrous oxide, continued inhalation does not occur. However, should inhalation continue, light anaesthesia supervenes and the mask drops away as the patient relaxes, or is removed if administration has been by attendant personnel.

Side Effects and Special Precautions

Prolonged analgesia may theoretically result in bowel distension, middle ear damage and rupture of ear drums.

Other Undesirable Effects (Frequency & Seriousness)

- Entonox should not be employed for analgesia in patients with head injuries with impairment of consciousness, maxillo-facial injuries, decompression sickness, or those heavily sedated
- Nitrous oxide diffuses into gas-filled body cavities, and care is essential when using it in patients at risk from such diffusion, such as those with abdominal distension, pneumothorax, or similar cavities in the pericardium or peritoneum
- The use of nitrous oxide causes inactivation of vitamin

B12 which is a co-factor of methionine synthase. Folate metabolism is consequently interfered with and DNA synthesis is impaired following prolonged nitrous oxide administration. These disturbances result in megaloblastic marrow changes. Exceptionally heavy occupational exposure and addiction have resulted in myeloneuropathy and subacute combined degeneration

- In patients with normal bone marrow, stores of mature granulocytes will normally be adequate to prevent leucopenia during exposure for up to 3 days : in patients exposed to nitrous oxide for longer periods of time, leucopenia will develop, and exposure for 4 days or longer can result in agranulocytosis
- Repeat exposure to nitrous oxide at intervals of less than 3 days will have a cumulative effect on DNA synthesis, and megaloblastic marrow changes have been reported following multiple short-term exposures
- Depletion of methionine has been implicated in the neurological deficit seen in chronic abusers of nitrous oxide
- Hypoxic anaesthesia is dangerous, and nitrous oxide should always be administered with oxygen
- Cylinders containing Entonox should be fitted with an approved regulator by which the rate of flow can be controlled. It is important that the regulator be free from all traces of oil or grease, otherwise a violent explosion may occur
- Nitrous oxide is known to have an ozone depleting potential.
  It is a "greenhouse gas" and may contribute to global warming.

Known Symptoms of Overdosage and Particulars of its Treatment

Inapplicable, unwitting or deliberate inhalation of Entonox will ultimately result in unconsciousness, passing through stages of increasing light-headedness and intoxication, and, if the victim were to be within a confined spare, death from anoxia could result. The treatment is removal to fresh air, and if necessary, the use of an oxygen resuscitator.

Identification

All cylinders containing Entonox shall be colour-coded in accordance with SABS 06-1957.

The cylinder shall have a French Blue body, with the shoulder being painted with blue and white quadrants. The symbols "N_2O and O_2" shall be stencilled in black on a white quadrant.

The name "Entonox" shall be stencilled in white on the body of the cylinder.

Presentation

All cylinders having a water capacity of more than 10 litres shall have valve protection guards fitted, the only exceptions being cylinders manufactured before 1985, as they have no provision for the fitting of guards.

Chevron labels, stating the name "Entonox" and the masses/volumes of the contents, shall be fitted to the shoulders of the cylinders in line with the valve outlet socket.

A "Tickopress" label stating the expiry date, the name of the filling site, and carrying the sequential number, shall be affixed to the shoulder of the cylinder.

A heat-shrink seal shall be fitted to the valve of the cylinder confirming that the cylinder has been properly filled and has passed the leak-test.

Storage Instructions

Never permit oil, grease, or any other readily combustible substance to come into contact with high pressure Entonox.

Full and empty cylinders should be segregated.

Use a "first-in - first-out" inventory system to prevent full cylinders being stored for excessive periods of time.

Keep out of reach of children.

General Information

Medical Oxygen

Oxygen is colourless, odourless and tasteless, so a super-oxygenated atmosphere cannot be detected by normal human senses.

In a super-oxygenated atmosphere, objects and especially organic materials (fabrics, wood, paper, etc.) which do not normally burn in air, may ignite violently at the slightest spark or contact with a source of fire (cigarettes, for example). Fatty substances (oils, greases, etc.) ignite spontaneously in contact with oxygen.

Safety Regulations

Oxygen is one of the elements in the triangle of fire.

The higher the concentration of oxygen, the greater the risk.

Oxygen is heavier than air. Therefore, the most common risks linked to super-oxygenation are on the floor or low down.

Oxygen represents 21% of the composition of ambient air. It is an oxidising agent, i.e. it maintains and activates the combustion of any combustible material.

Oxygen activates the combustion of any inflammable material. To avoid any risk of fire, follow the instructions in this section carefully.

General Instructions*

1 Eliminate any inflammable sources close to your source of oxygen. Your source of oxygen must be stored and used more than two metres away from any device which produces flames (fireplace, cooker, stove, water-heater, etc.).

2 Do not use or store your oxygen therapy equipment close to machinery which produces sparks (electrical appliances, friction or ignition toys, etc.).

3 Do not use aerosol sprays (lacquer, deodorant, etc.), solvent (alcohol, petrol, etc.) on the equipment or even close to it.

4 Use medical oxygen only for the treatment prescribed by your physician.

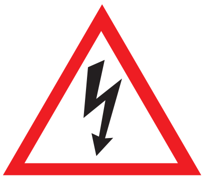
5 Do not smoke or allow others to smoke in the room where your oxygen therapy equipment is stored and used.

6 Do not grease or lubricate your equipment, tubes or oxygen goggles. Make sure your hands are clean when handling the equipment. Do not use near oil, grease, hand or face cream, etc.

7 High concentrations of oxygen are dangerous: aerate the room where you use the oxygen source; do not store empty or full oxygen tanks in a cupboard, a car boot, etc.

*** Consult the medication instruction leaflet before use.**

Installation



- Keep the equipment more than three metres away from any source of ignition
- Do not smoke or allow others to smoke near the equipment during handling
- Keep at least 15 cm space around the device to allow air to circulate
- Do not cover or place it behind curtains
- Do not use aerosol sprays (lacquer, deodorant, etc.) when the equipment is in operation
- Aerate the room in which you use the equipment
- Do not install the equipment in a garage or kitchen where oils and greases are used
- Do not install the equipment in a bathroom or wet area
- The equipment must be used vertically
- Use the electric cable supplied with the equipment to connect it
- Use a dedicated power outlet
- If an electrical extension or multiple adaptor has to be used, make sure it is standard equipment: (cable H05VVF 220-240 V 50/60 Hz 10 A)
- Place the equipment in a place where you can hear the alarm.

Warning

- Pets may damage the tubing
- Do not step on the tubing
- Bleach, chlorine, alcohol and scented oils must not be used to wash the equipment or consumables (mask, goggles or tubes). These solutions could damage your equipment and reduce its lifetime.

Hygiene

Precautions for Use

Wash your hands before any intervention.

Servicing

Before starting any cleaning procedure, set the switch to ‘0’ and disconnect the mains lead.

Do not apply any liquid directly onto the equipment casing.

Use a damp cloth or sponge with gentle household cleaner and dry it.

The oxygen concentrator must be dusted regularly and the dust filter must be cleaned every week (wash it in soapy water, rinse, leave to dry and put back in place).

To avoid any risk of electric shock, do not remove the concentrator casing. Only the technician is authorised to do this.

Consumables

Average consumption is about two sets of oxygen goggles or masks per month.

The end-pieces of the goggles must be rinsed under the tap every day and the goggles changed if they are damaged.

5

LIQUEFIED PETROLEUM GAS

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handigas

LPG

Afrox is the leading supplier of Liquefied Petroleum Gas (LPG) in sub-Saharan Africa and pioneered the LPG industry in South Africa under the brand name Handigas in the early 1950s, which is still the leading brand name in LPG today. With more than 2,5-million LPG cylinders and the largest bulk LPG storage and distribution infrastructure on the sub-continent, Afrox is uniquely positioned to meet the energy demands of industrial, commercial, agricultural and domestic applications, across a broad-based market sector.

Highly qualified in-house engineering expertise enables Afrox to offer end-to-end gas solutions from industrial and commercial space heating to large furnaces and curing ovens. From small boutique hotels to the largest casino resort complexes in Africa, from industrial catering to most fast food and restaurant franchise chains in the biggest shopping malls, Handigas is the gas chosen by chefs and project engineers alike.

Handigas is a clean burning fuel that provides all energy users with a safe, efficient and economical alternative for a diverse range of applications and is available through our extensive Afrox network of Gas & Gear sales centres and Handigas agents, which means that no matter where you are, Handigas is there.

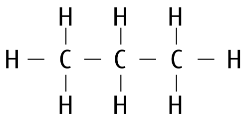
Definition of LPG

LPG (Liquefied Petroleum Gas) is the term applied to those hydrocarbons which are vapours at room temperature and can be liquefied by compressing them slightly. When LPG is liquefied, its volume decreases considerably so that it requires much less storage space. The liquid is transported in relatively light pressure cylinders and the customer converts it to gas by opening the valve on the cylinder which causes the liquid to vaporise as a result of a drop in cylinder pressure. LPG is composed of a mixture of mainly propane and butane (approximate ratio 60:40 by mass) but may contain some propylene and butylene as well as traces of ethane, ethylene, pentane and butadiene. It is colourless and odourless, but commercial LPG is usually stenched with a substance called ethyl mercaptan to give it a characteristic odour.

The Chemistry of LPG

Atoms of hydrogen (H) and carbon (C) combine to form hydrocarbon molecules which can be made up of different numbers of hydrogen and carbon atoms, hence the term 'hydrocarbon'.

A molecule containing three carbon atoms and eight hydrogen atoms is called propane:



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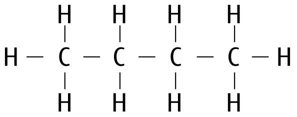
Molecule of propane (C_3H_8)

In a like manner, four carbon atoms bonded to 10 hydrogen atoms forms butane:



$$\begin{array}{ccccccccccc} & & H & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & \mid & & \mid & & \mid & & \mid & & \\ & & H & & H & & H & & H & & \end{array}$$

Molecule of butane (C_4H_{10})

There are two possible configurations for the butane molecule. The above arrangement consists of a straight C-chain and is called normal butane or n-butane. If the C-chain is branched, it is called iso-butane. Such a rearrangement of the atoms is known as isomerisation and has no significant effect on the fuel properties.

Hydrocarbons with single carbon bonds are known as saturated hydrocarbons while those with double or triple bonds are unsaturated hydrocarbons. Examples of saturated hydrocarbons are methane (CH_2), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}). Unsaturated hydrocarbons include ethylene (C_2H_4), propylene (C_3H_6), butylene (C_4H_8) and acetylene (C_2H_2).

Physical Properties of LPG

The properties of LPG mixtures can usually be calculated from the properties of the individual constituents (propane, butane, etc.) provided the proportions of the constituents are known. Following is a description of the most important physical properties of LPG mixtures.

1. Density

The density of LPG is defined as its mass per unit volume (kg/ℓ) at a given temperature. LPG liquid has a density of about 0,54 kg/ℓ at 15°C and is therefore lighter than water. It varies slightly with LPG composition and every batch of LPG produced at a refinery will have a specified density at a given temperature. LPG liquid is fairly light - about half the weight of water. To convert litres of LPG to kilograms, simply multiply the number of litres by the density.

LPG vapour has a density of about 1,9 times that of air and is therefore heavier than air. This is important when considering ventilation requirements and has an influence on the design of burners and certain meters for measuring vapour flow. Buildings used for storing LPG cylinders must have adequate floor level ventilation; in the event of a leak, the vapour being heavier than air will flow along the ground to the lowest level and remain there for a considerable period of time, and can be an explosion hazard.

2. Calorific Value (CV)

All substances which burn generate energy in the form of heat, which varies in quantity with the nature of the substance. The total amount of heat liberated by burning a substance is known as its Calorific Value or CV. It is usually expressed in megajoules per kg (MJ/kg). For LPG, it is 49,6 MJ/kg.

3. Thermal rate of expansion (expansion and contraction)

The thermal rate of expansion of liquid LPG is about 10 times that of water and since liquids can not be compressed, it is probably the most important property of LPG affecting the way the gas is stored, handled and filled. Storage tanks and portable cylinders filled to allow for an ullage space in the vessel and cylinders must never be filled to more than about 85% of the internal volume.

When the valve of an LPG is opened, the pressure inside the cylinder is reduced and the liquid starts to vaporise (boil) at lower pressure. This vaporisation of the gas causes cooling to occur and the temperature of the gas will decrease. If the gas off-take rate is too high, the gas temperature will decrease to below 0°C and ice will start to form on the lower outside wall of the cylinder. Because LPG contains propane and butane, with boiling points of -42,1°C and -0,5°C respectively, the mixture begins to separate – propane continues to boil off while the butane remains in liquid form at temperatures below its boiling point of -0,5°C. To avoid this situation, vaporiser units are used for LPG or pure propane can be used instead of Handigas (butane/propane mixture). It should be noted that low winter temperatures will aggravate this situation.

4. Vapour pressure

One litre of liquid Handigas will rapidly and totally vaporise when exposed to atmospheric pressure (100 kPa) to form about 275 litres of vapour at 15°C. In a closed cylinder containing some liquid Handigas, a relatively small quantity will vaporise in the restricted volume of the cylinder, to produce a cylinder pressure of about 250 kPa at 0°C. This closed cylinder pressure is equal to the vapour pressure, and it increases dramatically with temperature to 500 kPa at 20°C and 1 550 kPa at 60°C.

A liquid leak is far more serious than a gas leak due to the high volume of gas formed. This is why cylinders must always be stored, transported and used in the upright position. In air a gas leak will form a highly flammable mixture of about 10 000 litres from one litre of liquid gas.

As LPG consists of a mixture of propane and butane and since propane has a much higher vapour pressure than butane, the vapour pressure in a cylinder containing mostly propane will be much higher than that of a cylinder containing mostly butane. This relationship between pressure and temperature of pure propane and butane, and LPG (60:40 mix) is illustrated below.

Temp (°C)	Propane (kPa)	Butane (kPa)	LPG (kPa)
-20	150	0	±80
0	370	<5	±250
20	710	110	±500
40	1 250	280	±910
60	1 970	520	±1 550

This table clearly shows the high pressures that can develop due to an increase in temperature, particularly in the case of pure propane.

5. Table of the properties of propane, butane and a typical 60:40 LPG mix

Property	Propane	Butane	Handigas
Molecular weight	44,09	58,12	49,7 (av.)
Carbon content (wt%)	81,72	82,66	82,15
Hydrogen content (wt%)	18,28	17,34	17,85
Carbon: hydrogen ratio by weight	4,47	4,77	4,60
Density of liquid at 15°C (kg/ℓ)	0,510	0,575	0,536
Boiling point of liquid at atm. pres. (°C)	-42,1	-0,5	-42,1 -0,5
Density of gas at 15°C & atm. pres. (kg/m^3)	1,86	2,46	2,10
Volume ratio of gas:liquid at STP*	274:1	233:1	258:1
Volume of gas from 1 kg liquid at STP (ℓ)	537	405	484
Mass ratio of gas:air at 15°C & atm. pres.	1,52:1	2,01:1	1,716:1
Latent heat of vaporisation at 15°C (kJ/kg)	20,43	21,27	20,77
Vapour pressure at 20°C (kPa abs.)	710	110	500
Sp. heat of vapour at atm. pres. (cal/g.°C)	0,388	0,397	0,392
Net calorific value at 25°C (MJ/kg)	46,0	45,6	45,8
Gross calorific value at 25°C (MJ/kg)	49,8	49,4	49,6
Wobbe number (kcal/Nm^3)	19 000	21 600	
Limits of flammability in air (vol% gas)	2,2 – 10	1,8 – 9	1,8 – 10
Limits of flammability in oxygen (vol% gas)	2 – 50	2 – 50	2 – 50
Max. flame temperature in air (°C)	1 930	1 900	1 900
Max. flame temperature in oxygen (°C)	2 740	2 700	2 700
Max. flame speed in 25 mm tube (cm/sec)	82	82	82
Air reqd for combustion at STP* (m^3/kg LPG)	12,10	11,93	12,03
Air:gas vol. ratio for combustion at STP	22,5	29,5	24,9
O_2 vol. for combustion at STP* (m^3/kg fuel)	2,56	2,51	2,54

*STP: Standard Temperature & Pressure, defined as 0°C and 100 kPa absolute

6. Stench additive

LPG is practically odourless and colourless which makes leak detection difficult. A small amount of stenching additive (ethyl mercaptan) is therefore added to LPG before going to market. The additive is non-corrosive, non-toxic and the odour can be smelt in very low concentrations of vapour.

LPG Cylinders

Although a 'full' LPG cylinder contains 85% liquid, the ullage volume will contain vapour at a pressure that varies with temperature. As the temperature rises, more vaporisation occurs, resulting in an increase in the vapour pressure inside the cylinder (cylinder pressure). If the temperature falls, some of the vapour will condense and the vapour pressure will decrease. The cylinder pressure is dependent on the LPG composition (propane: butane ratio).

Handigas and propane cylinders are available in two valve types, namely vapour withdrawal or dual liquid/vapour withdrawal. The liquid withdrawal valves are for high demand applications where the vapour withdrawal capacity of vapour cylinders cannot supply the high demand required.

Note: Liquid withdrawal and propane cylinders **are not for domestic use.**

Physical Data for Various LPG Cylinders

Capacity (kg)		Water Capacity (ℓ)	Tare Mass (kg)	Height incl. Valve (mm)	Diameter (mm)
LPG	Propane				
48,0	45,0	113,4	45,0	1 288	380
19,0	18,0	45,4	21,0	890	300
14,0	n/a	34,0	17,5	720	300
9,0	8,0	22,7	13,3	545	300
6,0			9,45	370	300

Nominal Sizes for Low Pressure LPG Cylinders

Afrox currently supplies Handigas and propane in five different sized cylinders as shown above. However, propane in 8 kg and 18 kg size cylinders has to be specially requested.

When LPG is drawn from a cylinder at a fairly high rate, the liquid content will cool down noticeably. The cylinder becomes cold, cooling down the surrounding air as heat is withdrawn from it. Ideally, the rate of heat transfer must be sufficient to allow the liquid to keep boiling and so maintain an adequate gas pressure. If the liquid cools to below 0°C, condensation in the form of dew or frost may form on the outside of the cylinder adjacent to the liquid. When this happens, preferential propane vaporisation occurs, resulting in an accumulation of liquid butane that will not vaporise at such low temperatures.

When the transfer of heat to the liquid is insufficient and the gas becomes very cold, the rate of evaporation will slow down and the gas supplied from the cylinder will be reduced and could even stop altogether. This may occur in the following situations:

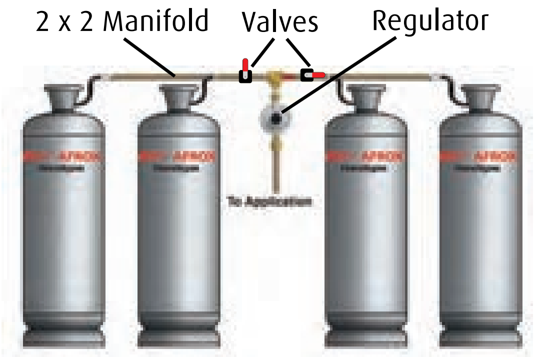
- Cylinder is located in a cold area with no warmth from the sun
- Cylinder is nearly empty, resulting in less heat absorption and more rapid cooling
- Cylinder is too small for application and cannot absorb sufficient heat from the air temperature to maintain draw-off rate.

Experience has shown that the various size LPG cylinders are capable of continuous gas delivery at maximum draw-off rates as given in the following table.

Cylinder Size (kg)	Max. Draw-Off Rate (kg/hr)	Rate of Energy Supply	
		(MJ/hr)	(kW)
48,0	1,0	48	13,3
19,0	0,5	24	6,6
14,0	0,4	16	4,4
9,0	0,25	10	2,8
6,0	0,15	7	1,9

The method of supplying LPG to a customer is dependent on a number of factors including the type of application and quantities of gas required. Most small to medium-sized customers are supplied in cylinders, either for single-user point or multi-user points. However, for fixed user points where high draw-off rates are required, a cylinder-manifold and pipe line reticulation can be installed on the customer's premises as shown below.

Double 2 Handigas Cylinder Manifold



Bulk Handigas

When significant quantities of Handigas or propane are required, a bulk storage/supply facility is recommended.

Storage tanks for LPG are pressure vessels designed and manufactured in accordance with international standards and comply with the Occupational Health and Safety Act requirements for pressure vessels and equipment.

The majority of storage tanks used by Afrox are of the horizontal (bullet) type. However, in cases where the storage area is limited, vertical tanks may be used. The Afrox range of tanks includes the following:

- Horizontal: 2,25 m^3, 4,5 m^3, 9 m^3, 22,5 m^3, 45 m^3, 70 m^3 and 90 m^3. Larger tanks are available on special order and can be viewed at some Afrox branches.
- Vertical: 4,5 m^3, 9 m^3, 22,5 m^3, 45 m^3 and 70 m^3.

The Market Place

LPG is marketed by Afrox under the brand name of Handigas and is an efficient source of energy that is relatively simple to store, transport and handle and will compete well against most other forms of energy.

Afrox is a major player in the development of industrial projects, shopping complexes, hotel/casino resorts, community and industrial townships, formal and informal urbanisation and other projects where fuel and energy is required.

The market can be broadly divided into the five following sectors:

- Industrial
- Commercial
- Agricultural
- Materials handling (forklift trucks)
- Retail
- Domestic
- Hospitality.

Handigas

(60:40 Propane - Butane mixture)

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Features	Benefits	Hazards
High calorific value. Highly combustible, having explosive limits in air of between 2,2 and 9,5% by volume	For profile cutting, oxy-LPG gives fast, clean cuts on thick plate	Fire and explosion hazard
Twice as heavy as air	High heating range	Heavier than air - collects in low-lying areas such as drains or ducts
Stenched to give a distinctive fish-like odour	Clean burning	Requires air ventilation when in use
Liquefiable gas	Compatible with air/fuel or oxy/fuel equipment	Can cause dizziness at high concentrations
Non-poisonous	Accidental discharge is quickly detected	Can asphyxiate (does not support life)
Available as a vapour or liquid withdrawal from cylinders	Highly combustible, compact, portable fuel with clean burning characteristics	
Supplied in cylinders or bulk tanks		

Applications

General light and heavy industrial sector

- Used for oxy-LPG or oxy-propane cutting and brazing. Can be used as an alternative fuel gas to acetylene for steel cutting applications when high cutting speed and efficiencies are not required
- Oxy-fuel equipment is widely used with LPG for preheating
- Glass and plastic industry heating and finishing applications
- Shrink wrap applications
- Space heating for small and large work areas
- Firing of many types of oven and furnace heating and curing processes
- Firing granular material drying ovens
- Ink and paint solvent drying
- Water proofing application
- Heating of road surfacing bitumen
- Large volume fluid tank heating
- Dual-fuel (Autogas) for cars and light delivery vehicles
- Fuel for forklift trucks
- Propane is used for carburising atmospheres in the heat treatment of steels.

Agricultural sector

- Heating of chicken brooders and greenhouses
- Crop drying
- Organic flame weeding
- Pest control
- General heating
- Many process and packaging processes.

Commercial, domestic and leisure sectors

- Most cooking applications, for both hob and oven uses
- General space heating for both indoors and outdoors
- Large central and small direct water heating applications in hotels and lodges
- Laundry heating and drying
- Outdoor aesthetic lighting effects
- Outdoor catering and special events
- Home cooking, heating and lighting
- Patio braaing, heating and lighting
- Camping cooking, heating and lighting.

Cylinder Size	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Handigas 48	48,0	± 500	5/8" LH-F	3634 LF
Handigas 48 (wet)	48,0 (wet)	± 500	Dual - 5/8" LH-F & 3/8" (SAE Flare) RH-M	3634 L F-W
Handigas 19	19,0	± 500	5/8" LH-F	3634 LE
Handigas 14	14,0	± 500	5/8" LH-F	3634 LD
Handigas 9	9,0	± 500	5/8" LH-F	3634 LC
Private gas fills	Various	± 500	3/8" RH-F (camping)	3634 P

Cylinder colours:
- Gas withdrawal - Dark Admiralty Grey, with Handigas branding
- Liquid withdrawal (wet) - Dark Admiralty Grey, with Handigas branding and vertical yellow strip on length of cylinder.

Most cylinders are available at all Afrox outlets.

Please check with your local Afrox branch or call 0860 020202.

MSDS available from www.afrox.com.

Afrox LPG 2 Burner Hotplate

Item Number	W012671

6 kg Handipack

Material Description	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Handipack Cyl/Cooker	6,0	± 500	3/8" RH-F (camping)	W902216

Cylinder colours:
- Gas withdrawal - Dark Admiralty Grey, with Handigas branding.

Available at all Afrox outlets.

Please check with your local Afrox branch or call 0860 020202.

MSDS available from www.afrox.com.

*Note: Privately owned cylinder

Cooker Ring and Deflector Plate

Item Number	W902125

Mixer Tube and Burner

Item Number	W902126

Forklift (Autogas)

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Cylinder Size	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Forklift 19	19,0	± 500	1&1/4" Acme RH-M	3634 LE.FV
Forklift 14	14,0	± 500	1&1/4" Acme RH-M	3634 LD.FV

Propane (C_3H_8)

Gas	Purity
Propane	>98%
Other Hydrocarbons	<2%

Cylinder Size	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Propane 45	45,0	± 500	5/8" LH-F	34 LF
Propane 45 (wet)	45,0 (wet)	± 500	Dual - 5/8" LH-F & 3/8" (SAE Flare) RH-M	34 LF.W
Propane 18	18,0	± 500	5/8" LH-F	34 LE
Propane 8	8,0	± 500	5/8" LH-F	34 LC

Cylinder colours:
- Gas withdrawal - Dark Admiralty Grey, with propane branding
- Liquid withdrawal (wet) - Dark Admiralty Grey, with propane branding and vertical yellow strip on length of cylinder.

45 kg cylinders are not available at all Afrox outlets.

Please check with your local Afrox branch or call 0860 020202.

8 kg and 18 kg cylinders are available by special arrangement.

MSDS available from www.afrox.com.

Handigas Dumpy (Mini Bulk)

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Dumpy Size (mm)	Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
900 dia, 1 600 high	193,0	± 500	ACME	1122

Dumpy installations are fixed installations installed on customers' premises by Afrox Customer Engineering Services and are filled on site by bulk road tankers.

MSDS available from www.afrox.com.

Handigas Bulk

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Vessel Sizes (m^3)	Vessel Content	Pressure kPa @ 20°C	Road Tanker Connection	Item Number
Horizontal: 9, 22,5, 45, 70, 90	As per vessel size	± 500	ACME	1122
Vertical: 4,5, 9, 22,5, 45, 70	As per vessel size	± 500	ACME	

Bulk installations are fixed installations installed on customers' premises by Afrox Customer Engineering Services and are filled on site by bulk road tankers.

MSDS available from www.afrox.com.

Propane Bulk

Gas	Purity
Propane	>98%
Other Hydrocarbons	<2%

Vessel Sizes (m^3)	Vessel Content (t)	Pressure kPa @ 20°C	Road Tanker Connection	Item Number
Horizontal: 9, 22,5, 45, 70, 90	4,5 - 45	± 710	ACME	5410
Vertical: 4,5, 9, 22,5, 45, 70	2,25 - 22,5	± 710	ACME	

Bulk installations are fixed installations installed on customers' premises by Afrox Customer Engineering Services and are filled on site by bulk road tankers.

MSDS available from www.afrox.com.

BE SAFE

Example of authentic, legally filled, Afrox **Red Seal** cylinder from an Afrox outlet.
Note: SERIAL NUMBER & AFROX ON SEAL

Always purchase Handigas from an authorised Afrox dealer

Handigas is the brand name for the Liquefied Petroleum Gas (LPG) sold by Afrox, which, like other petroleum fuels such as petrol, diesel and paraffin, is refined by the major oil refineries and is the cleanest burning of all these liquid fuels. Afrox's extensive network contributes to the wide availability of Handigas, making it a convenient source of LPG. Handigas is ideal for cooking, heating, hot water, braaing, camping and hiking.

Only authorised Afrox Handigas dealers may fill Afrox owned LPG cylinders, which carry the brand name Handigas and the Afrox **Red Seal** of safety. The Afrox **Red Seal** guarantee assures that:

- All the safety checks have been carried out at each fill
- The cylinder has been correctly filled to the right quantity of gas you have purchased
- The quality of the cylinder or the gas can be guaranteed
- You will get Afrox service back-up if the cylinder or gas is faulty.

Example of authentic, legally filled, Afrox 👍 **Red Seal** cylinder from an official Afrox distributor.
Note: SERIAL NUMBER & 👍 ON SEAL

Beware of rogue fillers

Rogue fillers are threatening public safety and putting lives at risk by illegally filling Afrox Handigas cylinders and conning consumers into believing they are buying a legitimate Afrox product. Beware of unethical operators who are not interested in safety and disregard or have no knowledge of legislation and best practices. Do not be fooled by what may appear to be a legitimate business selling Afrox Handigas – if it is not an Afrox Gas & Gear or an accredited Afrox Handigas distributor, then the cylinders are illegally filled (SANS 10019:2011). If you are sold Afrox Handigas without the uniquely serial numbered Afrox **Red Seal** or the Afrox distributor **Red Seal** of safety, shrink-wrapped over the cylinder valve, you are buying a potentially hazardous product.

Illegal filling, including transfilling, compromises safety and can result in damage, injury, and even loss of life. If you come across any illegal filling, please help and report it anonymously to the Liquified Petroleum Gas Association of South Africa (LPGASA) who will investigate and take the appropriate actions. For more information, visit **www.lpgas.co.za.**

How do I safely connect a gas cylinder to an appliance?

When connecting your gas appliance to the gas cylinder, always ensure that the connection is made correctly and is gas tight. A smell of gas will be detected if the connection is not tight. All gas appliances have rubber or fibre washers to seal the gas tightly at the point of connection to the gas cylinder. Always check that this washer or seal is in place and in good condition. The rubber or fibre seals and hoses do wear and need to be checked periodically and replaced occasionally. Some 'Handi' tips:

- ⚠ Only open valve 1½ turns
- ⚠ When lighting gas appliances that don't have auto ignition: first light the match or lighter, hold it to the gas burner, then open the gas. The gas will ignite immediately and the flame temperature will go from 0 to 1 970°C instantly
- ⚠ To ensure that fresh air is always available, have a window slightly open when using gas appliances, even in cold weather
- ⚠ Ensure LPG cylinders are always placed on a firm surface
- ⚠ Always shut off the gas supply at the cylinder valve when the appliance is not in use
- ⚠ It is very important to keep the gas jets clean. Before connecting the appliance to the gas cylinder, make sure that the valve is free of dirt and dust.

Like all electrical installations, it is legally required that fixed LPG appliances are fitted and piped to a gas cylinder(s) outside, and they must be installed by a certified LPG installer. Contact your Handigas dealer or Afrox Customer Care Centre on 0860 020202.

Where can I find Handigas?

Go to **afroxhandigas.co.za** to find your nearest Afrox Handigas outlet with Handigas in stock. Alternatively, contact the Afrox Customer Service Centre on 0860 020202 for assistance. You can also ask your local Gas & Gear outlet to recommend an authentic Afrox distributor in your area.


handigas

www.afroxshop.co.za

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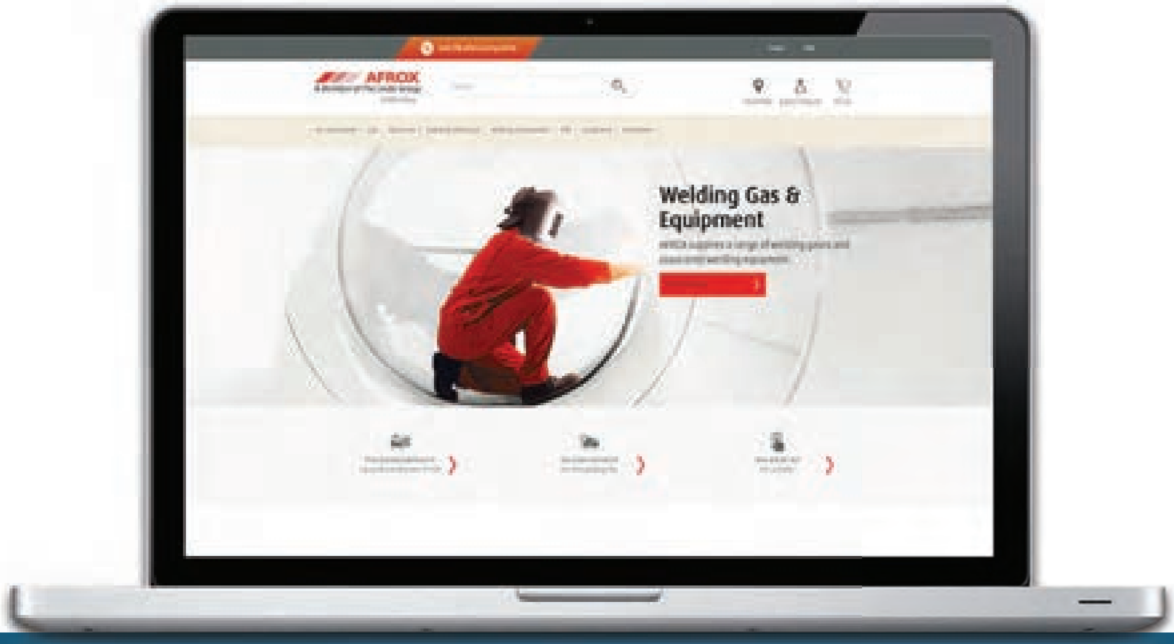

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www.**afroxshop**.co.za

AFROX
A Linde company

HOSPITALITY GASES

6

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HOSPITALITY GASES

As the leading supplier in southern Africa of gases to the hospitality sector, Afrox provides a dedicated gases solution, which includes Handigas for cooking and heating, Suremix for beer and draught dispensing, and the carbonation of soft drink beverages. Partigas (balloon gas) is used for latex and foil balloon inflation and decorative balloon fantasies. Our Sureserve offer provides a comprehensive 'one stop' service unrivalled in the industry and deliveries by highly experienced teams. Our offer is led by sales and service coordinators on one consolidated account. More than a pure dispense gas supplier, Sureserve offers an extensive range of cylinders, equipment technology and added value services, to provide total solutions for the diverse outlets in its market place.

Handigas

A clean burning liquid petroleum gas that provides all energy users with a safe, efficient and economical alternative for a diverse range of cooking and heating applications.

Suremix

A range of carbon dioxide/nitrogen based gases, for the carbonation and dispensing of draught beers, wines and soft drinks. Special mixtures for different lagers, pilsners, ales, stouts and draught beers ensure a perfect pour every time.

Partigas

Afrox balloon gas (helium) that takes special events to new heights. It's the quick, clutter-free promotional tool that is at the heart of a floating balloon fantasy and turns any bare, bleak space into a special occasion.

HANDIGAS

Handigas represents a significant portion of the hospitality service offer to the hospitality sector (hotels, resorts, conferencing centres, restaurants, fast foods, lodges and B&Bs) and is mainly used for cooking and heating. In all major metropoles, Handigas, Suremix and Partigas deliveries are carried out by specialised hospitality sales and service distribution teams, with all other regions in SA being serviced directly or by approved Afrox agents or distributors. Our significant footprint in SA and in neighbouring territories ensures that customers will have access to an Afrox product no matter where they are situated.

Our dedicated sales and customer engineering service teams will also ensure that required installations meet requirements in line with Afrox safety and legislated standards.

For product details on Handigas and propane, refer to section 5 - LPG.

SUREMIX GASES

Carbon Dioxide (CO_2) and CO_2 - Nitrogen (N_2) Mixtures

Applications

- Controlled storage and dispensing of all draught beers such as lagers, ales, pilsners and stouts
- Controlled storage and dispensing of soda fountain soft drinks
- Controlled storage and dispensing of non-carbonated wines and fruit juices
- Afrox recommends the use of particular percentage mixtures in line with the requirements and recommendations of each beverage supplier.

Features	Benefits	Hazards
Colourless and odourless gas	Acts to blanket beers and soft drinks from the atmosphere	CO_2 and N_2 are asphyxiants (do not support life)
CO_2 is soluble in water at moderate temperatures	Acts to maintain equilibrium of the gas content in beverages	CO_2 is toxic in high concentrations
Food grade certification	Provides better control of non-refrigerated beverages	
Approved by beer and soft drink companies	Enhances appearance, aroma and taste	
CO_2 is heavier than air	CO_2 can be added to beverages in controlled conditions to increase soluble levels	
CO_2 is slightly corrosive in the presence of moisture		No hazard

Suremix 100

Gas	Purity
Carbon dioxide	>99,9%
	Food grade

Material Description	Gas Content (kg/ℓ)	Cylinder Size (ℓ)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Suremix 100 large	31,3/20 400	50	6 000	No 8 Male RH	569 SE
Suremix 100 small	5,6/3 500	10	6 000	No 8 Male RH	569 IE

Cylinder colour: White valved guard, ivory body, shoulder and neck
Not all cylinder sizes are available at all Afrox outlets
Please check with your local Afrox branch or dial 0860 020202
MSDS available from www.afrox.com

Suremix 60

Gas	Purity
Carbon dioxide/nitrogen mix	>99,9%
	Food grade

Material Description	Gas Content (kg/ℓ)	Cylinder Size (ℓ)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Suremix 60 large	21,3/14 300	50	20 000	No 3 Female RH-F G5/8"	566 SE
Suremix 60 small	4,4/3 000	10	20 000	No 3 Female RH-F G5/8"	566 IE

Contains 60% CO_2 and 40% nitrogen
Cylinder colour: White valved guard, ivory body, purple shoulder and neck
Not all cylinder sizes are available at all Afrox outlets
Please check with your local Afrox branch or dial 0860 020202
MSDS available from www.afrox.com

Suremix 30

Gas	Purity
Carbon dioxide/nitrogen mix	>99,9%
	Food grade

Material Description	Gas Content (kg/ℓ)	Cylinder Size (ℓ)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Suremix 30 large	12,5/9 600	50	20 000	No 3 Female RH G5/8”	564 SE
Suremix 30 small	2,8/2 100	10	20 000	No 3 Female RH G5/8”	564 IE

Contains 30% CO_2 and 70% nitrogen

Cylinder colour: White valved guard, ivory body, green shoulder and neck

Not all cylinder sizes are available at all Afrox outlets

Please check with your local Afrox branch or dial 0860 020202

MSDS available from www.afrox.com

Suremix N

Gas	Purity
Nitrogen	>99,9%
	Food grade

Material Description	Gas Content (kg/ℓ)	Cylinder Size (ℓ)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Suremix N large	10,9/9 400	50	20 000	G3/4” RH-F	567 SE
Suremix N small	2,2/1 900	10	20 000	G3/4” RH-F	567 IE

Cylinder colour: Ivory body, grey shoulder and neck

Not all cylinder sizes are available at all Afrox outlets

Please check with your local Afrox branch or dial 0860 020202

MSDS available from www.afrox.com

Suremix Regulators

Content	Material Description	Item Number
1	Suremix 60/30 Regulator	W003038
1	Suremix N Regulator	W003038

Note: For Suremix N a nitrogen (G 3/4” RH-F) valve, inlet stem and nut (Item Number W003082) must be fitted

To convert this regulator to CO_2 (Suremix 100), user can purchase kit (Item Number W003067)

Suremix Drinks Calculator

	Item Number	Gas (kg)	Gas (ℓ)	Charges Pressure (kpa)	375 ml Soda Servings	Litres of Soda	Litres of Beer	50 Litre Beer Kegs	Beer g/ℓ	Soda g/ℓ
Suremix 30 (S)	564 IE	2,8	2 100	20 000			450	9	6	
Suremix 60 (S)	566 IE	4,4	3 000	20 000			450	9	10	
Suremix 100 (S)	569 IE	6,4	3 500	6 000	1 324	496	450	9	14	13
Suremix N (S)	567 IE	2,2	1 900	20 000	980	367				6
Suremix 30 (L)	564 SE	12,5	9 600	20 000			2 000	40	6	
Suremix 60 (L)	566 SE	21,3	14 300	20 000			2 000	40	11	
Suremix 100 (L)	569 SE	31,3	20 400	6 000	6 622	2 480	2 000	40	16	13
Suremix N (L)	567 SE	10,9	9 400	20 000	4 851	1 817				6

Average keg pressure @ 2,5 Bar

Beer = 8/9 50 ℓ kegs per Suremix 100 (S) | Soda = 4/5 20 ℓ syrup bags per Suremix 100 (S) (20 X 4 X 6,2)

PARTIGAS

Helium (He)

Gas	Purity
Helium	>99,9%
Impurities - air/methane	<0,9%

Features	Benefits	Hazards
Very low density, second lightest atom, approximately five times lighter than air	Ideally suited for inflating latex and foil balloons	Can cause asphyxiation at high concentrations
Colourless and odourless gas	Does not react with the latex material	
Non-reactive		

Material Description	Gas Content (kg/ℓ)	Cylinder Size (ℓ)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Partigas large	1,51/9 075	50	20 000	G5/8" RH-F No3	528 SE
Partigas medium	0,6/3 600	20	20 000	G5/8" RH-F No3	528 JE
Partigas small	0,13/780	10	20 000	G5/8" RH-F No3	528 UE

Applications

- Due to its non-flammability and very low density, it is ideally suited for filling floating latex and foil balloons
- Small parties
- Weddings and any special events
- Corporate promotions and exhibitions
- Blimp and large volume requirements.

Note: As helium is the second smallest molecule, the gas will penetrate the smallest opening in the balloon

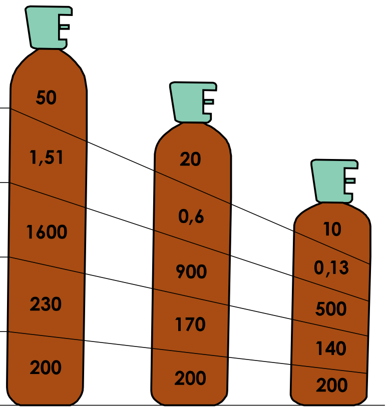
Cylinder colour: Lime green valved guards, brown body, shoulder and neck

All cylinder sizes may not be available from all Afrox outlets, and can be ordered in line with customer requirements.

Please check with your local Afrox branch or dial 0860 020202

Other sized cylinders may also be available on request

MSDS available from www.afrox.com



Cylinder size (ℓ)	50	20	10
Partigas (kg)	1,51	0,6	0,13
Height (mm)	1600	900	500
Diameter (mm)	230	170	140
Pressure (bar)	200	200	200
Size	Large	Medium	Small
Item Number	528-SE	528-JE	528-UE
Cylinder weight (kg)	76	29,6	9
Approximate number of balloons (300 mm)	650	250	50

Balloon Inflator

Content	Material	Description	Item Number
1	Conwin Classic Inflator		W101531
(Also available for short term use available on payment of a refundable deposit)			

Conwin's Classic Inflators are designed for convenience and reliability. The classic line is available with either a Soft-Touch Push Valve or a Flex-Tilt Valve outlet to suit your personal preference. The Soft-Touch Push Valve Extension Tip or Flex-Tilt Valve enables the Classic inflator to inflate latex and foil balloons. Optional pressure gauge measures how much helium is in the cylinder and enables users to calculate the number of balloons that can be inflated.

Manually inflates latex balloons

Place the balloon over the latex outlet and press downward on the Soft-Touch Push Valve until balloon has reached desired size. Use Conwin's Balloon Tying Discs to quickly and easily tie and attach ribbon.

Manually inflates foil balloons

Place the neck of the foil onto extension tip of the Soft-Touch Push Valve and begin inflating. For best results, inflate foil balloons as slowly as possible and remove balloon from the outlet while there are still wrinkles along the seam line. Auto-shut off inflators are available for specific use on foil balloons and these can be imported from our global Linde vendor, with a wide range of other equipment and accessories also available. Please contact the Afrox Product Manager for more information.

The Classic Inflator includes:

- The Balloon Outlet (Soft-Touch Push Valve)
- 1 Pressure Gauge (models available with or without gauge)
- 1 Ribbon Cutter
- 1 Disc Tyer Post

SPECIAL PRODUCTS & CHEMICALS

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Chemicals

Ammonia (NH_3, R-717)

CAS: 7664-41-7 UN: 1005

Characteristics

- Colourless liquefied gas with a penetrating and suffocating odour
- Combustible but hard to ignite.

Health Risks

- Toxic
- Irritates mucous membranes and eyes. High concentrations give rise to cramp in the windpipe and pulmonary oedema
- Good odour warning.

Transport

ADR Class 2, 2TC

DOT Class 2,3

Product Description	Size (kg)	Material Number	Recommended Regulator
Ammonia N3.5	68,0	540201-LH-N	W020120
Ammonia N3.5	1 400,0	540201-TE-C	Recommendation on Request
Ammonia N2.5	Bulk	5374	Recommendation on Request

Standard Specifications		
Ammonia RG (N3.5)	**Refrigerant Grade**	
Purity (%)	>99,95	
Maximum Impurities (ppm)	Moisture Oil	<100 <100
Stability Period (years)	3	
Material Code	540201-LH-N	
Valve	CGA240	
Pressure @ 20°C	8,56 bar	
Cylinder	Low pressure steel	
Mass of Gas in Cylinder	68 kg	
Volume of Gas @ 101,3 kPa (absolute)	93,4 m^3	
Flammability in Air	15 - 27%	
Applications	Refrigeration	
Precautions	Toxic corrosive gas	

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
▲	▲	🟥	●	●	▲	▲	🟥	▲	🟥		●	▲	●	🟥

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Ammonia is manufactured using the Haber-Bosch process, consisting of a direct reaction between hydrogen and nitrogen, in the molar proportions 3:1.

Applications

- Anhydrous ammonia, with the ASHRAE number R-717, is one of the oldest commercial refrigerants known. It is used in both absorption and compression type systems as well as being used in soil fertilisation. In soil fertilisation, it is used in the form of ammonia, ammonia salts, nitrates and urea. It is also added to fertilisers containing superphosphates and in making nitrogen containing solutions which consist of ammonia and ammonium nitrate or urea, or both in water. Anhydrous ammonia is also used in combination with chlorine to purify municipal and industrial water supplies.
- Ammonia, or rather dissociated ammonia, is used in such metal treating operations as nitriding, carbo-nitriding, bright annealing, furnace brazing, sintering, sodium hydride descaling, atomic hydrogen welding and other applications where protective atmospheres are required. It is used in extracting such metals as copper, nickel and molybdenum from their ores. It is also used to reduce atmosphere in heat treatment of metals and for the fabrication of silicium nitride.
- Dissociated ammonia is also used as a convenient source of hydrogen for the hydrogenation of fats and oils. Through the controlled combustion of dissociated ammonia in air, a source of pure nitrogen is achieved.
- The petroleum industry utilises anhydrous ammonia in neutralising the acid constituents of crude oil and in protecting equipment such as bubble plate towers, heat exchangers, condensers, and storage tanks from corrosion.
- High purity ammonia can be oxidising to nitric oxide which is converted to nitrogen dioxide to ultimately furnish nitric acid (Ostwald process); in the lead chamber process for manufacturing sulphuric acid, ammonia is oxidised to nitrogen oxides which are needed to convert sulphur dioxide to sulphuric acid. Most industrial and military explosives of the conventional types contain nitrogen and ammonia is the basic source of nitrogen in their manufacturing. Ammonia is used in the production of hydrogen cyanide.
- As a processing agent, ammonia is used in the manufacturing of alkalis, ammonium salts, dyes, pharmaceuticals, cuprammonium rayon, and nylon.
- A diluted solution of ammonia in water is used as a common household cleansing agent. More concentrated forms are used extensively as chemical reagents.
- A recent development is the substitution of ammonia for calcium in the bisulphite pulping of wood. This improves the yield and quality of the pulp. Ammonia is also used as a solvent for casein in the coating of paper.
- Ammonia is used in the rubber industry for stabilisation of raw latex to prevent coagulation during transportation and storage.
- Ammonia is used as a catalyst in the phenol-formaldehyde condensation and also in the urea-formaldehyde condensation to make synthetic resin.
- Ammonia is a reagent in copying machines (blue print and micro film).
- Ammonia is also used to produce proteins and can be used to improve the protein content of low quality hay.
- Ammonia is used as a component in calibration gas mixtures for gas detection systems as well as environmental emission monitoring.
- Ammonia is widely used in the semiconductor industry.
- Ammonia is used in the production of blue and white LEDs (Light Emitting Diodes).
- Ammonia can be used to neutralise nitric oxides emitted by diesel engines by selective catalytic reduction.

Carbon Monoxide (CO)


Toxic


Extremely Flammable

CAS: 630-08-0 UN: 1016

Characteristics

- Flammable
- Odourless and colourless gas.

Health Risks

- Toxic. Binds itself to the haemoglobin in the blood
- A headache is usually the first shown symptom.

Transport

ADR Class 2, 2A

DOT Class 2,2

Product Description	Size (kg)	Material Number	Recommended Regulator
Carbon Monoxide (Non-petrochemical)	9,0	540303-NE-C	W019120 or W019220

Other purities available to N5.5 on request

Standard Specifications		
Non-petrochemical source		
Purity (N2.5) (%)	≥99,5	
Maximum Impurities (ppm)	Oxygen and argon Hydrogen Water Nitrogen Other impurities	≤30 VPM ≤10 VPM ≤5 VPM ≤4 000 VPM ≤5 VPM
Stability Period (years)	5	
Material Code	540303-NE-C	
Valve	5/8” BSP LH female	
Pressure	150 bar	
Cylinder	40 ℓ aluminium	
Mass of Gas in Cylinder	9 kg	
Volume of Gas @ 101,3 kPa (absolute)	7,56 m^3	
Flammability in Air	12,5 - 74%	

Physical Data	
Molecular Weight	28,01
Boiling Point at 1,013 bar [°C]	-191,45
Boiling Point at 14,5 psi [°F]	-312,59
Density at 1,013 bar, 20°C [kg/m³]	1,165
Density at 1 atm, 70°F [lb/ft³]	0,072
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Vapour Pressure at 32°F [psi]	-
Vapour Pressure at 70°F [psi]	-
Flammability Range in Air [% volume]	12,5 - 74,0
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,859
Specific Volume at 1 atm, 70°F [ft³/lb]	13,9

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	▲	●	■	▲	●	●	●	▲	●	▲	▲	●	●	■

Legend: ● Good ▲ Fair ■ Avoid

Source

The most common carbon monoxide production plants are 'reformers' in which natural gas and steam react together to produce CO together with hydrogen. However, there are also many other production techniques such as incomplete combustion of natural gas and, for smaller quantities, the dehydration of formic acid using either sulphuric or phosphoric acids.

Applications

- The largest use of carbon monoxide is in the chemical industry where it is used in the synthesis of a wide variety of chemicals such as esters, ketones, aldehydes and glycols as well as for the production of phosgene, a common chemical intermediate.
- Some types of electronic components, such as reed relay switches, are encapsulated in a glass enclosure which is sealed by direct heating with a flame. In these cases, it is important that no water is produced in the flame as this would be sealed in the enclosure and lead to failure of the component. Hydrogen and hydrocarbon fuels are therefore not suitable and carbon monoxide is used.
- Atmospheres containing carbon monoxide are used to preserve fruit and vegetables during storage and shipment. The carbon monoxide provides a reducing atmosphere which inhibits the growth of organisms and the action of enzymes.
- Carbon monoxide is used in relatively large quantities and in a variety of ways in the primary metals industry: as a chemical reducing agent for the recovery of metals from ores; in the purification of aluminium waste; and in the

manufacture of metal carbonyls for conversion by thermal decomposition into high purity powdered metals.

- Carbon monoxide also serves for the production and regeneration of catalysts such as nickel carbonyl.
- Carbon monoxide is also used in both organic and inorganic chemical synthesis.
- Carbon monoxide is a component in gas mixtures for lung diffusion.
- Carbon monoxide is a component in laser gas mixtures.
- Carbon monoxide is a component in calibration gas mixtures.
- A necessity in the production of solar cells is super clean silicium, that is produced with the aid of carbon monoxide.
- Carbon monoxide is used as fuel in fuel cells.

Ethylene (C_2H_4, Ethene, R-1150)

Extremely Flammable

CAS: 74-85-1 UN: 1962

Characteristics

- Flammable
- Colourless gas with slight odour.

Health Risks

- Asphyxiant at high concentrations.

Transport

ADR Class 2, 2F

DOT Class 2,1

Product Description	Size (kg)	Material Number	Recommended Regulator
Ethylene N2.5	16,7	804450-SO-A	W019120 or W019220

Other purities available to N5.5 on request

Standard Specifications		
Ethylene (N2.5)		
Purity (%)	>99,5	
Maximum Impurities (ppm)	Other Hydrocarbons CO CO_2 O_2 H_2O Nitrogen	<4 000 <5 <15 <25 <5 <100
Stability Period (years)	5	
Material Code	804450-SO-A	
Valve	5/8" BSP LH female	
Pressure	91,1 bar	
Cylinder	50 ℓ WC CrMo steel cylinder	
Mass of Gas in Cylinder	16,7 kg	
Volume of Gas @ 101,3 kPa (absolute)	14,0 m^3	
Flammability in Air	3,1 - 32%	
Applications	Polymer manufacture	
Precautions	Flammable gas under pressure	

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	▲	●	●	●	●	●	●	▲	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Ethylene is produced by passing ethyl alcohol vapours over dehydrating catalysts at 360 - 470°C.
- It may also be produced by the pyrolysis of ethane.
- Cracking of petroleum is another source.

Applications

- Ethylene is the starting material for several industrial syntheses. It is employed as an intermediate in the chemical industry and for the production of plastics.
- Ethylene is employed for the production of:

  - Acetaldehyde

  - Acetic acid

  - Chloroethane

  - Chloroethene (vinyl chloride)

  - Dichloroethane

  - 1,1-dichloroethene (vinylidene chloride)

  - Epoxyethane (ethylene oxide)

  - Ethanediol (ethylene glycol)

  - Ethanol

  - Ethoxyethane

  - Ethyl benzene

  - Phenylethene (styrene)

  - Polychloroethene (polyvinyl chloride)

  - Polythene

  - Propanoic acid

  - Tetraethyl lead

  - Trichloroethane.
- Ethylene is used as a component in calibration gases for the automotive, gas, oil as well as the chemical industries.
- Ethylene supplied in cylinders is used for controlled ripening of fruit, especially bananas. A concentration of a few ppm in the warehouse atmosphere is used. Because of flammability considerations, it is strongly recommended to use a mixture of ethene in nitrogen in this application. (see ‘Ripegas’)
- Ethylene has also been used in agriculture to promote crop growth. In this case the gas is injected directly into the soil.
- It is used as a refrigerant especially in the petrochemical industry. It has the ASHRAE number R-1150.

Hydrogen Chloride (HCl)


Toxic

Corrosive

CAS: 7647-01-0 UN: 1050

Characteristics

- Colourless, liquefied gas with pungent odour
- Forms white fumes in humid air
- Corrosive in humid conditions.

Health Risks

- Highly corrosive
- Attacks the eyes and the mucous membranes
- Causes lung damage
- Good odour warning.

Transport

ADR Class 2, 2TC

DOT Class 2,3

Product Description	Size (kg)	Material Number	Recommended Regulator
Hydrogen Chloride N2.5	50,0	541801-SO-C	Recommendation on Request

Standard Specifications		
Hydrogen Chloride N2.5		
Purity (%)	>99,5 (weight)	
Impurities (ppm)	Inert gases* Chlorine Chlorinated hydrocarbons Water	<2 000 <10 <10 <10
	* H_2, N_2, O_2, Ar, CO_2, CO, CH_4	

The specifications refer to the liquid phase.

Physical Data	
Molecular Weight	36,461
Boiling Point at 1,013 bar [°C]	-85,1
Boiling Point at 14,5psi [°F]	-120,98
Density at 1,013 bar, 20°C [kg/m³]	1,526
Density at 1 atm, 70°F [lb/ft³]	0,095
Vapour Pressure at 0°C [bar]	25,6
Vapour Pressure at 20°C [bar]	42,02
Vapour Pressure at 32°F [psi]	371,1
Vapour Pressure at 70°F [psi]	625,37
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,655
Specific Volume at 1 atm, 70°F [ft³/lb]	10,5

Valve outlet size will be specified on quote and is not standard but dependant on Linde country of origin

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
🟥	🟥	🟥	🟥	▲	🟥	▲	▲	🟥	🟥	●	▲	●	▲	▲

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Hydrogen chloride is normally prepared in commercial quantities by the direct combination of chlorine and hydrogen. This is achieved by 'burning' chlorine in an atmosphere of hydrogen. Most of the hydrogen chloride produced in this way is normally dissolved directly in water to produce hydrochloric acid, but some companies collect the anhydrous hydrogen chloride.

Applications

- Hydrogen chloride is used to remove the remaining fibres from cotton seeds after the cotton wool has been separated and before the seed is stored for resowing the following season.
- Hydrogen chloride is used to separate cotton from wool.
- Hydrogen chloride is used in the manufacture of inorganic chlorides.
- Hydrogen chloride is used as the chlorine donor in excimer lasers.
- Hydrogen chloride is used to promote and regenerate catalysts in the petrochemical industry, and to add viscosity to oils.
- Hydrogen chloride is used for hydrochlorinations (e.g. production of chloromethane) and oxychlorinations (e.g. production of chloroethene). It is also used to produce chlorosulphonic acid and synthetic rubbers.
- Hydrogen chloride is used as a thermal etchant to remove material from unmasked areas and to prepare wafer surfaces for epitaxial deposition.
- High purity hydrogen chloride gas is widely used in the electronics industry. It is a chlorine carrier produced by high temperature cracking. It is used in the following applications:
  - Scouring furnaces (quartz chambers)
  - Dissolved in water as aqueous cleaning agent to prepare metal surfaces for electro-plating
  - Selective etching of windows in electronic microcircuits
  - Carrier for non-volatile elements in the form of gaseous chloride.
- Hydrogen chloride is used in pharmaceutical synthesis.
- Hydrogen chloride is also used for production of hard metals.

Hydrogen Sulphide (H_2S)

CAS: 7783-06-4 UN: 1053

Characteristics

- Flammable
- Extremely offensive odour, liquefied gas.

Health Risks

- Highly toxic
- Causes headaches, nausea, diarrhoea, and respiratory paralysis
- Warning! The sense of smell is fatigued quickly.

ADR Class 2, 2TF

DOT Class 2,3

Product Description	Size (kg)	Material Number	Recommended Regulator
Hydrogen Sulphide N2.5	63,0	542601-LF-C	Recommendation on Request

Not a stock item. Various purities available on request.

Standard Specifications		
Hydrogen Sulphide		
Purity (%)	>99,5 (vol)	
Impurities (ppm)	Carbon oxide sulphide Methane	<3 000 (vol.) <500 (vol.)

The specifications refer to the liquid phase.

Physical Data	
Molecular Weight	34,082
Boiling Point at 1,013 bar [°C]	-60,35
Boiling Point at 14,5psi [°F]	-76,61
Density at 1,013 bar, 20°C [kg/m³]	1,426
Density at 1 atm, 70°F [lb/ft³]	0,089
Vapour Pressure at 0°C [bar]	10,64
Vapour Pressure at 20°C [bar]	18,40
Vapour Pressure at 32°F [psi]	154,40
Vapour Pressure at 70°F [psi]	274,52
Flammability Range in Air [% volume]	4,0 - 44,0
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,701
Specific Volume at 1 atm, 70°F [ft³/lb]	11,2
Valve Connection	G5/8" LH-F BS341 No. 4

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
▲	■	▲	▲	▲	▲	●	●	■	●	▲	▲	▲	●	■

Legend: ● Good ▲ Fair ■ Avoid

Source

- Hydrogen sulphide occurs as a by-product from many chemical processes. It is an off-gas in the production of viscose rayon, synthetic rubber, various petroleum products, dyes and leather processing.
- It can also be manufactured by treatment of many metallic sulphides with a mineral acid such as hydrochloric or sulphuric acid.

Applications

- Small quantities of hydrogen sulphide are used as a dopant for indium phosphide and gallium arsenide semiconductors, and as a precursor for the growth of zinc sulphide semiconductors.
- Hydrogen sulphide is used for metal separation, removal of metallic sulphides. In hot wire galvanising it is used in conjunction with natural gas to speed up the galvanising process.
- Hydrogen sulphide is used to regenerate certain types of catalyst used in the petrochemical industry.
- Hydrogen sulphide is used in calibration mixtures for the petrochemical industry.
- Hydrogen sulphide is used in mixtures for emission control applications.
- Hydrogen sulphide is used as an analytical reagent in chemical analysis.
- Hydrogen sulphide is used for preparation of phosphors, oil additives and for production of additives for high pressure lubricants and cutting oils.
- Hydrogen sulphide is used in the chemical industry for production of sulphurated compounds, as mercaptans, sulphides, etc.
- Hydrogen sulphide is also used as a solvent and as an odorant in town gas.
- Hydrogen sulphide is used in the separation of heavy water, from normal water with some nuclear power stations.
- Hydrogen sulphide is used for surface treatment of metals.

Methane (CH_4, R-50)


Extremely Flammable

CAS: 74-82-8 UN: 1971

Characteristics

- Flammable
- Colourless and odourless gas.

Health Risks

- Asphyxiant at high concentrations.

Transport

ADR Class 2,1F

DOT Class 2,1

Product Description	Size (kg)	Material Number	Recommended Regulator
Methane N3.5	8,1	541403-SE-C	W019120 or W019220

Other purities available to N5.5 on request

Standard Specifications		
Methane (N3.5)		
Purity (%)	>99,95	
Maximum Impurities (ppm)	Nitrogen	<100
	Oxygen	<20
	Ethane	<300
	Ethylene	<10
	Other HC	<20
	Water	<20
	Carbon dioxide	<50
Material Code	541403-SE-C	
Valve	G5/8” LH-F BS341 No. 4	
Pressure	200 bar	
Cylinder	50 ℓ WC CrMo steel cylinder	
Mass of Gas in Cylinder	8,1 kg	
Volume of Gas @ 101,3 kPa (absolute)	12,94 m^3	
Flammability in Air	5 - 15%	
Applications	Laboratory synthesis of chemicals	
Precautions	Flammable	

Physical Data	
Molecular Weight	16,043
Boiling Point at 1,013 bar [°C]	-161,49
Boiling Point at 14,5psi [°F]	-258,66
Density at 1,013 bar, 20°C [kg/m³]	0,668
Density at 1 atm, 70°F [lb/ft³]	0,042
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Vapour Pressure at 32°F [psi]	-
Vapour Pressure at 70°F [psi]	-
Flammability Range in Air [% volume]	5,0 - 15,0
Specific Volume at 1,013 bar, 20°C [m³/kg]	1,496
Specific Volume at 1 atm, 70°F [ft³/lb]	23,8

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	■	●	●	●	●	●	●	▲	●	●	●	●

Legend: ● Good ▲ Fair ■ Avoid

Source

- Methane is the principal constituent of natural gas (typically natural gas is 87% methane). It is therefore commonly produced by purifying gas.
- Pure methane may also be obtained from the cracking of petroleum fractions.

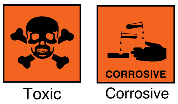
Applications

- Methane is used as a heating fuel for domestic purposes and above all for industrial heating:
  - In the steel industry, with open hearth furnaces, in the presence of fuel oil, and in reheating furnaces for semi-products prior to rolling or forging, oxy-cutting of metal, for heat treatment of non-ferrous metals and supply to infrared heating elements used for surface treatment
  - In thermal power plants
  - In glass making, annealing kilns for pharmaceutical ampoules, ceramic kilns
  - In the textile industry
  - In the chemical industry, petrochemical furnaces, heating of tanks containing resins for paints, vulcanisation of plastics
  - In food and farm industries, coffee roasting ovens, malt drying in breweries, dehydration of plant fodder, powdered milk production
  - In cement plants
  - In paper mills.
- Methane was employed in the gas batteries used by the Apollo space missions.
- High purity methane is used as a fuel gas in flame photometers.
- When mixed with argon or xenon, methane is used as a gas filling for proportional counters and other types of radiation detectors.
- As natural gas, it is also used as fuel for vehicles.
- In the chemical field, methane serves as a raw material for the production of methanol, synthetic ammonia, acetylene, carbon black, carbon disulphide, hydrocyanic acid, chloromethane, methylene chloride, carbon tetrachloride and chloroform.
- In the steel industry, natural gas is used for direct reduction of powdered minerals, and to produce hard metal.
- Methane finds extensive use in various mixtures for quality control laboratories in the petrochemical and fuel gas industries.
- Methane is used in gas cooled nuclear reactors. The methane is used to dope the carbon dioxide coolant in order to prevent erosion of the carbon control rods in the nuclear core.
- Methane is used for efficiency testing of gas burners and engines.
- Methane is also used in synthetic town gas mixtures.
- Methane mixtures are commonly used for calibrations in the automotive industry and in the environmental field.
- Methane mixed with argon is used as make-up gas in electro-chemical detectors (EC detectors).

Note:

Methane is controlled under the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Sulphur Dioxide (SO_2)



CAS: 7446-09-5 UN: 1079

Characteristics

- Colourless, liquefied gas with pungent odour
- Dry gas is not corrosive.

Health Risks

- Toxic
- Irritates the eyes and respiratory passages
- 50 - 100 ppm is considered to be the maximum permissible concentration for exposures of 30 - 60 min
- Normally the odour is detected at 3 ppm, by taste at 0,7 ppm.

Transport

ADR Class 2, 2TC

DOT Class 2,3

Product Description	Size (kg)	Material Number	Recommended Regulator
Sulphur Dioxide N3.0	78,0	540901-LJ-N	W020121
Sulphur Dioxide N3.0	1 000,0	540901-TB-N	Recommendation on Request
Sulphur Dioxide (Afrox owned)	75,0	540902-LJ-N	Recommendation on Request
ISO Container		5409	

Standard Specifications

Sulphur Dioxide (78 kg) 540901-LJ-N

Purity (%)	>99,9	
Maximum Impurities (ppm) Mass/mass	Specification. Oil	<100
	Residue	<100
	Sulphuric acid	<100
	Arsenic	<3
	Lead	<10
	Zinc	<25
	Copper and zinc	<50
	Selenium	<10
Material Code	540901-LJ-N	
Valve	CGA240 modified	
Pressure	3,36 bar @ 20°C	
Cylinder	Low pressure steel	
Mass of Gas in Cylinder	78 kg	
Volume of Gas @ 101,3 kPa (absolute)	28,3 m^3	
Flammability in Air	Not flammable	
Applications	Wine and juice preservative	
Precautions	Toxic and corrosive gas	

Standard Specifications		
Sulphur Dioxide (75 kg Afrox owned) 540902-LJ-C		
Purity (%)	>99,9	
Maximum Impurities (ppm) Mass/mass	Specification. Oil Residue Sulphuric acid Arsenic Lead Zinc Copper and zinc Selenium	<100 <100 <100 <3 <10 <25 <50 <10
Material Code	540902-LJ-C	
Valve	Liquid: CGA 240 Vapour: BS 341 No.10 (G$^1/_2$”)	
Pressure	3,36 bar @ 20°C	
Cylinder	Low pressure steel	
Mass of Gas in Cylinder	75 kg	
Volume of Gas @ 101,3 kPa (absolute)	27,2 m^3	
Flammability in Air	Not flammable	
Applications	Wine and juice preservative	
Precautions	Toxic and corrosive gas	

Physical Data	
Molecular Weight	64,065
Boiling Point at 1,013 bar [°C]	-10,02
Boiling Point at 14,5 psi [°F]	13,98
Density at 1,013 bar, 20°C [kg/m^3]	2,712
Density at 1 atm, 70°F [lb/ft^3]	0,169
Vapour Pressure at 0°C [bar]	1,55
Vapour Pressure at 20°C [bar]	3,36
Vapour Pressure at 32°F [psi]	22,51
Vapour Pressure at 70°F [psi]	50,67
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m^3/kg]	0,368
Specific Volume at 1 atm, 70°F [ft^3/lb]	5,92

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
▲	■	▲		▲	▲	●	▲	■	■	●	▲	●	●	■

Legend: ● Good ▲ Fair ■ Avoid

Source

- Sulphur dioxide may be produced by a variety of routes, such as the combustion of sulphur or pyrites; alternatively, as a by-product of smelter operations.
- It can also be prepared by the reaction of an acid on a metallic sulphide, or by the action of sulphuric acid directly on a metal such as copper.

Applications

- Sulphur dioxide is used in the manufacture of sulphite, hydrogen sulphites and sulphuric acid.
- Sulphur dioxide is used in magnesium foundries as protection gas (an alternative to SF_6).
- Sulphur dioxide is used as a bleaching agent particularly for certain types of dried food, and also to bleach glue, elation, sugar, textiles, fats and oils.
- Sulphur dioxide is used to sterilise wine and beer making equipment in order to inhibit the growth of moulds and bacteria, and control wine fermentation. Sulphur dioxide may be used in a variety of disinfecting and fumigation applications.

- Sulphur dioxide is used as a component in environmental calibration gases.
- Sulphur dioxide is used in gas mixtures for car emission monitoring.
- Sulphur dioxide is also used in the float glass manufacturing process.
- Sulphur dioxide may be used:

  - As a refrigerant
  - In laboratory research on corrosion problems
  - To remove excess chlorine in textile bleaching and water treatment
  - In preparation of chrome leather tanning
  - As solvent.

Sulphur Hexafluoride (SF_6)

Environmental Hazard

CAS: 2551-62-4 UN: 1080

Characteristics

- Colourless and odourless gas.

Health Risks

- Asphyxiant at high concentrations.

Transport

ADR Class 2, 2A

DOT Class 2,2

Product Description	Size (kg)	Material Number	Recommended Regulator
Sulphur Hexafluoride N3.0	9,0	541601-IE-C	W019141 or W019241
Sulphur Hexafluoride N3.0	20,0	541602-SE-C	W019141 or W019241
Sulphur Hexafluoride N3.0	50,0	541601-SE-C	W019141 or W019241

Standard Specifications		
Sulphur Hexafluoride		
Purity (%)	>99,9	
Maximum Impurities (ppm)	Air	<2500
	Carbon tetrafluoride	<1000
	Moisture	<120
	Mineral oil	<10
	Acidity, in terms of HF	<0.3
	Hydrolysable fluorides in terms of HF	<1
Stability Period (years)	5	
Material Code	541601-SE-C	
Valve	5,8” RH male BS 341-6	
Pressure	21,61 bar	
Cylinder	50 ℓ WC CrMo steel 230 mm x 1 665 mm 70 kg empty	
Mass of Gas in Cylinder	50 kg	
Volume of Gas @ 101,3 kPa (absolute)	7,99 m^3	
Flammability in Air	Not flammable	
Applications	Electrical insulating gas in high voltage switchgear	
Precautions	Asphyxiant	

Physical Data	
Molecular Weight	146,06
Boiling Point at 1,013 bar [°C]	-63,9
Boiling Point at 14,5 psi [°F]	-83,0
Density at 1,013 bar, 20°C [kg/m^3]	6,154
Density at 1 atm, 70°F [lb/ft^3]	0,382
Vapour Pressure at 0°C [bar]	12,90
Vapour Pressure at 20°C [bar]	21,60
Vapour Pressure at 32°F [psi]	187,2
Vapour Pressure at 70°F [psi]	321,70
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m^3/kg]	0,543
Specific Volume at 1 atm, 70°F [ft^3/lb]	8,772

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Sulphur hexafluoride is manufactured by direct fluorination of pure (elemental) sulphur, generally by companies who produce fluorine for other purposes such as the production of fluorocarbons.

Applications

- One of the principal uses of sulphur hexafluoride is as an insulating medium in circuit breakers, switch gear, power substations and gas insulated transmission lines. For these applications, the gas used must meet or exceed ASTM D2472 and IEC specifications.
- Sulphur hexafluoride is used as a plasma etching gas.
- Sulphur hexafluoride is often used as a filling gas in double glazing as it reduces the sound transmission and the heat transfer.
- Certain HF/DF chemical lasers use sulphur hexafluoride as the fluorine source. This type of laser is used mainly in R&D applications.
- As sulphur hexafluoride is both inert and considerably denser than air, it is suitable for blanketing open baths of certain molten metals, particularly magnesium.
- Sulphur hexafluoride is used in laboratories as a carrier gas media in supercritical fluid chromatography (SFC), and as media in supercritical fluid extraction (SFE) for sample preparation.
- Sulphur hexafluoride is being used for medical purposes such as a contrasting agent for ultrasound examinations, and in retinal surgery.
- Sulphur hexafluoride is used in a wide variety of applications as a leak detection gas. Examples of this application are aluminium beer barrels, water supply pipelines, and various aircraft and automobile parts.
- Sulphur hexafluoride is also used:
  - As filling in loudspeakers
  - In eye surgery
  - As tyre filling gas.

Note:

Sulphur hexafluoride is controlled under the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

FoodFresh™

All food is subject to deterioration. This means loss of flavour, loss of colour and microbial spoilage. These effects can be retarded and shelf-life extended dramatically, by use of Modified Atmosphere Packaging (MAP). No artificial preservatives or freezing is neccesary.

Food spoilage is usually the result of bacterial action, oxidation, enzyme action, mould growth or the accumulation of metabolic by-products. MAP employs the properties of specific gases or gas mixtures to slow down those decay mechanisms that have the dominant effect on packaged food products.

Customers prefer natural products and quality appearance, where juices and aromas have been sealed in. The benefits of extended shelf-life and cost saving make MAP a very economical option giving you a competitive advantage.

Afrox has developed an extensive range of MAP gases, called FoodFresh™. FoodFresh™ fulfils the requirements of quality assurance, hygiene and freshness demanded by the food industry. It is supplied in dedicated high capacity, high pressure steel cylinders, and the certificate of compliance is your guarantee of quality.

All FoodFresh™ items are also FSSC 22000 certified which deems it safe for human consumption.

Product Description	**Product Mass (kg)**	**Filling Pressure (bar)**	**Use For**	**Material Number**	**Valve Connection**	**Recommended Regulator**	**O_2**	**CO_2**	**N_2**
FoodFresh™ 1	31,3	-	Sparkling Water Poultry (Raw)	518701-SE-C	5/8" BSP RH Ext	W019140 or W019240	-	100	-
FoodFresh™ 1 PCC	175	-	Sparkling Water	518701-PA-C	5/8" BSP RH Ext	W019140 or W019240	-	100	-
FoodFresh™ 2	11,0	200	Fats and Oils Pasta (Dry) Dried Products (Milk powder & snacks)	518702-SE-C	3/4" BSP RH Int	W019130 or W019230	-	-	100
FoodFresh™ 2 PCC	120	-	Fats and Oils Pasta (Dry)	518702-PA-C	3/4" BSP RH Int	W019130 or W019230	-	-	100
FoodFresh™ 4	12,69	200	Blanched Vegetables Fresh Fruit & Vegetables Salads (Non-meat containing)	518704-SE-C	5/8" BSP RH Int	W019110 or W019210	-	15	85
FoodFresh™ 5	13,37	200	Cheese (Soft) Meat (Cured, cooked, uncooked & smoked meat. Pork - fresh) Confectionary (Bread-type)	518705-SE-C	5/8" BSP RH Int	W019110 or W019210	-	20	80
FoodFresh™ 7	14,9	200	Cheese (Soft) Meat (Loaf-type speciality meat) Meat (Cooked) Biltong Poultry (Cured/ smoked, cooked) Fish (Cooked) Shellfish (Cooked) Cooked-chilled or Ready Meals Confectionary (Meat filled) Salads (Meat containing) Salami	518707-SE-C	5/8" BSP RH Int	W019110 or W019210	-	30	70

Product Description	Product Mass (kg)	Filling Pressure (bar)	Use For	Material Number	Valve Connection	Recommended Regulator	O_2	CO_2	N_2
FoodFresh™ 9	9,1	100	Cheese (Hard) Fish (Oily) Pasta Pizza Ready Meals Cakes Smoked Fish	518709-SE-C	5/8" BSP RH Int	W019110 or W019210	-	50	50
FoodFresh™ 22	15,0	200	Red Meat Fresh Sausage Mutton (Raw)	518722-SE-C	5/8" BSP RH Int	W019110 or W019210	80	20	-
FoodFresh™ 24	12,8	200	Fresh Fruit & Vegetable Salads (Non-meat containing) Lettuce	518724-SE-C	5/8" BSP RH Int	W019110 or W019210	5	15	80

HiQ Life Science Range

Afrox has introduced further analytical criteria and all HiQ Life Science gases are not only analysed for accuracy of composition but from now on also for harmful impurities such as sulphur dioxide, nitric oxide and volatile organic compounds. HiQ Life Science gases are exclusively available from Afrox and are several custom blended (made to order) specialty gas mixtures that assist in fertility treatment, clinical blood and pulmonary function testing, and anaerobic and aerobic specialty gas mixtures used to maintain biological atmospheres in incubators for cell culture growth.

A Certificate of Analysis is provided for each mixture which provides details on the analysis results, adding additional certainty that the mixture will not be harmful to life in its required application.

Material Number	Product Description	Size (kg)	Recommended Regulator	Valve Connection	O_2	CO_2	N_2	CH_4	CO
590001-RC-A	HiQ LS 1	8,563	W019210	RH INT 5/8" BSP	5%	6%	89%		
590002-NE-A	HiQ LS 2	7,118	W019220	LH INT 5/8" BSP	21%		78,40%	0,30%	0,30%
590003-RC-A	HiQ LS 3	8,676	W019210	RH INT 5/8" BSP	5%	7,44%	87,56%		
590004-RC-A	HiQ LS 4	8,657	W019211	RH INT 5/8" BSP	5%	7,20%	87,80%		
590005-RC-A	HiQ LS 5	8,485	W019212	RH INT 5/8" BSP	5%	5%	90%		

Helium

Helium (He, R-704)

CAS: 7440-59-7 EC: 231-168-5 UN: 1046 (Compressed); 1963 (Refrigerated liquid)

Helium Baseline 5.0				
Purity (%)	≥ 99,999			
Impurities (ppm)	O_2 ≤ 2	N_2 ≤ 5	C_nH_m ≤ 0,5	H_2O ≤ 3
Typical Filling Pressure	20°C: 200 bar(a)			

Helium NF3				
Purity (%)	≥ 99,999			
Impurities (ppm)	O_2 ≤ 3	N_2 ≤ 5	C_nH_m ≤ 0,5	H_2O ≤ 0,5
Typical Filling Pressure	20°C: 200 bar(a)			

Helium is a unique product with many applications in various sectors. The unique cryogenic properties (boiling point -269°C), small molecules and inert nature, lends it to very specific uses. Afrox supplies various grades of helium, from ultra-high purity liquid helium for medical use, to technical grade and Partigas.

Characteristics

- Colourless and odourless gas
- Non-reactive.

Health Risks

- Asphyxiant at high concentrations.

Transport

ADR Class 2, 1 A

DOT Class 2,2

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Helium Baseline 5.0	0,30	Instrument Grade	524103-IE-C	5/8" BSP RH Int	W019110 or W019210
Helium Baseline 5.0	1,51	Instrument Grade	524203-SE-C	5/8" BSP RH Int	W019110 or W019210
Helium NF3	1,51	NF3 Grade	524206-SE-A	5/8" BSP RH Int	W019110 or W019210
Helium HP N4.5	1,51	High Purity	524102-SE-C	5/8" BSP RH Int	W019110 or W019210
Helium Tech N2.7	1,51	Technical	524101-SE-C	5/8" BSP RH Int	W019110 or W019210
Helium Tech MCP N2.7	22,65	Technical	524101-ME-C	5/8" BSP RH Int	W019110 or W019210
Liquid Helium	Bulk	Ultra-high Purity	5222-PC	5/8" BSP RH Int	No Regulator Required

Physical Data	
Molecular Weight	4,003
Boiling Point at 1,013 bar [°C]	-268,93
Density at 1,013 bar, 20°C [kg/m^3]	0,166
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m^3/kg]	6,024

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- The primary source of helium is from natural gas wells. It is obtained by a liquefaction and stripping operation.

Applications

- Helium is inert and the least soluble of all gases in liquids and is therefore used as a pressurisation gas for:
    - Cryogenic rocket propellants in space/missile applications
    - Heavy water in nuclear reactors
    - For all liquids at room or low temperatures.
- Being inert, helium is used as a constituent in neutral atmospheres, e.g. in heat treatment applications requiring a protective atmosphere.
- Helium is used extensively in the welding industry as an inert shielding gas for arc welding. It is also used in conjunction with helium ('leak') detectors to test the integrity of fabricated components and systems.
- Helium is used as a combined cooling and shielding medium for the pulling of optical fibres.
- Helium is used for cooling of uranium rods in nuclear reactors.
- Helium is used in various types of gas lasers as a buffer or carrier gas.
- Gas mixtures of helium and hydrocarbons are also used as fill gases for nuclear counters.
- Helium is used in mixtures with neon and argon for filling electronic tubes such as the familiar neon sign.
- Various mixtures of helium and oxygen are used as breathing gases for divers who must work at great depths and therefore high pressures. The use of helium to dilute the oxygen instead of nitrogen, as in air, prevents nitrogen being dissolved in the blood, which is the cause of nitrogen narcosis (also known as 'bends').
- Helium is used to fill large balloons for upper atmosphere and cosmic ray studies. Small helium balloons are used by weather forecasters to carry meteorological instruments.
- Due to non-flammability and low density, it is ideal for filling toy balloons (in mixtures with nitrogen), airplane tyres, advertising blimps and geostationary balloons (certain projects are under way for the realisation of balloons designed to serve as television transmission and observation relays).
- Helium mixtures with hydrocarbons are used in flushing Geiger counters used for the detection of α, β, γ and X-rays.
- Helium is used as a propellant in the 'helium cannon' used in model firing tunnels. It also finds use as a working gas in some hypersonic wind tunnels.
- Helium is used as a carrier gas or as a purge gas for a variety of semiconductor processes.
- Helium is used as a calibration gas and a balance gas in calibration mixtures. It is also used as carrier gas in gas chromatography. It is used as a purge gas and a zero (span) gas for analytical instruments.
- Helium is used for epitaxial crystal growth (inert atmosphere).
- Helium is also used for vacuum breaking in heat treatment furnaces.
- Helium is also used as airbag inflating gas in high pressure capsules.
- Helium is used to create inert furnace atmospheres in special glass processing, and processing of valuable metals.
- Helium is used for degassing in high performance liquid chromatography (HPLC).
- Liquid helium is used to cool the superconductive magnets in NMR (Nuclear Magnetic Resonance) for analytical or medical purposes and in the R&D to study processes around Absolute Zero.
- Liquid helium is used in MRI (Magnetic Resonance Imagery) in hospitals all over Africa.

Laser Gases

Afrox offers a complete range of products and services specifically tailored to the laser market, ensuring that you get maximum productivity and return on your investment. Afrox has worked closely with laser manufacturers to ensure that laser gases meet their requirements for purity. Laser gases can either be supplied as pure gases or as premixed gases, depending on your laser machine.

Pures

Product Description	Material Number	Purity (%)	Impurities (ppm)	Product Content	Filling Pressure
Helium Baseline 5.0	524203-SE-C	MIN 99,999	Moisture<=3 N_2<=5 O_2<=2 CnHm<=0,5	1,51 kg	200 bar
Argon Baseline 5.0	512203-SE-C	MIN 99,999	Moisture<=3 N_2<=5 O_2<=2 CnHm<=0,5	17,4 kg	200 bar
Nitrogen Baseline 5.0	511203-SE-C	MIN 99,999	Moisture<=3 O_2<=2 CnHm<=0,5	11,0 kg	200 bar
Carbon Dioxide CP	514202-SE-C	MIN 99,995	Moisture<= 5 O_2<=5 N_2<= 10 CnHm<=2	37,5 kg	200 bar

Mixtures

Description	Material Number	Composition	Impurities (ppm)	Valve Connection	Product Content	Filling Pressure
Rofin Lasermix	521100-SE-A	O_2 2,85 - 3,15%; Xe 2,85 - 3,15%; CO_2 3,8 - 4,2%; CO 5,7 - 6,3%; N_2 18,05 - 19,95%; Balance He	-	5/8″ BSP RH Int	1,35 m^3	150 bar
Lasermix 312	521110-SE-A	CO_2 2,983 - 3,297%; N_2 29,83 - 32,97%; Balance He	-	5/8″ BSP RH Int	10 m^3	200 bar
Lasermix 321	521140-SE-A	CO_2 4,75 - 5,25%; N_2 52,25 - 57,75%; Balance He	H_2O<5 CnHm<1	5/8″ BSP RH Int	7,4 kg	200 bar
Lasermix 331	521150-SE-A	CO_2 4,75 - 5,25%; N_2 33,25 - 36,75%; Balance He	-	5/8″ BSP RH Int	3,8 kg	200 bar
Lasermix 362 (old 402)	521130-SE-A	CO_2 5,4%; N_2 27%; Balance He		5/8″ BSP RH Int	4,8 kg	200 bar
Ammada 2 Lasermix	521120-SE-A	CO_2 5%; N_2 34; Balance He	-	5/8″ BSP RH Int	4,13 kg	150 bar
Lasermix 322	521160-SE-C	CO_2 4,5%; N_2 13,5%; Balance He	-	5/8″ BSP RH Int	2,4 kg	150 bar

Mining Calibration Mixtures

Carbon monoxide is formed whenever carbonaceous material combusts incompletely, and is a very common pollutant in occupational and non-occupational environments. It is toxic, as it binds with haemoglobin in place of oxygen, and reduces the oxygen available to human tissue, with the most serious effect on the brain. In order to calibrate and check CO measuring and warning devices, Afrox has developed a number of calibration standards. Because methane (CH_4) does not interfere chemically with CO, it is possible to combine these two components with air to produce unique calibration standards for the calibration of dual CH_4/CO measuring devises. Each cylinder is supplied with a certificate of analysis, on which the actual concentrations are clearly stated.

Product Description	Size (kg)	Volume (m^3)	Filling Pressure (bar)	Composition	Material Number	Recommended Regulator
COCal 400	6,2	5,1	130	410 - 450 ppm CO; Balance Air	519123-NE-A	W019120 or W019220
COCal 450	6,2	5,1	130	450 - 480 ppm CO; Balance Air	519124-NE-A	W019120 or W019220
CO-MethCal 100/14	6,1	5,1	130	105 - 120 ppm CO; 1,30 - 1,49% CH_4; Balance Air	519130-NE-A	W019120 or W019220
CO-MethCal 130/15	6,1	5,1	130	120 - 140 ppm CO; 1,40 - 1,59% CH_4; Balance Air	519131-NE-A	W019120 or W019220
CO-MethCal 150/14	6,1	5,1	130	149 - 180 ppm CO; 1,30 - 1,49% CH_4; Balance Air	519135-NE-A	W019120 or W019220
CO-MethCal 200/14	6,1	5,1	130	160 - 240 ppm CO; 1,30 - 1,49% CH_4; Balance Air	519136-NE-A	W019120 or W019220
CO-MethCal 400/24	6,1	5,2	130	400 - 480 ppm CO; 2,30 - 2,45% CH_4; Balance Air	519134-NE-A	W019120 or W019220
CO-MethCal 400/24/17	6,1	5,2	130	400 - 480 ppm CO; 2,30 - 2,45% CH_4; 16 - 18% O_2; Balance Air	519129-NE-A	W019120 or W019220
CO-MethCal 400/14/17	6,1	5,2	130	400 - 480 ppm CO; 1,30 - 1,45% CH_4; 16 - 18% O_2; Balance Air	519138-NE-A	W019120 or W019220
CO-MethCal 450/14	6,1	5,1	130	360 - 540 ppm CO; 1,30 - 1,49% CH_4; Balance Air	519133-NE-A	W019120 or W019220
MethCal 14	7,7	6,4	130	1,30 - 1,50% CH_4; Balance Air	519114-SH-A	W109120
MethCal 14	1,5	1,3	130	1,30 - 1,50% CH_4; Balance Air	519114-IH-A	W109220
MethCal 14 (Lecture bottle)	38,6 g	0,03	80	1,30 - 1,49% CH_4; Balance Air	519114-SO-C	W101535*
MethCal 25	7,7	6,5	130	2,40 - 2,54% CH_4; Balance Air	519115-SH-A	W019120 or W019220

Valve connection 5/8" BSP LH Int

*CGA170

Cylinder Code	Cylinder Description	Water Capacity (ℓ)	Height (m)	Diameter (m)	Empty Mass (kg)	Max Fill Pressure (bar)
NE	Large Aluminium Cylinder	40	1,51	0,23	52	20 000
IJ	Small Aluminium Cylinder	10	0,68	0,18	16	20 000
SH	Large Steel Cylinder - Flammable	50	1,54	0,23	70	20 000
IH	Small Steel Cylinder - Flammable	10	0,60	0,18	18	20 000
SO	Lecture Bottle	0,4	-	-	-	-

Process Gases

Process gas mixtures are used for process applications, such as blanketing, instrument support gases and leak detection. These are specialised mixtures for process specific applications where the high accuracy and thetraceability of gases are not required. They are not suitable for calibration purposes. Cylinders can be supplied with a batch certificate of conformance (COC).

The process gases that have been in demand, have been identified, and we keep them in stock for your convenience. Please contact us for any mixtures that you may need large volume of in future, to work out a supply plan to suit your needs.

Product Description	Mass of Product (kg)	Volume (m^3)	Fill Pressure (bar)	Material Code	Stock Category
10% H_2; Balance N_2	7,6	7,2	150	519201-SH-C	STO/LASS
12% H_2; Balance N_2	7,4	7,1	150	519202-SH-C	STO/LASS
25% H_2; Balance N_2	6,3	7,1	150	519204-SH-C	MTO
4% H_2; Balance Ar	12,4	7,8	150	519212-SH-C	MTO
4% H_2; Balance N_2 MCP	122	108	150	519205-MH-C	LASS
5% H_2; Balance Ar	12,3	7,7	150	519211-SH-C	STO/LASS
5% H_2; Balance N_2	8,0	7,2	150	519207-SH-C	STO/LASS
8% H_2; Balance Ar	11,8	7,7	150	519208-SH-C	STO/LASS
4% H_2; Balance N_2	13,4	8,0	150	519205-SH-C	STO/LASS
5% CO_2; 5% H_2; Balance N_2	13,4	8,0	150	519206-SH-C	STO
35% H2; Balance Ar	7,515	7,2	150	519209-SH-C	

Valve connection 5/8” BSP LH Int

Recommended regulator for mixtures containing hydrogen: W019120 or W019220

Product Description	Mass of Product (kg)	Volume (m^3)	Fill Pressure (bar)	Material Code	Stock Category
5% CO_2; Balance Ar	13,4	8,0	150	519216-SE-C	STO/LASS

Valve connection 5/8” BSP RH Int

Recommended regulator for mixtures not containing hydrogen: W019110 or W019210

Cylinder Code	Cylinder Description	Water Capacity (ℓ)	Height (m)	Diameter (m)	Empty Mass (kg)	Max Fill Pressure (kPa)
SH	Large Steel Cylinder - Flammable	50	1,54	0,23	70	20 000
SE	Large Steel Cylinder	50	1,54	0,23	70	20 000
MH	15 x SH in a frame	15 x 50	2,10	1,2 x 1,5	1 650	20 000

Propellants

Propellants are mixtures of propane and butane to match a required vapour pressure. The product is purified to remove any smell and discoloration.

Hazards

- Propellants are flammable and can form explosive mixtures with air
- At high concentrations, it can act as an asphyxiant with possible anaesthetic effects after prolonged inhalation.

Uses and Features

- Used to expand polystyrene and polyethylene in foam blowing applications
- Used as a propellant in aerosol applications.

Precautions in Use

- Since the product is unstenched, leaks are difficult to detect. All connections should be tested for leaks with a soapy water solution after installation.

Material Compatibility

- Any common, commercially available metals may be used because it is non-corrosive.

Physical Data

- Appearance/odour colourless with slightly ethereal smell
- These values will differ depending on the composition of the blend. Please contact your Special Products representative.

Cosmetic Butane

A number of blends can be mixed to various vapour pressures. Various blends include:

- CB31
- CB36
- CB40
- CB44
- CB48
- CB56
- CB62

Afrox Standard Propellant Blend ordering information and Package size

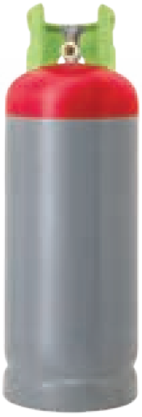
Product Description	Cylinder Net Mass	Product Code
Butane	48 kg	544128-LF-C
CB-31	48 kg	544131-LF-C
CB-36	48 kg	544136-LF-C
CB-40	48 kg	544140-LF-C
CB-44	48 kg	544144-LF-C
CB-45	48 kg	544145-LF-C
CB-46	48 kg	544146-LF-C
CB-48	48 kg	544148-LF-C
CB-50	48 kg	544150-LF-C
CB-56	48 kg	544156-LF-C
CB-62	48 kg	544162-LF-C
CB-66	48 kg	544166-LF-C
CB-74	48 kg	544174-LF-C
Propane IG-Wet	45 kg	508413-LF-C
Propane IG	45 kg	508403-LF-C
Propane IG	9 kg	508403-LC-C
Bulk Cosmetic Propellant	BULK	580099

Propane (C_3H_8, R-290)


Extremely Flammable

CAS: 74-98-6 UN: 1978

Propane Instrument Grade N1.7					
Purity (%)	≥ 97				
Impurities (ppm)	S ≤ 1	C_nH_m ≤ 3%	H_2O ≤ 50	Unsaturates ≤ 0,1%	1,3 Butadiene ≤ 1 400
Typical Filling Pressure	15°C: 7,3 bar(a)				



Characteristics

- Flammable
- Colourless, liquefied gas.

Health Risks

- Asphyxiant at high concentrations.

Transport

ADR Class 2,2F

DOT Class 2,1

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Propane Pure	Bulk	N1.7	580099	5/8" BSP LH Int	Recommendation on Request
Propane IG	45,0	N1.7	508403-LF-C	5/8" BSP LH Int	W019120 or W019220
Propane IG	9,0	N1.7	508403-LC-C	5/8" BSP LH Int	W019120 or W019220
Propane IG	45,0	Wet N1.7	508413-LF-C	5/8" BSP LH Int	No Regulator Required

Physical Data	
Molecular Weight	44,097
Boiling Point at 1,013 bar [°C]	-42,04
Density at 1,013 bar, 20°C [kg/m^3]	1,868
Vapour Pressure at 0°C [bar]	4,76
Vapour Pressure at 20°C [bar]	8,39
Flammability Range in Air [% volume]	2,1 - 9,5
Specific Volume at 1,013 bar, 20°C [m^3/kg]	0,535

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	■	●	●	●	●	■	●	■	●	●	●	▲

Legend: ● Good ▲ Fair ■ Avoid

Source

- Propane is a constituent of crude petroleum and natural gas from which it is obtained by refining and processing operations.

Applications

- Propane is of interest as a specialty gas mainly in mixtures used to calibrate process control analysers in the petrochemical industry. It is also used in its pure form as the fuel gas in flame photometers.
- Propane is used:
  - For heating of industrial premises and apartments
  - As fuel supply to hot air generators used in farming for drying harvests
  - For heating animal breeding areas
  - In hotels and restaurants
  - In portable heating units at work sites, markets, etc.
  - In the iron and steel industry: burners for heat treatment furnaces, radiation panels for surface treatment, metal oxy-cutting
  - In the chemical industry: burners for ceramic kilns, in paintwork finishing installations, incinerators in petrochemical furnaces
  - As a clean fuel for intra-plant vehicles, such as fork-lift trucks, where petrol fumes or soot would be considered unpleasant
  - Extensively as a refrigerant in chemical, petroleum refining and gas processing operations
  - As a refrigerant in high/medium/low temperature; commercial and industrial refrigeration and A/C
  - In heat pumps, and mixed with iso-butane it is used in high/medium temperature refrigeration; commercial and domestic refrigeration
  - In metallurgy to create controlled atmospheres. It is employed in gaseous cementation processes
  - As an aerosol propellant mixed with iso-butane.
- Propane is one of the main components in liquid petroleum gas (LPG).
- As a refrigerant it has the ASHRAE number R-290.
- Propane is used for efficiency testing of gas burners and engines.
- Propane is used in emission calibration mixtures for the automotive industry.
- Propane is used as a component in calibration gases for the gas, oil and chemical industry.

Afrox Standard Propellant Blend Vapour Pressure

Product Description	Product Code	Blending Tolerance	Absolute Vapour Pressure			Vapour Pressure Gauteng and Inland			Vapour Pressure Sea Level		
			kPa (absolute) @ 25°C			kPa (gauge) for altitude 85 kPa @ 25°C			kPa (gauge) for sea level 101.325 kPa @ 25°C		
		+/- kPa	Target	Min	Max	Target	Min	Max	Target	Min	Max
Butane	544128-LF-C	20	275	255	295	190	170	210	175	155	195
CB-31	544131-LF-C	10	325	315	335	240	230	250	225	215	235
CB-36	544136-LF-C	10	375	365	385	290	280	300	275	265	285
CB-40	544140-LF-C	10	415	405	425	330	320	340	315	305	325
CB-44	544144-LF-C	10	425	415	435	340	330	350	325	315	335
CB-45	544145-LF-C	10	435	425	445	350	340	360	335	325	345
CB-46	544146-LF-C	10	445	435	455	360	350	370	345	335	355
CB-48	544148-LF-C	10	465	455	475	380	370	390	365	355	375
CB-50	544150-LF-C	10	485	475	495	400	390	410	385	375	395
CB-56	544156-LF-C	10	515	505	525	430	420	440	415	405	425
CB-62	544162-LF-C	10	555	545	565	470	460	480	455	445	465
CB-66	544166-LF-C	10	585	575	595	500	490	510	485	475	495
CB-74	544174-LF-C	10	635	625	645	550	540	560	535	525	545
Propane - Wet	508413-LF-C	20	835	815	855	750	730	770	735	715	755
Propane N-1	508403-LF-C	20	835	815	855	750	730	770	735	715	755
Propane N-1	508403-LC-C	20	835	815	855	750	730	770	735	715	755

Afrox Standard Propellant Blend Technical Data

Product Description	Product Code	Absolute Vapour Pressure	Calculated Density 25°C in kg/l	Component % by Volume			Component % by Mass		
				n-Butane as 90% of total Butanes	Iso-Butane as 10% of total Butanes	Propane	n-Butane as 90% of total Butanes	Iso-Butane as 10% of total Butanes	Propane
Butane	544128-LF-C	275	0,568	87,3%	9,7%	3,0%	88,0%	9,4%	2,6%
CB-31	544131-LF-C	325	0,563	80,9%	9,0%	10,1%	82,4%	8,8%	8,8%
CB-36	544136-LF-C	375	0,557	74,5%	8,3%	17,2%	76,6%	8,2%	15,2%
CB-40	544140-LF-C	415	0,553	69,4%	7,7%	23,0%	71,9%	7,7%	20,5%
CB-44	544144-LF-C	425	0,551	68,0%	7,6%	24,4%	70,7%	7,5%	21,8%
CB-45	544145-LF-C	435	0,550	66,7%	7,4%	25,9%	69,4%	7,4%	23,2%
CB-46	544146-LF-C	445	0,549	65,4%	7,3%	27,3%	68,3%	7,3%	24,5%
CB-48	544148-LF-C	465	0,547	62,9%	7,0%	30,1%	65,9%	7,0%	27,1%
CB-50	544150-LF-C	485	0,545	60,3%	6,7%	33,0%	63,4%	6,8%	29,8%
CB-56	544156-LF-C	515	0,541	56,4%	6,3%	37,3%	59,7%	6,4%	33,9%
CB-62	544162-LF-C	555	0,537	51,3%	5,7%	43,0%	54,8%	5,8%	39,4%
CB-66	544166-LF-C	585	0,533	47,4%	5,3%	47,3%	50,9%	5,4%	43,6%
CB-74	544174-LF-C	635	0,528	41,0%	4,6%	54,4%	44,5%	4,8%	50,7%
Propane - Wet	508413-LF-C	835	0,493	0,9%	0,1%	99,0%	1,0%	0,1%	98,8%
Propane N-1	508403-LF-C	835	0,493	0,9%	0,1%	99,0%	1,0%	0,1%	98,8%
Propane N-1	508403-LC-C	835	0,493	0,9%	0,1%	99,0%	1,0%	0,1%	98,8%

The above percentages are dependent on impurities in the raw material and may vary slightly.

Butane Specifications

Composition	Units	Limits	Spec
Total Aromatics	Mole %	max	N/A
Total Unsaturates	Mole %	max	1,0
Methane C_1	Mole %	max	0,1
Ethane C_2	Mole %	max	0,1
Ethene C_2	Mole %	max	0,1
Acetylene C_2	Mole %	max	0,1
Propane C_3	Mole %	max	0,1
Propene C_3	Mole %	max	0,1
iso-Butane i-C_4	Mole %	max	30
Butane n-C_4	Mole %	max	70 - 99,9
iso-Butene	Mole %	max	0,2
1 Butene	Mole %	max	0,2
Trans-2-Butene	Mole %	max	0,2
iso-Pentane	Mole %	max	0,2
Pentene	Mole %	max	0,2
n-Pantane	Mole %	max	0,2
C_5 Plus	Mole %	max	2
1.3 Butadiene	ppm	max	1
Total Mercaptan	ppm	max	0,05
Olefins	ppm	max	N/A
Water	ppm	max	10
Free Water	ppm		None
Oil Stain on Evap.	1 min		None
Residue	ml	max	0,05
Comb. Fluoride	ppm		10
Copper Corrosion	rating		1
Total Sulphur	ppm	max	1,0
Odour			Pleasant non-sulphurous odour

Pure Propane Specifications

Composition	Units	Limits	Spec
Total Aromatics	Mole %	max	0,1
Total Unsaturates	Mole %	max	0,1
Methane C_1	Mole %	max	0,1
Ethane C_2	Mole %	max	0,1
Ethene C_2	Mole %	max	0,05
Acetylene C_2	Mole %	max	0,1
Propane C_3	Mole %	max	98,5 min
Propene C_3	Mole %	max	0,1
iso-Butane i-C_4	Mole %	max	2
Butane n-C_4	Mole %	max	0,1
iso-Butene	Mole %	max	0,1
1 Butene	Mole %	max	0,1
Trans-2-Butene	Mole %	max	0,1
iso-Pentane	Mole %	max	0,1
Pentene	Mole %	max	0,1
n-Pantane	Mole %	max	0,1
C_5 Plus	Mole %	max	2
1.3 Butadiene	ppm	max	1
Total Mercaptan	ppm	max	0,05
Olefins	ppm	max	ND
Water	ppm	max	10
Free Water	ppm		None
Oil Stain on Evap.	1 min		None
Residue	ml	max	0,05
Comb. Fluoride	ppm		ND
Copper Corrosion	rating		1
Total Sulphur	ppm	max	1,0
Odour			Pleasant non-sulphurous odour

Pures


Extremely Flammable

Afrox stocks a wide range of scientific pures, with your laboratory needs in mind. The material codes and descriptions listed will guide you to make the right choice.

Acetylene (C_2H_2, Ethyne)

CAS: 74-86-2 EC: 200-816-9 UN: 1001

Acetylene Instrument Grade	
Purity (%)	≥ 99,0
Impurities	PH_3 ≤ 0,1%
Typical Filling Pressure	15°C:15 bar(a)

Characteristics

- Flammable
- Colourless gas with ether-like odour when very pure, otherwise garlic-like
- Supplied dissolved in acetone or DMF (N,N-dimethylmethanamide)
- Can decompose instantaneously at pressures higher than 1 bar
- Acetylene can be delivered as a non-dissolved gas for specific R&D applications.

Health Risks

- Asphyxiant, anaesthetic.

Transport

ADR Class 2, 4F

DOT Class 2,1

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Acetylene IG N2.0	8,0	Instrument Grade	508103-DC-C	5/8" BSP LH Int	W019220 or W019120

Physical Data	
Molecular Weight	26,038
Boiling Point at 1,013 bar [°C]	-84,15
Density at 1,013 bar, 20°C [kg/m³]	1,090
Vapour Pressure at 0°C [bar]	26,4
Vapour Pressure at 20°C [bar]	43,41
Flammability Range in Air [% volume]	2,2 - 85,0
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,917

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	🟥	▲	●	●	🟥	▲	🟥	▲	▲	🟥	●	●	▲	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Acetylene is manufactured commercially by reaction between calcium carbide and water, and as a by-product of ethylene production.

Applications

- Acetylene is used as a raw material for the production of electrically conducting plastics, such as polyacetylene.
- Acetylene is used with high purity synthetic air or nitrous oxide as a fuel for the flame in atomic absorption flame spectroscopy. This is used in water, soil, food and biological research laboratories where sensitivity and accuracy of results are important.
- Acetylene is most commonly used in combination with oxygen for cutting or welding materials such as mild steel, where the standard industrial grade is sufficient.
- Acetylene with low phosphine levels is required for lead brazing or welding.
- Acetylene is used in organic synthesis (laboratory work) as well as in chemical synthesis.
- Acetylene is used as carbon source in the production of molecular manufacturing like fullerenes; well known examples are bucky balls or carbon nanotubes.
- Acetylene is used in the cultivation of plants; it improves the forming of new flowers.
- Acetylene is used as a component in calibration gases for the gas, oil as well as chemical industry.
- This unsaturated hydrocarbon exhibits high chemical reactivity, and is an important intermediate in the chemical industry. It is employed for the production of:
    - Acetaldehyde
    - Acrylic acids
    - Acrylic ethers
    - Acrylonitride
    - Carbazole
    - Butenyne (vinyl acetylene)
    - Chloroethene (vinyl chloride)
    - Diols
    - Ethene
    - Ethenoxyethenes (vinyl ethers)
    - Ethenyl acetate (vinyl acetate)
    - Ethenyl amides (vinyl amides)
    - Ethenyl sulphides (vinyl sulphides)
    - Neoprene
    - Phenylethene (styrene)
    - Polyoxymethylene
    - Pyrrolidine
    - Trichloroethene
    - Very fine carbon black, called ‘acetylene black’.

Air, Synthetic (80% N_2 + 20% O_2)

CAS: 132259-10-0 EC: Not Available UN: 1002

Air IG Zero				
Impurities (ppm)	CO ≤ 0,5	CO_2 ≤ 0,5	C_nH_m ≤ 5	H_2O ≤ 3
Typical Filling Pressure	20°C: 200 bar(a)			

Transport

ADR Class 2, 1 A

DOT Class 2,2

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Air IG Zero	2,3	Instrument Grade	513207-IE-C	5/8" BSP RH Int	W019110 or W019210
Air IG Zero	11,6	Instrument Grade	513207-SE-C	5/8" BSP RH Int	W019110 or W019210

Physical Data	
Molecular Weight	28,975
Boiling Point at 1,013 bar [°C]	-194,3
Density at 1,013 bar, 20°C [kg/m³]	1,205
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,830

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Synthetic air is produced by mixing pure oxygen (20%) and pure nitrogen (80%). This eliminates all kinds of impurities present in normal ambient air.

Applications

- Air is a source of oxygen and nitrogen.
- Air is the source of oxygen for burning, respiration of plants and animals, decay and industrial oxidations.
- Synthetic air is used as zero gas in the running and calibration of environmental monitoring and test measurements where levels of sulphur and nitric oxides can affect the measurement equipment.
- Synthetic air is used in medical gas mixtures.
- Synthetic air is regularly used as the oxidiser for flame ionisation detectors in chromatography and total hydrocarbon analysers.
- Synthetic air is used together with acetylene in atomic absorption flame spectrometry.
- Synthetic air is used as a balance gas for many calibration gases.

Argon (Ar, R-740)

CAS: 7440-37-1 UN: 1006

Argon Baseline 5.0				
Purity (%)	≥ 99,999			
Impurities (ppm)	$O_2 \leq 2$	$N_2 \leq 5$	$C_nH_m \leq 0,5$	$H_2O \leq 3$
Typical Filling Pressure	20°C: 200 bar(a)			

Characteristics

- Colourless and odourless gas
- Non-reactive
- Inert.

Health Risks

- Asphyxiant at high concentrations.

Transport

ADR Class 2, 1 A

DOT Class 2.2

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Argon Baseline 5.0	17,4	Instrument Grade	512203-SE-C	5/8″ BSP RH Int	W019110 or W019210
Argon Baseline 5.0	3,5	Instrument Grade	512203-IE-C	5/8″ BSP RH Int	W019110 or W019210
Argon Baseline MCP	15 x 17,4	Instrument Grade	512203-ME-C	5/8″ BSP RH Int	W019110 or W019210
Argon Baseline PCC	200	Instrument Grade	512203-PA-C	5/8″ BSP RH Int	W019110 or W019210
Argon HP PCC	200	High Purity	512102-PA-N	5/8″ BSP RH Int	W019110 or W019210
Argon PCC Uncertified	200	High Purity	512101-PA-N	5/8″ BSP RH Int	W019110 or W019210

Physical Data	
Molecular Weight	39,948
Boiling Point at 1,013 bar [°C]	-185,87
Density at 1,013 bar, 20°C [kg/m^3]	1,662
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m^3/kg]	0,602

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- The most common source of argon is an air separation plant. Air contains approx. 0,93% (vol.) argon. A crude argon stream containing up to 5% oxygen is removed from the main air separation column via a secondary ('side-arm') column. The crude argon is then further purified to produce the various commercial grades required.

Applications

- Argon is one of the most common carrier gases in gas chromatography. Argon is used as a carrier gas in sputtering, plasma etching and ion implantations, and as a blanket atmosphere in crystal growth.
- Argon is also the choice gas for ICP spectroscopy (Inductively Coupled Plasma spectroscopy).
- Argon is used in atomic absorption spectrometry as a blanket gas in the graphite furnace.
- One of the most common applications of argon, either pure or in various mixtures, is as a shielding gas for arc welding.
- Many Geiger-counting tubes contain argon or argon mixed with organic vapours or other gases, for example 10% methane in argon.
- Argon is used in blends with, for example, fluorine and helium in excimer lasers.
- Argon is one of the principal gases used for filling incandescent (filament) lamps, generally in a mixture with nitrogen, krypton or neon, for phosphorescent tubes in mixtures with neon.
- Argon is used as an insulation gas in high-efficiency multi-pane windows to improve thermal insulation.
- The argon-oxygen decarburising (AOD) process is the most common method of refining stainless steel and uses large quantities of both gases supplied either in liquid form or via pipeline from an on-site plant.
- Argon is used in the iron and steel industry to prevent oxidation of molten metals and alloys as well as for degassing and desulphurisation of molten steel and iron baths.
- The pharmaceutical industry uses argon to displace oxygen in the top of intravenous drug containers, extending product shelf-life.
- Argon is used, often in a mixture with hydrogen, as a protective atmosphere for the heat treatment of certain metals, particularly those which are susceptible to nitriding when treated in a nitrogen-based atmosphere. This includes stainless steels and many different specialised and therefore small-scale applications.
- Argon is used for wine preservation to eliminate air by the heavier argon, to prevent oxidation and extend the product quality for opened bottles and barrels.
- Liquid argon is used in cryosurgery, e.g. cryoablation to destroy cancer cells.
- Argon, R-740, is used in gas mixtures for non-CFC ultra-low temperature refrigeration applications.
- Argon is, sometimes in combination with nitrogen, used to inflate airbags.
- Argon is used, often in combination with nitrogen and/or carbon dioxide, as a clean fire extinguishing gas, since the inert properties do not damage any materials extinguished.

Carbon Dioxide

CAS: 124-38-9   EC: 204-696-9   UN: 1013; 2187 (Refrigerated liquid)

Carbon Dioxide IG 3.0	
Purity (%)	≥ 99,9
Impurities	Permanent gases + $H_2O \leq 0{,}1\%$

Carbon Dioxide CP Grade 4.5					
Purity (%)	≥ 99,995				
Impurities (ppm)	$O_2 \leq 5$	$N_2 \leq 10$	$C_nH_m \leq 2$	$H_2O \leq 5$	$CO \leq 2$
Typical Filling Pressure	15°C: 51 bar(a)				

Characteristics

- Liquefied, colourless gas.

Health Risks

- Asphyxiant at high concentrations
- Increases the breathing rate.

Transport

ADR Class 2, 2A

DOT Class 2,2

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Carbon Dioxide IG N3.0	31,3	Instrument Grade	514103-RC-C	5/8" BSP RH Ext	W019140 or W019240
Carbon Dioxide IG N3.0	5,6	Instrument Grade	514203-RC-C	5/8" BSP RH Ext	W019140 or W019240
Carbon Dioxide PCC	175	Uncertified	514101-PA-N	5/8" BSP RH Ext	W019140 or W019240
Carbon Dioxide CP Grade N4,5	31,3	Chemically Pure	514202-SE-C	5/8" BSP RH Ext	W019140 or W019240
Carbon Dioxide EP N2.5	31,3	Pharmaceutical	514106-RC-C	5/8" BSP RH Ext	W019140 or W019240

Physical Data	
Molecular Weight	44,01
Boiling Point at 1,013 bar [°C]	-56,56
Density at 1,013 bar, 20°C [kg/m³]	1,839
Vapour Pressure at 0°C [bar]	34,5
Vapour Pressure at 20°C [bar]	57,3
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,544

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	■	●	▲	●	●	●	●	■	●	▲	●	●	●	■

Legend: ● Good ▲ Fair ■ Avoid

Source

- Carbon dioxide is recovered from many different sources. It is obtained as an off-gas from fermentation processes, lime-stone kilns, natural CO_2 springs as well as gas streams from chemical and petrochemical operations. Recently, CO_2 is also recaptured from the off-gas from power plants.

Applications

- Carbon dioxide is used extensively as a neutralising agent for pH control, for example, in cement curing water treatment and in many other commercially important chemical applications.
- Carbon dioxide is used in many consumer products ranging from aerosol packaging to air guns that require pressurised gas because it is inexpensive and non-flammable; in the operation of pneumatic equipment where other power sources are not available or suitable, and for the transfer of hazardous and flammable liquids.
- Owing to its stimulating effect on the nerve centres, carbon dioxide is employed in medicine in mixtures with oxygen, for reanimating victims of asphyxiation (drowning, electrocution, carbon monoxide poisoning, diphtheritic toxin morphine or scopolamine). It also serves in the treatment of certain skin affections.
- Carbon dioxide is used for the chemical vapour deposition of silicon dioxide.
- Mixed with ethylene oxide, it is employed as a fumigant in the destruction of insects in grain silos, as well as in leguminous plants, dates and dried figs.
- A substantial volume of carbon dioxide is used for carbonating beverages such as beer and many soft drinks and conservation of wine, unfermented grape juice and various fruit juices.
- Carbon dioxide is used to modify atmospheres, for example in green houses where it increases plant growth rates or combined with nitrogen to prolong quality in food packaging applications (MAP). (See FoodFresh™)
- Carbon dioxide, when mixed with helium and nitrogen, is used as the active medium in carbon dioxide lasers. Such lasers have a variety of applications, for instance piercing small holes into cigarette papers and the marking of food and drink packages, cutting metals, welding, engraving, etc.
- Carbon dioxide is used as an inerting agent for various mild steel welding operations, often in combination with argon.
- Carbon dioxide is used for foam blowing.
- Carbon dioxide is used in Coleman nitrogen analysers.
- Carbon dioxide is used as media for supercritical fluid extraction (SFE) in sample preparation and as a carrier gas for analytical and preparative supercritical fluid chromatography (SFC).
- Compressed carbon dioxide is used as a replacement for blasting powder in quarrying and mining operations.
- Solid carbon dioxide is used as blasting agent.
- Liquid carbon dioxide is becoming increasingly used as a refrigerant in mechanical refrigerating systems due to its environmental credentials. It has the ASHRAE number R-744. It can be used in direct expansion systems or as a secondary refrigerant with ammonia. 'Dry ice', or solid CO_2, is commonly used as a refrigerant.
- Liquid/solid carbon dioxide is used for cooling gas chromatography ovens.
- Possible refrigerant for MAC (mobile air-conditioning) due to European phase-out of tetrafluoroethane (R-134a).
- Carbon dioxide is used in mixtures for car emission monitoring and environmental monitoring.
- Carbon dioxide is used for fire extinguishing.
- Carbon dioxide is often used in combination with ethylene oxide for sterilising purposes.
- Carbon dioxide is also used for blood analysis and dehydration of penicillin.
- Carbon dioxide is used for production of paints and varnishes.

Hydrogen (H_2, R-702)

CAS: 1333-74-0 EC: 215-605-7 UN: 1049 (Compressed); 1966 (Refrigerated liquid)

Hydrogen Baseline 5.0				
Purity (%)	≥ 99,999			
Impurities (ppm)	$O_2 \leq 2$	$N_2 \leq 5$	$C_nH_m \leq 0,5$	$H_20 \leq 3$
Typical Filling Pressure	20°C: 200 bar(a)			

Characteristics

- Flammable
- Odourless and colourless gas.

Health Risks

- Asphyxiant at high concentrations. Binds itself to the haemoglobin in the blood. A headache is usually the first shown symptom.

Transport

ADR Class 2, 1 F

DOT Class 2,1

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Hydrogen Baseline 5.0	0,74	Instrument Grade	510203-SH-C	5/8" BSP LH Int	W019120 or W019220
Hydrogen Baseline MCP	11,1	Instrument Grade	510203-MH-C	5/8" BSP LH Int	W019120 or W019220

Physical Data	
Molecular Weight	2,016
Boiling Point at 1,013 bar [°C]	-252,76
Density at 1,013 bar, 20°C [kg/m³]	0,084
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	4,0 - 74,5
Specific Volume at 1,013 bar, 20°C [m³/kg]	11,90

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Hydrogen is most frequently produced for on-site usage by steam reforming of natural gas. Such plants may also be used as sources of hydrogen for the merchant market. Other sources are electrolysis plants, where the hydrogen is a by-product of chlorine production, and various waste gas recovery plants, such as at oil refineries or steel plants (coke oven gas). Hydrogen is also produced by electrolysis of water.

Applications

- High purity hydrogen finds widespread usage in the electronics industry as a reducing agent and as a carrier gas.
- High purity hydrogen is used as a carrier gas in gas chromatography.
- Hydrogen finds some usage in the welding and cutting of metals.
- Hydrogen is used in large quantities, (bulk supply or on-site generation) for the hydrogenation of vegetable and animal oils to produce margarine and other fats, hydrotreatment of petroleum products and hydrosulphuration of fuels in order to eliminate sulphur.
- Hydrogen in large quantities is used in petrochemical processes that include hydrodealkylation, hydro-desulphurisation and hydrotreatment.
- Hydrogen is used in leak testing applications.
- Hydrogen is used extensively in the metals industries because of its ability to reduce metal oxides and prevent oxidation of metals during heat treatment. It may be used either pure, as is often the case when heat treating stainless steel, or in a mixture with inert gases, argon or nitrogen. It is used in the production of carbon steels, special metals and semiconductors.
- Hydrogen is used for combustion;
    - In industry, it is used to supply oxygen-hydrogen torches for glass working (quartz, Pyrex®, etc.), in the fabrication of artificial precious stones (ruby, etc.) and for underwater oxy-cutting
    - In the laboratory, it is used in analyser flames, reducing flame photometry detection instruments, flame ionisation detection instruments and fuel cells.
- Extremely pure hydrogen is used in the chemical industry for fine reduction processes.
- Liquefied hydrogen is used as a rocket fuel. In the laboratory, liquid hydrogen is employed for solid physics research.
- In the nuclear industry, para-hydrogen is employed to fill bubble chambers.
- In electrical power plants, hydrogen is used as a coolant gas in turbogenerators.
- Hydrogen is used for synthesis of ammonia.
- Hydrogen is used as a reagent to produce high purity water.
- Hydrogen is used as fuel in fuel cell applications.

Nitrogen (N_2, R-728)

CAS: 7727-37-9   EC: 231-783-9   UN: 1066 (Compressed); 1977 (Refrigerated liquid)

Nitrogen Baseline 5.0			
Purity (%)	≥ 99,999		
Impurities (ppm)	O_2 ≤ 2	C_nH_m ≤ 0,5	H_2O ≤ 3
Typical Filling Pressure	20°C: 200 bar(a)		

Characteristics

- Colourless and odourless gas.

Health Risks

- Asphyxiant at high concentrations.

ADR Class 2, 1 A

DOT Class 2,2

Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Nitrogen Baseline 5.0	11,0	Instrument Grade	511203-SE-C	3/4″ BSP RH Int	W019130 or W019230
Nitrogen Baseline MCP	165,0	Instrument Grade	511203-ME-C	3/4″ BSP RH Int	W019130 or W019230
Nitrogen Baseline 5.0	2,2	Instrument Grade	511203-IE-C	3/4″ BSP RH Int	W019130 or W019230
Nitrogen Baseline PCC	120	Ultra-high Purity	511204-PA-C	3/4″ BSP RH Int	W019130 or W019230
Nitrogen PCC	120	Uncertified	511201-PA-N	3/4″ BSP RH Int	W019130 or W019230
Nitrogen Pharma Grade 5.6	11,0	Pharmaceutical Grade	511206-SE-A	3/4″ BSP RH Int	W019130 or W019230

Physical Data	
Molecular Weight	28,014
Boiling Point at 1,013 bar [°C]	-195,8
Density at 1,013 bar, 20°C [kg/m³]	1,165
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,858

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Nitrogen is produced in large quantities at air separation plants which liquefy and subsequently distil air into nitrogen, oxygen and usually argon. If very high purity nitrogen is required, the nitrogen produced may need to go through a secondary purification process. The lower range of nitrogen purities can also be produced with membrane techniques, and medium to high purities with pressure swing adsorption (PSA) techniques.

Applications

- Nitrogen is used in large quantities in the chemical industry for blanketing, purging and pressure transfer of flammable chemicals.
- High purity nitrogen is used in large quantities by the semiconductor industry as a purge or carrier gas as well as for blanketing equipment such as furnaces when not in production.
- Nitrogen is used as a purge gas.
- Nitrogen is commonly used as carrier gas in gas chromatography.
- Nitrogen is used as zero gas for analytical instruments.
- Nitrogen is commonly used as a balance gas in mixtures.
- Nitrogen is used in the electronic industry for inerting of epitaxial reactors.
- Nitrogen is used in mixtures with carbon dioxide for modified atmosphere packaging (MAP) of food stuffs. (See FoodFresh™)
- Nitrogen is used extensively, either pure or, more commonly, in a mixture with a reducing gas such as hydrogen or natural gas, to provide an oxygen-free atmosphere during heat treatment of various metals.
- Nitrogen is used in the Haber-Bosch process for production of ammonia.
- Nitrogen is used as a fire extinguishing gas in mines.
- Nitrogen is used to fill tyres to lower wear and limit the risks of blow-outs.
- Liquid nitrogen is used in cold traps to improve the efficiency of vacuum pumps by condensing or solidifying residual gases in the vacuum.
- Liquid nitrogen may be used for shrink fitting of close tolerance components.
- Liquid nitrogen is used to freeze a wide variety of delicate food, such as hamburgers, strawberries, shrimps, etc.
- Liquid nitrogen may also be used for cryogenic grinding of plastics, rubbers and some other chemicals products.
- Liquid nitrogen is used in the nuclear industry, for scientific research.
- Liquid nitrogen is used to store biological materials like tissue, cells, etc.
- Liquid nitrogen is also used for cryosurgery.
- Liquid nitrogen is used in the area of superconductivity.

Nitrous Oxide (N_2O, R-744A)


Oxidising

CAS: 10024-97-2 EC: 233-032-0 UN: 1070; 2201 (Refrigerated liquid)

Nitrous Oxide IG N2.0				
Purity (%)	≥ 99			
Impurities (ppm)	CO ≤ 10	NO ≤ 3	H_2O ≤ 50	CO_2 ≤ 100
Typical Filling Pressure	15°C: 46 bar(a)			

Characteristics

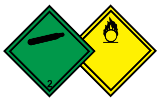
- Colourless and odourless gas.

Health Risks

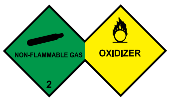
- Asphyxiant at high concentrations.

Transport

ADR Class 2, 20



DOT Class 2,2



Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Nitrous Oxide IG N2.0	31,3	Instrument Grade	508503-RC-C	BS 341 No. 13 11/16" x 20 tpi RH Ext	W019150 or W019250

Physical Data	
Molecular Weight	44,013
Boiling Point at 1,013 bar [°C]	-88,48
Density at 1,013 bar, 20°C [kg/m³]	1,843
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,543

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
▲	▲	●	🟥	▲	●	▲	●	🟥	▲	●	●	●	●	▲

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Nitrous oxide is obtained most commonly by the thermal decomposition of ammonium nitrate. It may also be obtained by controlled reduction of nitrites or nitrates, by the slow decomposition of hyponitrites or by the thermal decomposition of hydroxylamine.

Applications

- Nitrous oxide (often called 'laughing gas') is commonly used as a general anaesthetic in both medical and dental surgeries. To be effective as an anaesthetic, nitrous oxide must be inhaled in relatively high concentrations mixed with air or oxygen.
- Nitrous oxide serves in industry as a leak detector for vacuum and pressurised enclosures, buried piping, etc.
- Nitrous oxide is used as an oxygen source in the chemical vapour deposition of silicon oxynitride layers.
- Nitrous oxide is used in calibration mixtures for environmental control.
- The nitrous oxide-acetylene flame is employed in the laboratory for the analysis of refractory elements such as aluminium, vanadium, titanium and calcium oxides, by flame emission spectrometry. The use of this flame also permits determination of a certain number of trace metals by atomic absorption spectrometry.

- Nitrous oxide is used as an oxidiser in some types of analytical instruments.
- Nitrous oxide may be used as an aerosol propellant in various fields:
  - For whipped cream (because it improves the foaming characteristics of the cream), syrups, concentrates of coffee, chocolate and various flavours, sauces for grilled meats, vinaigrette, etc.
  - Pharmaceutical field
  - Cosmetics (perfumes, eau de cologne, hair spray, etc.)
  - Household products, paints, varnishes and insecticides
  - Aerosols for use at low temperature, such as de-icers, engine boosters, etc.
- Nitrous oxide is used as an oxygen enrichment medium for high performance internal combustion engines (drag racing).
- Nitrous oxide is used as raw material for the production of rocket fuel.

Note:

Nitrous oxide is controlled under the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Oxygen (O_2, R-732)

CAS: 7782-44-7 EC: 231-956-9 UN: 1072 (Compressed); 1073 (Refrigerated liquid)

Oxygen HiQ 5,0				
Purity (%)	≥ 99,999			
Impurities (ppm)	$N_2 \leq 3$	$C_nH_m \leq 0,5$	$H_2O \leq 3$	$H_2 \leq 3$
Typical Filling Pressure	20°C: 200 bar(a)			

Characteristics

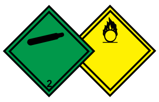
- Colourless and odourless gas
- Many materials burn in oxygen that do not normally burn in air
- Reduces the flash-point temperature and increases the combustion speed.

Health Risks

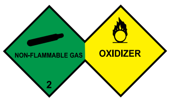
- Continuous inhalation of concentrations higher than 75% may cause nausea, dizziness, respiratory difficulty and convulsions.

Transport

ADR Class 2, 20



DOT Class 2,2



Product Description	Size (kg)	Grade	Material Number	Valve Connection	Recommended Regulator
Oxygen HiQ 5.0	14	Ultra-high Purity	509304-SE-C	5/8" BSP RH Int	W019110 or W019210
Oxygen PCC	168	Uncertified	509101-PA-N	5/8" BSP RH Int	W019110 or W019210
Oxygen IG N2,5	12,3	Instrument	509203-SE-C	5/8" BSP RH Int	W019110 or W019210

Physical Data	
Molecular Weight	31,999
Boiling Point at 1,013 bar [°C]	-182,98
Density at 1,013 bar, 20°C [kg/m³]	1,332
Vapour Pressure at 0°C [bar]	-
Vapour Pressure at 20°C [bar]	-
Flammability Range in Air [% volume]	Non-combustible
Specific Volume at 1,013 bar, 20°C [m³/kg]	0,751

Material Compatibility

Aluminium	Buna® N	Brass	Butyl rubber	Carbon steel	Copper	Kel-F®	Monel®	Neoprene®	Nylon®	Polythene	PVC	Stainless steel	Teflon®	Viton®
●	▲	●	▲	●	●	●	●	▲	●	●	●	●	●	▲

Legend: ● Good ▲ Fair 🟥 Avoid

Source

- Oxygen is obtained on a commercial scale by the liquefaction and subsequent distillation of air. For very high purity oxygen, it is normally necessary to take the product from an air separation plant through a secondary purification and distillation stage. Alternatively, high purity oxygen may be produced by the electrolysis of water. Lower purities of oxygen can also be produced with membrane technique.

Applications

- Many oxidation reactions in the chemical industry use pure oxygen rather than air in order to benefit from higher reaction rates, easier product separation, higher yields or smaller equipment size.
- High purity oxygen is used for the formation of silicon dioxide and metal oxide, as an etchant for photoresist and in mixtures with halocarbons for etching silicon. Oxygen is also used in conjunction with hydrogen to fuel torches for welding, brazing, glass blowing and tube sealing a variety of electronic components such as reed relay switches.
- High purity oxygen is used in conjunction with high purity methane in Advanced Gas Cooled (AGR) nuclear reactors to maintain an appropriate carbon balance in the CO_2.
- Gas coolant in the nuclear core.
- High purity oxygen is used in the optical fibre production process.
- Injecting oxygen into sewage treatment plants accelerates the decomposition of sewage.
- Oxygen is used for chemical synthesis.
- Oxygen is used to supplement or replace air in burners used in many different industries in order to obtain increased temperatures. Typical applications are found in the steel, non-ferrous, glass and concrete industries, amongst many others.
- Oxygen is used for flame sealing of glass ampuls for finished products for the pharmaceutical industry and the chemical industry.
- Oxygen is used for enrichment of air during fermentation.
- Mixed with other gases, oxygen serves in the production of breathable atmospheres ($O_2 + CO_2$: reanimation; O_2 + He or $O_2 + N_2$: underwater diving).
- Oxygen is used in some cases for modified atmosphere packaging (MAP) of food stuffs. It is used in mixtures with carbon dioxide and/or nitrogen.

Refrigerants

The Afrox Refrigerants Range

Afrox Refrigerants supplies the complete range of refrigerant gases.

Our product range includes:

- HFC gases such as R134A, R404A, R410A and R507A
- HFO refrigerant including 1234YF
- HCFC replacement gas such as R427a
- Natural refrigerants including R744 (refrigerant-grade CO_2), ammonia (R717), and hydrocarbons (R600a and R290).

We also provide technical support and advice relating to legislation and HCFC alternatives. Whatever your application, wherever your location, Afrox will have the right refrigerant for you.

Quality Guarantee

Afrox guarantees that products are of the highest quality and will meet customer requirements. All disposable cylinders are dot 39 Cylinders.

Sales and Technical Advice

Afrox has a team of knowledgeable & experienced people to assist with queries.

Placing Orders

Orders for Afrox refrigerants may be placed directly with our national call centre on 0860 020202. Orders may also be collected from Afrox Gas & Gear retail centres and branches around the country.

Description

All fluorocarbon refrigerant gases contain one or more carbon and fluorine atoms and are organic compounds. Atoms of chlorine, hydrogen and bromine may also be present.

Characteristics

Some characteristics of these gases include:

- High density
- Low boiling point
- Low viscosity and surface tension
- Excellent chemical and thermal stability
- Capacity to be supplied in liquefied gas form, using low pressure cylinders.

Applications

Many of the current refrigeration and HVAC applications would not be possible without the use of fluorocarbon refrigerants. Different refrigerants due to their properties allow for their conditions of cooling.

Classification	High Temp.	Medium Temp.	Low Temp.	Very Low Temp.
Evaporator Temperature	Above 0°C	0°C to -25°C	-25°C to -50°C	Below -50°C

The table below provides a quick summary of the four main refrigeration process segments and the relevant process temperatures for each.

	High Temp.	Medium Temp.	Low Temp.	Very Low Temp.
Domestic Refrigeration	✓	✓		
Commercial Refrigeration		✓	✓	
Industrial Refrigeration	✓	✓	✓	✓
Transport Refrigeration		✓	✓	

ASHRAE Designations

ASHRAE designates a number which identifies different refrigerants based on the chemical makeup and stability of each product.

The designations are:

R10 to R50	Methane series refrigerants
R10 to R170	Ethane series refrigerants
R216ca to R290	Propane series refrigerants
RC316 to RC318	Cyclic organic compound refrigerants
R400 to R411B	Zeotropic blend refrigerants
R500 to R509	Azeotropic blend refrigerants
R600 to R620	Miscellaneous organic compound refrigerants
R630 to R631	Nitrogen compounds
R702 to R764	Inorganic compounds
R1112A to R1270	Unsaturated organic compounds

Ozone Depletion

Traditional fluorocarbon refrigerants, such as R12, R22, and R502, have been identified as contributing to ozone depletion and the greenhouse effect.

The reason for this is that these refrigerants contain chlorine molecules. Once released, the chlorine molecules are held within the polar stratospheric clouds.

These compounds, which include hydrochloric acid and hydrogen chloride, are not reactive to ozone in their compound state and remain inactive during winter.

During spring, however, ultraviolet radiation penetrates the atmosphere and encounters these stratospheric ice clouds.

The radiation acts as a catalyst, resulting in reactions on the surface of the clouds which release reactive chlorine monoxide. It is this chlorine monoxide which destroys the ozone.

The effect halons, CFCs and HCFCs have had on the ozone layer are internationally recognised by the Montreal Protocol of which South Africa is a signatory.

Global Warming

Greenhouse gases can potentially alter these favourable conditions on earth by trapping the heat that earth radiates back to space. Thus the potential for global warming increases with the concentration of these greenhouse gases.

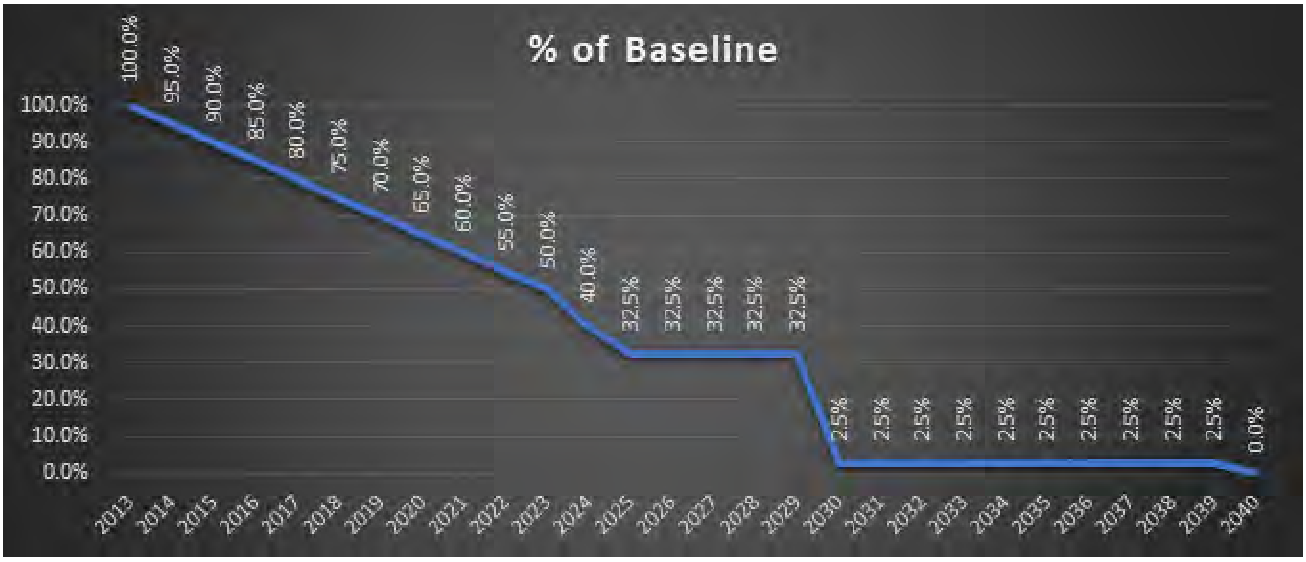
HFC refrigerants, as fluorinated compounds, contribute to the greenhouse effect due to the longevity of their atmospheric life.

To counteract these problems, the control on emissions of greenhouse generating gases was ratified within the Kyoto Protocol in 1997.

Phasing Out of HCFCs Timeframe

- Freeze consumption in 2013 at the baseline consumption (2009-2010)
- 2014 to 2023 is 5% reduction year on year off the baseline
- 2024 a further 10% reduction to a level of 50% off baseline
- 2025 to 2029 reduction to a level of 32,5% of baseline
- 2030 to 2039 reduction to 2,5% of baseline
- 2040 is a total phase out of HCFC use.

Action	Date
Quota system for the assignment of import licenses for all HCFC	1 January 2013
Ban on import of HCFC-141b either in pure form or as a component of blended chemicals; for the purpose of placing on the market or use in the production of polyurethane foams or as solvents or any other application	1 January 2016
Ban of import of any new or used air-conditioning systems or equipment fitted with a compressor and pre-charged or partially charged with HCFC-22 or any refrigerant or refrigerant blend containing any HCFC	1 July 2014
Ban on the use of HCFC-22 (or any other refrigerant containing HCFCs), either in pure form or as a component of blended refrigerants; in the construction, assembly or installation of any new refrigeration or air-conditioning system or equipment which requires a compressor to be fitted in South Africa	1 January 2015
Mandatory recovery and recycling of HCFCs and other ODS refrigerant	1 September 2014
License/certification required for anyone purchasing refrigerant	1 January 2015



Refrigerants R134A

R134A is an HFC, it is a colourless, non-flammable gas at atmospheric pressure with a slight odour. Supplied at low pressure in welded metal cylinders.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

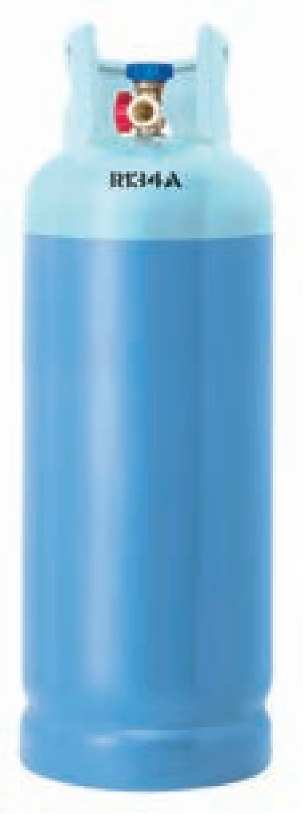
Hazards

- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	Purity
HFC-134A, 1, 1, 1, 2 Tetrafluoroethane $C_2H_2F_4$	>99,7 (%)

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R134A**
Boiling Point	-26,3°C
Bubble Pressure (absolute)	572,1 kPa
Relative Density Air = 1	3,601
Molecular Weight	102 kg/kmol
Critical Temperature	101°C
Critical Pressure	4 059 kPa
Liquid Density	1 225 kg/m³
ODP R11 = 1	0
GWP CO_2 = 1	1 300

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
W341045	Disposable	13,6	1/4" flare
578013-LG-N	Cylinder	60,0	5/8" BSPF right hand male
578013-TC-N	Drum	850,0	
578013-LC-N	Cylinder	22,0	



Retrofit Information

Replacement for:	R12	With the phasing out of CFCs, R134a was introduced as a replacement for R12 systems in flooded evaporators and shell and tube systems chillers, white goods and automotive
Other alternatives/replacements:	R1234yf	Due to the high GWP of R134a, this gas is being replaced by HFO R1234yf in automotive and other applications using R134a. White goods is moving across to the hydrocarbon refrigerants R600, R600a and R290
Compatible lubricants:	PAG-Auto, POE	

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	1 300
Global Warming Potential (Rating)	☀ ☀ ☼

Safety Information

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Domestic Refrigeration

Commercial Refrigeration

Transport/Refrigeration

Commercial Refrigeration:
Plug-ins & Vending Machines

Industrial Refrigeration

Residential & Light Air-conditioning

Industrial/Commercial Air-conditioning
DX Chillers

Industrial/Commercial
Centrifugal Compressors

Mobile Air-conditioning

Temperature Range

Med High

Refrigerants R427A

R427A, also known as Forane® 427A, is an HFC blend. It is a non-toxic, non-flammable, zero-ODP (Ozone Depletion Potential) refrigerant. R427A has the lowest GWP of R22 retrofit replacement refrigerants.

Gas	%
Forane® – 134a (1,1,1,2-Tetrafluororethane)	50
Forane® – 125 (Pentafluoroethane)	25
Forane® – 32 (Difluoromethane)	15
Forane® – 143a (1,1,1-Trifluoroethane)	10
Purity of each component (%)	≥99,5 wt

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R427A**
Moisture	≤10 ppm
Chlorine Ion Test	Negative
Air Vapour Phase	≤1,5%
Total Acidity	≤ 1 ppm
Boiling Point	-42,7°C
Temperature Glide	7 K
Latent Heat of Vaporisation at n.b.p.	223,3 kJ/K
Critical Temperature	85,3°C
Critical Pressure	4,39 MPa
Liquid Density at 20°C	1,172 kg/m^3
Vapour Pressure at 20°C	0,97 MPa
ODP R11 = 1	0
GWP CO_2 = 1	2 138

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
578042-LA-N	Cylinder	10,0	5/8" BSPF right hand female
578042-LG-N	Cylinder	59,0	5/8" BSPF right hand female
578042-TA-N	Drum	800,00	5/8" BSPF right hand female

Retrofit Information:

Replacement for:	R22
Retrofit gas or design for new equipment?	R427A is suitable as a retrofit gas for R22
Other alternatives/replacements:	R417A, R422A, R422D, R424A, R434A, R437A, R438A
Compatible lubricants:	POE

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	2 138
Global Warming Potential (Rating)	☀ ☀ ☼

Safety Information

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Commercial Refrigeration

Commercial Refrigeration:
Plug-ins & Vending Machines

Industrial/Commercial Air-conditioning
DX Chillers

Industrial Refrigeration

Residential & Light Air-conditioning

Temperature Range

Low Med High

Refrigerants R22

R22 is an HCFC. It is a colourless, non-flammable, non-toxic gas. In low concentrations, it is odourless. In higher concentrations, its odour is mild. It is shipped in steel cylinders as a liquefied gas.

QUOTA RESTRICTION
- due to HCFC phase out

Precautions in Use

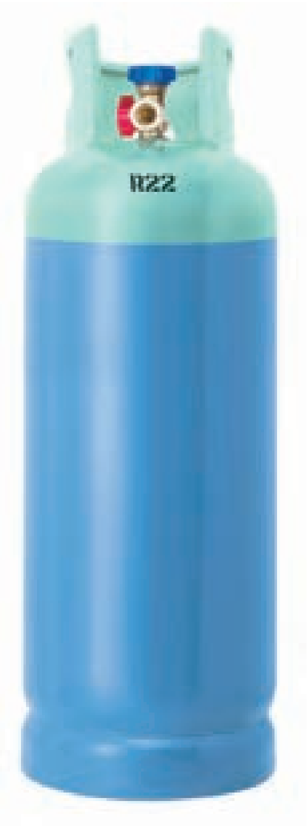
- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Dangerous for the ozone layer - part of phase-out schedule
- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	Purity
HCFC-22 Chlorodifluoromethane $CHClF_2$	>99,5 (%) wt

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R22**
Boiling Point	-40,8°C
Bubble Pressure (absolute)	910,3 kPa
Relative Density Air = 1	3,032
Molecular Weight	86,47 kg/kmol
Critical Temperature	96,13°C
Critical Pressure	4 989 kPa
Liquid Density	1 210 kg/m^3
ODP R11 = 1	0,055
GWP CO_2 = 1	1 760



Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
W341078	Disposable	13,6	1/4" flare
577022-LG-N	Cylinder	59,0	5/8" BSPF right hand male
577022-TA-N	Drum	785,0	

Retrofit Information:

Replacement for:	R12	Designed as a safer, less toxic alternative to replace NH3 systems Operates at similar pressure to temperature parameters
Other alternatives/replacements:	R404a, R417A, R422A, R422D, R424A, R427A, R428A, R434A, R438A	
Compatible lubricants:	MO, AB	

All virgin HCFCs, including R22, are being phased out as of 1 January 2013.

Environmental Impact

Ozone Depletion Potential (ODP)	0,055
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	1 760
Global Warming Potential (Rating)	☀ ☀ ☀

HCFCs contribute both to ozone depletion and global warming. Therefore the use of HCFCs including R22 is being phased out according to the schedule detailed set by the Montreal Protocol due to its ozone depleting potential. Afrox recommends considering alternative solutions.

Safety Information

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Commercial Refrigeration

Commercial Refrigeration: Plug-ins & Vending Machines

Industrial/Commercial Air-conditioning DX Chillers

Industrial Refrigeration

Residential & Light Air-conditioning

Industrial/Commercial Centrifugal Compressors

Transport/Refrigeration

Temperature Range

Low Med High

Refrigerants R404A

R404A is an HFC blend. It is a colourless, non-flammable gas mixture at atmospheric pressure with a slight odour. Supplied in low pressure cylinders. R404a is a near azeotropic blend of refrigerant and may be used as an alternative gas for R22 systems with an oil change.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	%
HFC-143a Trifluoroethane	52
HFC-125 Pentafluoroethane	44
HFC-134a Tetrafluoroethane	4
Purity (%)	>99,7

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R404A**
Boiling Point	-46,6°C/-45,8°C
Bubble Pressure (absolute)	1 088 kPa
Relative Density Air = 1	3,429
Molecular Weight	97,6 kg/kmol
Critical Temperature	72,15°C
Critical Pressure	3 735 kPa
Liquid Density	1 066 kg/m^3
ODP R11 = 1	0
GWP CO_2 = 1	3 922

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
W341079	Disposable cylinder	10,9	1/4” flare
578040-LG-C	Cylinder	44,0	5/8” BSPF right hand male

Retrofit Information:

Replacement for:	R502, R22
Retrofit gas or design for new equipment?	R404A is suitable for use in new equipment as a replacement for older R502 applications. It can also be used to retrofit some old systems with an oil change
Other alternatives/replacements:	R407A, R407F, R442A
Compatible lubricants:	POE

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	3 922
Global Warming Potential (Rating)	☀ ☀ ☀

Safety Information

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Commercial Refrigeration

Commercial Refrigeration :
Plug-ins & Vending Machines

Industrial Refrigeration

Transport/Refrigeration

Temperature Range

Low

Med

Refrigerants R152A

R152A is most commonly used as a component within other refrigerant blends, as a propellant, and in some XPS foams. Its relatively low global warming potential when compared to other HFCs is desirable; however, its flammability creates challenges, thus limiting its use.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Extremely flammable gas
- Contact with liquid may cause frostbite and injury
- Inhalation of high concentration of vapour is harmful to health
- Material can be decomposed by high temperatures forming hydrofluoric acid, and possibly carbonyl fluoride

Gas	%
1,1-Difluoroethane $C_2H_4F_2$	100

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R152A**
Chemical Symbol	CH2H4F2
Molecular weight	66,05 kg/kmol
Critical temperature	113,26 °C
Critical Pressure	47,6 bar
Specific Gravity	2.36
Boiling point @ 101,325 kPa	-24,70C
ODP	0
GWP	138

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
578015-LG-N	Cylinder	47,0	G5/8" LH-F
578015-TB-N	Drum	658	5/8" BSPF right hand male

Retrofit Information:

Replacement for:	R134a
Retrofit gas or design for new equipment?	R152a is suitable for use in new equipment
Other alternatives/replacements:	R134a, R227ea, R245fa, R600a, Pentanes
Compatible lubricants:	-

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	138
Global Warming Potential (Rating)	☀

Safety Information

ASHRAE Safety Group (2013)	A2
ASHRAE Flammability	Yes
ASHRAE Toxicity	No

Common Refrigerant Applications

Propellant

Foam Blowing Agent

Temperature Range

High

Refrigerants R407C

R407C is an HFC blend. It is a colourless and non-flammable gas mixture at atmospheric pressure with a slight odour. Supplied in low pressure cylinders.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	%
HFC-32 Difluoromethane	23
HFC-125 Pentafluoroethane	25
HFC-134a Tetrafluoroethane	52
Purity (%)	>99,7

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R407C**
Boiling Point	-43,8°C/-36,7°C
Bubble Pressure (absolute)	864,8 kPa
Relative Density Air = 1	3,022
Molecular Weight	86,2 kg/kmol
Critical Temperature	86,79°C
Critical Pressure	4 597 kPa
Liquid Density	1 157 kg/m^3
ODP R11 = 1	0
GWP CO_2 = 1	1 774

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
W341107	Disposable Cylinder	11,3	1/4" flare

Retrofit Information:

Replacement for:	R22
Retrofit gas or design for new equipment?	R407C is suitable for use in new equipment. It can also be used to retrofit some old R22 systems with an oil change
Other alternatives/replacements:	R407A, R407F
Compatible lubricants:	POE

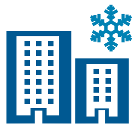
Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	1 774
Global Warming Potential (Rating)	☀ ☀ ☼

Safety Information

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

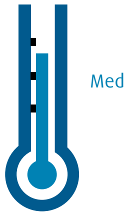


Industrial/Commercial Air-conditioning
DX Chillers

Industrial Refrigeration

Residential & Light Air-conditioning

Temperature Range



All virgin HCFCs, including R22, are being phased out as of 1 January 2013.

Refrigerants R417A

R417A (ISCEON® 59) has been primarily developed to replace R22 in air-conditioning applications but has also been successfully utilised in refrigeration applications such as commercial refrigeration.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	%
HFC - 1,1,1,2-Tetrafluoroethane - R134a	50
HFC -Pentafluoroethane - R125	46,6
HC - N-butane - R600	3,4
Purity (%)	>99,8

Physical Data	
Reference: Pabs = 101,325 kPa T = 25°C	**R417A**
Boiling Point	-41,2°C/-40,1°C
Bubble Pressure (absolute)	8,57 bar
Relative Density Air = 1	1 172,20 kg/m^3
Molecular Weight	109 kg/kmol
Critical Temperature	89,89°C
Critical Pressure	4 102 kPa
Liquid Density	41,07 kg/m^3
ODP R11 = 1	0
GWP CO_2 = 1	2 346

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
W341083	Disposable Cylinder	13,0	1/4” flare

Retrofit Information:

Replacement for:	R22
Retrofit gas or design for new equipment?	R407C is suitable for use in new equipment. It can also be used to retrofit some old R22 systems with an oil change
Other alternatives/replacements:	R407A, R407F
Compatible lubricants:	POE

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	2 346
Global Warming Potential (Rating)	☀ ☀ ☼

Safety Information

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Industrial/Commercial Air-conditioning
DX Chillers

Industrial Refrigeration

Residential & Light Air-conditioning

Temperature Range

Refrigerants R410A

R410A is an HFC blend. It is non-flammable and non-toxic. It operates at high pressures and cannot be used as a retrofit for R22 systems. Systems designed for R410A can take advantage of its ability to use smaller components.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	%
HFC-32 Difluoromethane	50
HFC-125 Pentafluoroethane	50
Purity (%)	>99,7 wt

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R410A**
Boiling Point	-51,6°C/-51,5°C
Bubble Pressure (absolute)	1 437 kPa
Relative Density Air = 1	2,543
Molecular Weight	72,58 kg/kmol
Critical Temperature	72,13°C
Critical Pressure	4 770 kPa
Liquid Density	1 087 kg/m^3
ODP R11 = 1	0
GWP CO_2 = 1	2 088

Item Number	Cylinder Size	Contents (kg)	Valve Outlet Connection
W341134	Disposable cylinder	11,3	1/4" flare

Retrofit Information:

Replacement for:	R22, R13B1
Retrofit gas or design for new equipment?	R410A is suitable for new equipment designed to operate with the higher pressure necessary for this gas
Other alternatives/replacements:	R32, MO89, R23, R508B
Compatible lubricants:	POE

All virgin HCFCs, including R22, are being phased out as of 1 January 2013.

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	2 088
Global Warming Potential (Rating)	☀ ☀ ☼

Safety Information:

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

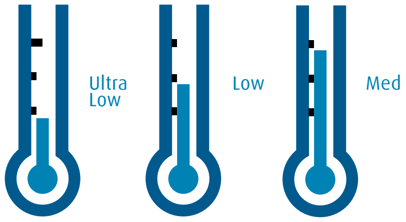
Industrial Refrigeration

Industrial/Commercial Centrifugal Compressors

Industrial/Commercial Air-conditioning DX Chillers

Residential & Light Air-conditioning

Temperature Range



Refrigerants R507A

R507A is an HFC blend. It is a colourless, non-flammable gas mixture at atmospheric pressure with a slight odour. Supplied in low pressure cylinders.

Precautions in Use

- Wear safety goggles, use leather/plastic protective gloves, wear overall and safety shoes when handling cylinders.

Hazards

- Asphyxiant in high concentrations
- Sudden expansion will produce low temperatures.

Gas	%
HFC-125 Pentafluoroethane	50
HFC-143a Trifluoroethane	50
Purity (%)	>99,7 wt

Physical Data	
Reference: Pabs = 101,325 kPa T = 20°C	**R507A**
Boiling Point	-46,7°C/-40°C
Bubble Pressure (absolute)	1 126 kPa
Relative Density Air = 1	3,471
Molecular Weight	98,86 kg/kmol
Critical Temperature	70,74 °C
Critical Pressure	3 714 kPa
Liquid Density	1 070 kg/m^3
ODP R11 = 1	0
GWP CO_2 = 1	3 985

Item Number	Cylinder Size	Contents (kg)	Charging Pressure kPa at 20°C	Valve Outlet Connection
W341080	Disposable	11,3	Vapour Pressure	1/4" flare

Retrofit Information:

Replacement for:	R502, R22
Retrofit gas or design for new equipment?	R507A is suitable for use with new equipment in applications that used to use R502
Other alternatives/replacements:	R404A, R407A, R407F
Compatible lubricants:	POE

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	3 985
Global Warming Potential (Rating)	☀ ☀ ☀

Safety Information:

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Industrial Refrigeration

Industrial/Commercial Centrifugal Compressors

Temperature Range

Low

Med

HFOs

Refrigerant solutions with zero ODP and very low GWP.

HFOs (hydrofluoro-olefins) are the fourth generation of fluorine based gases. HFC refrigerants are composed of hydrogen, fluorine and carbon atoms connected by single bonds between the atoms.

HFO 1234yf, which is sold under the brand names Opteon^{TM} YF, is produced by Du Pont. This is a low GWP (Global Warming Potential) replacement for R134a for use in mobile air-conditioning (MAC) systems in the automotive sector.

HFO refrigerants are categorised as having zero ODP (Ozone Depletion Potential) and low GWP and so offer a more environmentally friendly alternative to CFCs, HCFCs and HFCs.

Opteon^{TM} YF (R1234yf)

R1234yf is a next generation refrigerant gas.

It combines environmental benefits with excellent cooling performance. Consequently, Opteon® YF has been chosen by many automotive OEMs as the low GWP refrigerant of choice.

Afrox offers this refrigerant in a range of package sizes to suit all applications.

Please contact the special gases division at the Afrox Customer Service Centre on 0860 020202.

Retrofit Information:

Replacement for:	R134a
Retrofit gas or design for new equipment?	R1234yf is designed for new systems. It is slightly flammable and therefore is not suitable for retrofitting existing R134a systems
Other alternatives/replacements:	SOLSTICE yf
Compatible lubricants:	PAG-Auto, POE

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	4
Global Warming Potential (Rating)	☀ ☼ ☼

Safety Information:

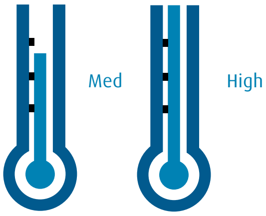
ASHRAE Safety Group (2013)	A2L
ASHRAE Flammability	Yes (Low)
ASHRAE Toxicity	No

Common Refrigerant Applications

Domestic Refrigeration

Mobile Air-conditioning

Temperature Range



Natural Refrigerants

Much of the refrigeration and air-conditioning equipment today uses flourocarbon refrigerants to facilitate the heat transfer process. These refrigerants are synthetic chemicals that have an impact on the environment and lead to global warming.

Alternatives to these chemicals do exist.

Natural refrigerants have zero-ozone depleting potential and very low global warming potential. These products were used before the 1950s prior to fluorocarbon production and are now being used more extensively due to their low impact on the environment.

Natural refrigerants are chemicals which occur in nature's bio-chemical processes. They do not deplete the ozone layer and make a negligible (or zero in the case of R-717 ammonia) contribution to global warming. Their high efficiency means they make a much lower, indirect contribution to global warming than many synthetic refrigerants.

Afrox has a wealth of experience and expertise in environmentally friendly refrigerants. We offer a wide selection of products including:

- R717 (Ammonia)
- R744 (Carbon dioxide)

Ammonia R717

Ammonia has been used in industrial applications since the 1930s and is generally acknowledged as the most efficient refrigerant. It has a low boiling point and is favoured because it is a highly energy efficient refrigerant.

Afrox offers the highest industry specification for refrigerant ammonia, meeting both the IIAR and ASHRAE specifications.

Afrox refrigerant grade ammonia is 99,98% pure with minimal levels of moisture and other impurities (<200 ppm and <10 ppm oil) making it ideal for usage in all types of refrigeration systems.

Product Description	Size (kg)	Material Number	Recommended Regulator
Ammonia N3.5	68,0	540201-LH-N	W020120
Ammonia N3.5	1 400,0	540201-TE-C	Recommendation on Request
Ammonia N2.5	Bulk	5374	Recommendation on Request

Contact the Afrox Customer Service Centre on 0860 020202.

Retrofit Information:

Replacement for:	R22, R134a
Retrofit gas or design for new equipment?	R717 is suitable for new R717 systems. It is a toxic and slightly flammable refrigerant and therefore not suitable for retrofitting existing fluorocarbon refrigerant systems
Other alternatives/replacements:	R134a
Compatible lubricants:	Consult OEM

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	0
Global Warming Potential (Rating)	☀ ☀ ☀

Common Refrigerant Applications

Industrial Refrigeration

Transport/Refrigeration

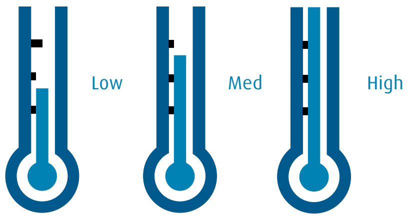
Industrial/Commercial Air-conditioning DX Chillers

Industrial/Commercial Centrifugal Compressors

Safety Information:

ASHRAE Safety Group (2013)	**B2L**
ASHRAE Flammability	**Yes (Low)**
ASHRAE Toxicity	**No**

Temperature Range



R744 (Refrigerant Grade Carbon Dioxide)

R744 is an environmentally friendly product. It has excellent thermodynamic properties and low energy usage, making it suitable for a range of applications. Refrigeration CO_2 systems require tight controls on moisture, oil and other impurities. Industrial grade CO_2 does not meet this requirement.

Carbon dioxide is a traditional refrigerant which dates back to 1850. R744 is now regaining popularity due to its low environmental impact.

One major difference between R744 and other refrigerants is its pressure/temperature characteristic. Due to its high pressure and low critical temperature refrigeration systems require special equipment.

R744 is often used as a secondary refrigerant along with ammonia, thereby opening up applications where ammonia as a single-stage refrigerant would not be applicable.

Refrigerant grade CO_2 is available in a variety of cylinder sizes and drums.

Product Description	Size (kg)	Material Number	Recommended Regulator
R744 (Carbon Dioxide) (Dry)	31,3	502922-RC-C	Recommendation on Request
R744 (Carbon Dioxide) (Wet)	31,3	503169-RC-C	Recommendation on Request
R744 (Carbon Dioxide) (Dry)	5,6	502922-HB-C	Recommendation on Request

Contact the Afrox Customer Service Centre on 0860 020202.

Retrofit Information:

Replacement for:	R134a, R404A, R22 systems
Retrofit gas or design for new equipment?	R744 is suitable for new R744 systems. It has high pressure and a low critical temperature, therefore it is not suitable for retrofitting existing fluorocarbon refrigerant systems
Other alternatives/replacements:	R290
Compatible lubricants:	Consult OEM

Environmental Impact

Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	☁ ☁ ☁
Global Warming Potential (GWP)	1
Global Warming Potential (Rating)	☀ ☼ ☼

Safety Information:

ASHRAE Safety Group (2013)	A1
ASHRAE Flammability	No
ASHRAE Toxicity	No

Common Refrigerant Applications

Commercial Refrigeration

Commercial Refrigeration: Plug-ins & Vending Machines

Industrial/Commercial Air-conditioning DX Chillers

Industrial Refrigeration

Transport/Refrigeration

Industrial/Commercial Centrifugal Compressors

Mobile Air-conditioning

Temperature Range

Low

Med

High

Refrigerant Recovery

Afrox, in conjunction with Hudson Technologies (a leading US refrigeration technology company), has developed a set of exclusive services for the refrigeration industry to keep your business running at the right temperature. Our technology is designed to help contractors and plant owners to ensure their refrigeration plant operates as close as possible to its design parameters and minimise running costs per unit output.

Service	Summary
Recovery	Removal of refrigerant from equipment and collection in an appropriate vessel and may include return of the refrigerant to the plant.
Reclamation	This is the recovery of refrigerant from systems being decommissioned or converted. The refrigerant can be resold. This includes the analytical testing of the refrigerant.
Recycling	Reduce the contaminant levels in used refrigerant by passing product through Hudson equipment (the ZugiBeast). Recycle includes no analytical testing of the refrigerant.

Please contact the special gases cell at CSC on 0860 020202

Whether your application is air-conditioning, commercial refrigeration, process chilling or heat extraction, we can help you satisfy regulatory compliance when your refrigerant gases approach the end of their life cycle.

Our recovery and reclamation solutions minimise the impact of used refrigerants upon the environment. They ensure that used gas is safely removed from a cooling system and on collection reclaimed or destroyed in a way that avoids its release into the atmosphere.

Why the need for refrigerant recovery?

It is well understood that many fluorocarbon refrigerant gases contribute to ozone depletion and global warming.

The Montreal and Kyoto Protocols called for countries around the world to help the environment and phase out harmful refrigerants, replacing them with next-generation fluorocarbon and natural refrigerants. Legislation is also driving the need to reduce emissions via reduced charge sizes within refrigeration systems, improved equipment design, better maintenance and inspection procedures. Companies have also come to recognise their ethical obligation to protect the environment.

Even with these changes, any refrigerant will, however, end up as waste when it comes to the end of its life within the refrigeration/cooling system. It is therefore a business imperative to responsibly dispose of used refrigerants.

At Afrox we have the expertise to help you reclaim and reuse refrigerants wherever possible. Refrigerant reclamation delivers measurable business benefits. Enabling you to meet environmental obligations through best-practice. It:

- Avoids the release of ozone depleting and global warming gases
- Eliminates the need to produce new refrigerants

We provide comprehensive, cost-effective services tailored to the needs of refrigeration systems large or small through the:

- Supply of recovery cylinders that enable on-site collection (small volumes)
- Direct collection of larger volumes in drums
- On-site recovery and system rectification service (selected areas)
- Refrigerant reclamation
- Environmentally friendly waste destruction services
- Expert advice regarding legal requirements including waste gas management regulations certification and environmental reporting
- Certification of treatment - legal proof of responsible refrigerant care.

At Afrox we guarantee the quality of our reclaimed refrigerants - unlike recycled products, they meet Air-conditioning, Heating and Refrigeration Institute (AHRI) 700 specification. This ensures:

- Reduced risk of hydrolysis, corrosion or compressor failure
- Reduced risk of rogue thermodynamic properties in the fluid
- Optimal equipment operation and energy efficiency
- Compliance with consumer and legislative demand
- Delivery of the corporate sustainability agenda.

Key Business Benefits

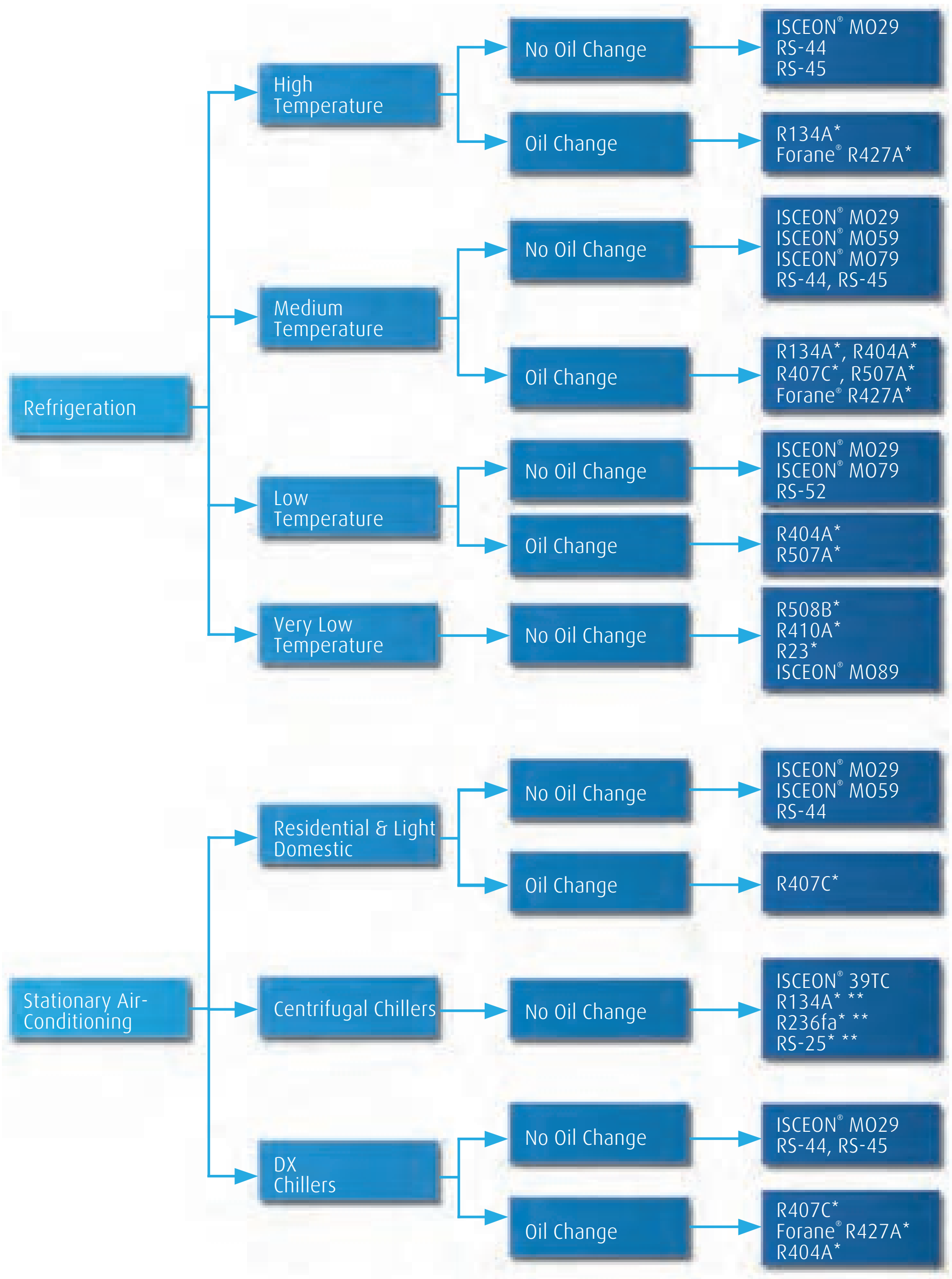
The benefits for your company are universal:

- Minimise risk associated with used refrigerants - avoid harmful ozone depletion and global warming
- Eliminate unnecessary production of new refrigerants - reuse/reclaim to maintain current volumes
- Satisfy consumer and legislative demand
- Deliver on the corporate sustainablity agenda
- Outsource specialist expertise and focus on what you do best.

Afrox - your coolest refrigerant partner

HFC Guide

Guide to the HFC Retrofit Gases into Existing HCFC Systems



* Polyolester oil (POE) must be used

** Possible replacement products in centrifugal chillers. Consult compressor manufacturer first

Note: ISCEON® MO79 and RS-52 are retrofit gases for R502 and will require systems to be suitable for R502 pressures, and an expansion device suitable for R404A.

For all other applications, refer to Afrox.

Contact the refrigerants team on 0860 020202.

Dew Point Pressure Chart (Gauge Pressure) @ Altitude 85 kPa

Replace	R11	R12			R22			R502			Replace
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
-50	-83,227	-55,52	-58,973	-53,5	-20,48	-34,93	24,5	1,08	-2,73	-7,56	-50
-48	-82,940	-51,92	-55,816	-49,78	-13,56	-28,94	33,8	10,16	5,89	0,39	-48
-46	-82,628	-47,97		-45,705	-6,09	-22,39	48,1	19,97	15,2	8,98	-46
-44	-82,27	-43,64	-48,57	-41,28	2,04	-13,27	61,3	30,54	25,2	18,24	-44
-42	-81,867	-38,91	-44,437	-36,42	10,8	-7,53	75,6	41,92	36,1	28,2	-42
-40	-81,414	-33,75	-39,934	-31,15	20,2	0,87	90,9	54,15	47,7	38,99	-40
-38	-80,907	-28,14	-35,037	-25,43	30,4	9,96	107,3	67,26	60,2	50,47	-38
-36	-80,341	-22,05	-29,722	-19,23	41,3	19,8	124,9	81,29	73,6	62,73	-36
-34	-79,71	-15,44	-23,964	-12,53	53	30,4	143,7	96,3	87,9	75,92	-34
-32	-79,009	-8,29	-17,736	-5,29	65,5	41,8	163,8	112,3	103,2	90,01	-32
-30	-78,232	-0,57	-11,012	2,52	78,9	54	185,2	129,37	119,5	105,04	-30
-28	-77,373	7,76	-3,765	10,93	93,2	67,1	208,1	147,53	136,9	121,07	-28
-26	-76,424	16,7	4,033	19,97	108,5	81,2	232,4	166,83	155,4	138,13	-26
-24	-75,38	26,4	12,412	29,67	124,7	96,2	258,2	187,32	175	156,27	-24
-22	-74,23	36,7	21,4	40,07	142	112,3	285,6	209,04	195,9	175,53	-22
-20	-72,97	47,8	31,03	51,19	160,4	129,4	314,7	232,03	218	195,97	-20
-18	-71,59	59,7	41,35	63,09	179,6	147,7	345,5	256,36	241,4	217,62	-18
-16	-70,09	72,4	52,38	75,79	200,5	167,1	378,1	282,06	266,2	240,53	-16
-14	-68,44	85,9	64,08	89,33	222,4	187,7	412,5	309,18	292,4	264,76	-14
-12	-66,65	100,4	76,58	103,75	245,5	209,6	448,8	337,77	320	290,36	-12
-10	-64,71	115,7	89,9	119,09	269,9	232,8	487,1	367,88	349,1	317,36	-10
-8	-62,6	132,1	104,04	135,39	295,6	257,4	527,3	399,57	379,8	345,83	-8
-6	-60,31	149,4	119,06	152,68	322,8	283,4	570	432,89	412,1	375,82	-6
-4	-57,84	167,9	134,99	171,01	351,4	310,8	614,8	467,89	446	407,38	-4
-2	-55,17	187,4	151,86	190,43	381,3	339,9	661,8	504,63	481,6	440,56	-2
0	-52,29	208	169,71	210,96	413,1	370,1	711,1	543,17	519	475,41	0
2	-49,2	229,8	188,57	232,67	446,4	402,8	762,9	583,55	558,3	511,99	2
4	-45,87	252,9	208,49	255,59	481,2	436,8	817,2	625,85	599,4	550,36	4
6	-42,29	277,2	229,53	279,77	517,8	472,6	874,1	670,12	642,4	590,57	6
8	-38,46	302,9	251,66	305,25	556,1	510,3	934	716,43	687,5	632,68	8
10	-34,35	329,9	274,97	332,08	596,2	549,9	996	764,84	734,6	676,75	10
12	-29,97	358,3	299,51	360,31	638,1	591,6	1 061	815,42	783,8	722,82	12
14	-25,28	388,2	325,29	389,96	681,9	635,3	1 129	868,23	835,2	770,97	14
16	-20,28	419,6	352,37	421,15	727,7	681,2	1 200	923,35	888,8	821,26	16
18	-14,95	452,5	380,78	453,87	775,3	729,3	1 275	980,86	945	873,73	18
20	-9,29	487,1	410,57	488,16	825,3	779,8	1 352	1 040,82	1 003	928,46	20
22	-3,26	523,3	441,78	524,14	877,3	832,7	1 433	1 103,31	1 064	985,5	22
24	3,13	561,2	474,45	561,8	931	888,1	1 517	1 168,43	1 127	1 044,92	24
26	9,92	600,6	508,64	601,2	988	946	1 605	1 236,25	1 193	1 106,79	26
28	17,1	642,3	544,37	642,41	1 046	1 007	1 696	1 306,86	1 261	1 171,15	28
30	24,7	685,6	581,71	685,49	1 107	1 070	1 791	1 380,34	1 333	1 238,09	30
32	32,8	730,9	620,68	730,48	1 171	1 137	1 889	1 456,81	1 407	1 307,66	32
34	41,3	778,1	661,35	777,45	1 236	1 206	1 990	1 536,35	1 483	1 379,94	34
36	50,2	827,4	703,76	826,45	1 305	1 279	2 099	1 619,06	1 563	1 454,998	36
38	59,7	878,7	747,95	877,53	1 376	1 354	2 210	1 705,06	1 646	1 532,87	38
40	69,7	932	793,97	930,77	1 449	1 434	2 325	1 794,45	1 732	1 613,66	40
42	80,1	988	841,88	986,21	1 525	1 516	2 444	1 887,36	1 822	1 697,42	42
44	91,2	1 046	891,72	1 043,91	1 604	1 602	2 568	1 983,9	1 914	1 784,23	44
46	102,8	1 106	943,5	1 103,95	1 686	1 692	2 697	2 084,2	2 010	1 874,16	46
48	115	1 169	997,4	1 166,38	1 771	1 785	2 830	2 188,38	2 110	1 967,29	48
50	127,7	1 234	1 053,4	1 231,27	1 858	1 883	2 968	2 296,6	2 213	2 063,67	50
52	141,1	1 301	1 111,3	1 298,69	1 949	1 984	3 112	2 408,99	2 320	2 163,4	52
54	155,1	1 371	1 171,6	1 368,69	2 043	2 090	3 260	2 525,71	2 430	2 266,54	54
56	169,8	1 444	1 234,3	1 441,35	2 140	2 200	3 414	2 646,9	2 545	2 373,18	56
58	185,2	1 520	1 299,2	1 516,73	2 240	2 314	3 573	2 772,75	2 664	2 483,37	58
60	201,3	1 598	1 366,5	1 594,92	2 343	2 433	3 738	2 903,41	2 787	2 597,23	60
62	218	1 679	1 436,1	1 675,97	2 450	2 556	3 908	3 039,08	2 914	2 714,81	62
64	235,5	1 763	1 508,3	1 759,97	2 560	2 684	4 085	3 179,93	3 046	2 836,2	64
66	253,8	1 850	1 583,1	1 846,99	2 674	2 817	4 267	3 326,17	3 183	2 961,48	66
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
Replace	R11	R12			R22			R502			Replace

Bubble Point Pressure Chart (Gauge Pressure) @ Altitude 85 kPa

Replace	R11	R12			R22			R502			Replace
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
-50	-83,227	-55,52	-41,51	-35,08	-20,46	-9,93	24,8	2,96	0,68	-7,56	-50
-48	-82,946	-51,92	-36,77	-29,71	-13,56	-2,00	36,1	12,02	9,51	0,39	-48
-46	-82,628	-47,07	-31,63	-23,89	-6,06	8,58	48,4	21,8	19,0	8,98	-46
-44	-82,270	-43,64	-26,05	-17,59	2,04	15,6	61,7	32,3	29,3	18,2	-44
-42	-81,867	-38,91	-20,03	-10,78	10,80	25,8	76,0	43,7	40,4	28,2	-42
-40	-81,414	-33,75	-13,53	-3,44	20,2	36,6	91,3	55,8	52,2	38,9	-40
-38	-80,907	-28,14	-6,52	4,47	30,4	48,2	107,8	68,9	65,0	50,4	-38
-36	-80,341	-22,05	1,02	12,97	41,3	60,6	125,4	82,8	78,6	62,7	-36
-34	-79,710	-15,44	9,12	22,1	53,0	71,9	144,3	97,8	93,2	75,9	-34
-32	-79,009	-8,29	17,8	31,9	65,5	88,2	164,4	113,7	108,7	90,0	-32
-30	-78,232	-0,57	27,1	42,4	78,9	103,4	185,9	130,7	125,3	105,0	-30
-28	-77,373	7,76	37,1	53,6	93,2	119,6	208,8	148,8	143,0	121,1	-28
-26	-76,424	16,7	47,7	65,5	108,5	137,0	233,2	168,0	161,8	138,1	-26
-24	-75,380	26,4	59,0	78,2	124,7	155,4	259,1	188,4	181,7	156,3	-24
-22	-74,23	36,7	71,1	91,8	142,0	175,0	286,6	210,0	202,9	175,5	-22
-20	-72,97	47,8	83,9	106,2	160,4	195,8	315,8	233,0	225,3	196,0	-20
-18	-71,59	59,7	97,5	121,6	179,8	217,9	346,7	257,2	249,0	217,8	-18
-16	-70,09	72,4	112,0	137,8	200,5	241,3	379,4	282,8	274,1	240,5	-16
-14	-68,44	85,9	127,3	155,0	222,4	266,0	413,9	309,9	300,6	264,8	-14
-12	-66,65	100,4	143,5	173,2	245,5	292,2	450,3	338,4	328,5	290,4	-12
-10	-64,71	115,7	160,7	192,5	269,9	319,8	488,8	368,5	358,0	317,4	-10
-8	-62,60	132,1	178,8	212,8	295,6	348,9	529,3	400,2	389,0	345,8	-8
-6	-60,31	149,4	197,9	234,3	322,8	379,6	572,0	433,5	421,6	375,8	-6
-4	-57,84	167,9	218,0	256,9	351,4	411,9	610,8	468,5	455,8	407,4	-4
-2	-55,17	187,4	239,2	280,7	381,5	446,0	664,0	505,2	491,8	440,6	-2
0	-52,29	208,0	261,6	305,6	413,1	481,7	713,5	543,8	529,5	475,4	0
2	-49,20	229,8	285,0	332,2	446,4	519,2	765,5	584,2	569,1	512,0	2
4	-45,87	252,9	309,6	359,8	481,2	558,6	820,0	626,5	610,5	550,4	4
6	-42,29	277,2	335,5	388,9	517,8	599,9	877,0	670,8	653,9	590,6	6
8	-38,46	302,8	362,6	419,3	556,1	643,2	937	717,1	699,3	632,7	8
10	-34,33	329,0	390,9	451,2	596,2	688,4	999	765,5	746,7	676,8	10
12	-29,87	358,3	420,6	484,6	638,1	735,8	1 065	816,1	796,2	722,8	12
14	-25,28	388,2	451,7	519,6	681,9	785,3	1 133	868,9	847,9	771,0	14
16	-20,38	419,6	484,1	556,1	727,7	837,0	1 204	924	901,8	821,3	16
18	-14,95	452,5	518,0	594,2	775,5	891,0	1 279	981	958	873,7	18
20	-9,29	487,1	553,3	634,0	825,3	947	1 357	1 041	1 017	928	20
22	-3,26	523,3	590,2	675,5	877,3	1 006	1 437	1 104	1 078	986	22
24	3,13	561,2	628,6	718,8	931	1 067	1 522	1 168	1 141	1 045	24
26	9,92	600,8	668,5	763,8	988	1 131	1 610	1 236	1 207	1 107	26
28	17,1	642,3	710,1	810,7	1 046	1 197	1 701	1 306	1 276	1 171	28
30	24,7	685,6	753,4	859,5	1 107	1 266	1 796	1 379	1 347	1 239	30
32	32,8	730,9	798,4	910,2	1 171	1 337	1 895	1 455	1 422	1 308	32
34	41,3	778,1	845,1	963	1 236	1 412	1 998	1 534	1 499	1 380	34
36	50,2	827,4	893,6	1 018	1 305	1 489	2 105	1 616	1 579	1 455	36
38	59,7	878,7	944	1 074	1 376	1 569	2 216	1 700	1 662	1 533	38
40	69,7	932	996	1 133	1 449	1 652	2 331	1 788	1 748	1 614	40
42	80,1	988	1 050	1 194	1 525	1 738	2 451	1 880	1 837	1 697	42
44	91,2	1 046	1 106	1 258	1 604	1 828	2 575	1 975	1 930	1 784	44
46	102,8	1 106	1 164	1 323	1 686	1 920	2 704	2 073	2 026	1 874	46
48	115,0	1 169	1 224	1 391	1 771	2 016	2 838	2 174	2 125	1 967	48
50	127,7	1 234	1 286	1 461	1 858	2 114	2 976	2 280	2 228	2 064	50
52	141,1	1 301	1 350	1 534	1 949	2 217	3 119	2 389	2 335	2 163	52
54	155,1	1 371	1 417	1 609	2 043	2 322	3 268	2 502	2 446	2 267	54
56	169,8	1 444	1 485	1 686	2 140	2 431	3 421	2 619	2 560	2 373	56
58	185,2	1 520	1 556	1 766	2 240	2 544	3 580	2 739	2 679	2 483	58
60	201,3	1 598	1 629	1 849	2 343	2 660	3 745	2 865	2 801	2 597	60
62	218,0	1 679	1 704	1 933	2 450	2 780	3 915	2 994	2 928	2 715	62
64	235,5	1 763	1 782	2 021	2 560	2 904	4 091	3 128	3 059	2 836	64
66	253,8	1 850	1 862	2 112	2 674	3 031	4 273	3 266	3 195	2 961	66
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
Replace	R11	R12			R22			R502			Replace

Dew Point Pressure Chart (Gauge Pressure) @ Sea Level 101,3 kPa

Replace	R11	R12			R22			R502			Replace
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
-50	-99,527	-71,82	-75,27	-69,8	-36,78	-51,23	8,2	-15,22	-19,03	-23,86	-50
-48	-99,246	-68,22	-72,12	-66,08	-29,86	-45,24	19,5	-6,14	-10,41	-15,91	-48
-46	-98,928	-64,27	-68,66	-62,005	-22,36	-38,69	31,8	3,7	-1,1	-7,32	-46
-44	-98,57	-59,94	-64,87	-57,58	-14,26	-31,57	45	14,2	8,9	1,9	-44
-42	-98,167	-55,21	-60,74	-52,72	-5,5	-23,88	59,3	25,6	19,8	11,9	-42
-40	-97,714	-50,05	-56,23	-47,45	3,9	-15,43	74,6	37,9	31,4	22,8	-40
-38	-97,207	-44,48	-51,54	-41,73	14,1	-6,54	91	51,0	43,9	34,1	-38
-36	-96,641	-38,35	-46,02	-35,53	25	3,5	106,6	65,0	57,3	46,4	-36
-34	-96,01	-31,74	-40,26	-28,83	36,7	14,1	127,4	80,0	71,6	59,6	-34
-32	-95,309	-24,59	-34,04	-21,59	49,2	25,5	147,5	96,0	86,9	73,7	-32
-30	-94,532	-16,87	-27,31	-13,76	62,6	37,7	166,9	113,1	103,2	88,7	-30
-28	-93,673	-8,54	-20,07	-5,37	76,9	50,8	191,8	131,2	120,6	104,8	-28
-26	-92,724	0,4	-12,27	3,7	92,2	64,9	216,1	150,5	139,1	121,8	-26
-24	-91,68	10,1	-3,89	13,4	108,4	79,9	241,9	171,0	158,7	140,0	-24
-22	-90,53	20,4	5,1	23,8	125,7	96	269,3	192,7	179,6	159,2	-22
-20	-89,27	31,5	14,7	34,9	144,1	113,1	298,4	215,7	201,7	179,7	-20
-18	-87,89	43,4	25,0	46,8	163,5	131,4	329,2	240,1	225,1	201,3	-18
-16	-86,39	56,1	36,0	59,5	184,2	150,8	361,8	265,8	249,9	224,2	-16
-14	-84,74	69,6	47,8	73,0	206,1	171,4	396,2	292,9	276,1	248,5	-14
-12	-82,95	84,1	60,3	87,5	229,2	193,3	432,5	321,5	303,7	274,1	-12
-10	-81,01	99,4	73,6	102,8	253,6	216,5	470,8	351,6	332,8	301,1	-10
-8	-78,9	115,8	87,7	119,1	279,3	241,1	511,2	383,3	363,5	329,5	-8
-6	-76,61	133,1	102,8	136,4	306,5	267,1	553,7	416,6	395,8	359,5	-6
-4	-74,14	151,6	118,7	154,7	335,1	294,5	598,5	451,6	429,7	391,1	-4
-2	-71,47	171,1	135,6	174,1	365,2	323,6	645,5	488,3	465,3	424,3	-2
0	-68,59	191,7	153,4	194,7	396,8	354,2	694,8	526,9	502,7	459,1	0
2	-65,5	213,5	172,3	216,4	430,1	386,5	746,6	567,3	542	495,7	2
4	-62,17	236,6	192,2	239,3	464,9	420,5	800,9	609,8	583,1	534,1	4
6	-58,59	260,9	213,2	263,5	501,5	456,3	857,8	653,8	626,1	574,3	6
8	-54,76	286,6	235,4	289,0	539,8	494	918	700,1	671,2	616,4	8
10	-50,65	313,6	258,7	315,8	579,9	533,6	980	748,5	718,3	660,5	10
12	-46,27	342	283,2	344,0	621,8	575,5	1 045	799,1	767,3	706,5	12
14	-41,58	371,9	309,0	373,7	665,6	619	1 113	851,9	818,9	754,7	14
16	-36,58	403,3	336,1	404,9	711,4	664,9	1 184	907	872,5	805,0	16
18	-31,25	436,2	364,5	437,6	759,2	713	1 259	965	929	857,4	18
20	-25,59	470,8	394,3	471,9	809	763,5	1 336	1 025	987	912	20
22	-19,56	507	425,5	507,8	861	816,4	1 417	1 087	1 048	969	22
24	-13,17	544,9	458,2	545,5	915	871,6	1 501	1 152	1 111	1 029	24
26	-6,38	584,5	492,3	584,9	972	930	1 589	1 220	1 177	1 090	26
28	0,8	626	528,1	626,1	1 030	991	1 680	1 291	1 245	1 155	28
30	8,4	669,3	565,4	669,2	1 091	1 054	1 775	1 364	1 317	1 222	30
32	16,5	714,6	604,4	714,3	1 155	1 121	1 875	1 441	1 391	1 291	32
34	25	761,8	645,1	761,2	1 220	1 190	1 976	1 520	1 467	1 364	34
36	33,9	811,1	687,5	810,2	1289	1 263	2 083	1 603	1 547	1 439	36
38	43,4	862,4	731,7	861,2	1 360	1 338	2 194	1 689	1 630	1 517	38
40	53,4	916	777,67	914	1 433	1 418	2 309	1 778	1 716	1 597	40
42	63,8	972	825,58	970	1 509	1 500	2 428	1 871	1 806	1 681	42
44	74,9	1 030	875,43	1 028	1 588	1 586	2 552	1 968	1 898	1 768	44
46	86,5	1 090	927	1 088	1 670	1 676	2 681	2 068	1 994	1 858	46
48	98,7	1 153	981	1 150	1 755	1 769	2 814	2 172	2 094	1 951	48
50	111,4	1 218	1 037	1 215	1 842	1 867	2 952	2 280	2 197	2 047	50
52	124,8	1 285	1 095	1 282	1 933	1 968	3 096	2 393	2 304	2 147	52
54	138,8	1 355	1 156	1 352	2 027	2 074	3 244	2 509	2 414	2 250	54
56	153,5	1 428	1 218	1 425	2 124	2 184	3 398	2 631	2 529	2 357	56
58	168,9	1 504	1 283	1 500	2 224	2 298	3 557	2 756	2 648	2 467	58
60	185	1 582	1 350	1 579	2 327	2 417	3 722	2 887	2 771	2 581	60
62	201,7	1 663	1 420	1 660	2 434	2 540	3 892	3 023	2 898	2 699	62
64	219,2	1 747	1 492	1 744	2 544	2 668	4 069	3 164	3 030	2 820	64
66	237,5	1 834	1 567	1 831	2 658	2 801	4 251	3 310	3 166	2 945	66
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
Replace	R11	R12			R22			R502			Replace

Bubble Point Pressure Chart (Gauge Pressure) @ Sea Level 101,3 kPa

Replace	R11	R12			R22			R502			Replace
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
-50	-99,527	-71,82	-57,81	-51,38	-36,78	-26,23	8,5	-13,34	-15,62	-23,86	-50
-48	-99,246	-68,22	-53,07	-46,01	-29,86	-18,30	19,8	-4,28	-6,79	-15,91	-48
-46	-98,928	-64,27	-47,93	-40,19	-22,36	-9,72	32,1	5,5	2,7	-7,32	-46
-44	-98,576	-59,94	-42,35	-33,89	-14,26	-0,5	45,4	16,8	13,8	1,9	-44
-42	-98,167	-55,21	-36,33	-27,08	-5,50	9,5	59,7	27,4	24,1	11,9	-42
-40	-97,714	-50,05	-29,83	-19,74	3,9	20,3	75,0	39,5	35,9	22,6	-40
-38	-97,207	-44,44	-22,82	-11,83	14,1	31,9	91,5	52,6	48,7	34,1	-38
-36	-96,641	-38,35	-15,28	-3,33	25,0	44,3	109,1	66,5	62,3	46,4	-36
-34	-96,010	-31,74	-7,16	5,8	36,7	57,6	126,8	81,5	76,9	59,6	-34
-32	-95,309	-24,59	1,5	15,6	49,2	71,9	148,1	97,4	92,4	73,7	-32
-30	-94,532	-16,87	10,8	26,1	62,6	87,1	169,6	114,4	109,0	88,7	-30
-28	-93,673	-8,54	20,8	37,3	76,9	103,3	192,5	132,5	126,7	104,8	-28
-26	-92,724	0,4	31,4	49,2	92,2	120,7	216,9	151,7	145,5	121,8	-26
-24	-91,680	10,1	42,7	61,9	108,4	139,1	242,8	172,1	165,4	140,0	-24
-22	-90,53	20,4	54,8	75,5	125,7	158,7	270,3	193,7	186,6	159,2	-22
-20	-89,27	31,5	67,6	89,9	144,1	179,5	299,5	216,7	209,0	179,7	-20
-18	-87,89	43,4	81,2	105,3	163,5	201,6	330,4	240,9	232,7	201,3	-18
-16	-86,39	56,1	95,7	121,5	184,2	225,0	363,1	266,5	257,8	224,2	-16
-14	-84,74	69,6	111,0	138,7	206,1	249,7	397,6	293,6	284,3	248,5	-14
-12	-82,95	84,1	127,2	156,9	229,2	275,9	434,0	322,1	312,2	274,1	-12
-10	-81,01	99,4	144,4	176,2	253,8	303,5	472,5	352,2	341,7	301,3	-10
-8	-78,90	115,8	162,5	196,5	279,3	332,6	513,0	383,9	372,7	329,5	-8
-6	-76,61	133,1	181,6	218,0	306,5	363,3	555,7	417,2	405,3	359,5	-6
-4	-74,14	151,6	201,7	240,6	335,1	395,6	600,5	452,2	439,5	391,1	-4
-2	-71,47	171,1	222,9	264,4	365,2	429,7	647,7	488,9	475,5	424,3	-2
0	-68,59	191,7	245,3	289,5	396,8	465,4	697,2	527,5	513,2	459,1	0
2	-65,50	213,5	268,7	315,9	430,1	502,9	749,2	567,9	552,8	495,7	2
4	-62,17	236,6	293,3	343,5	464,9	542,3	803,7	610,2	594,2	534,1	4
6	-58,59	260,9	319,2	372,6	501,5	583,6	860,7	654,5	637,6	574,3	6
8	-54,76	286,6	346,3	403,0	539,8	626,9	921	700,8	683,0	616,4	8
10	-50,65	313,6	374,6	434,9	579,9	672,1	983	749,2	730,4	660,5	10
12	-46,27	342,0	404,3	468,3	621,8	719,5	1 049	799,8	779,9	706,5	12
14	-41,58	371,9	435,4	503,3	665,6	769,0	1 117	852,6	831,6	754,7	14
16	-36,58	403,3	467,8	539,8	711,4	820,7	1 188	908	885,5	805,0	16
18	-31,25	436,2	501,7	577,9	759,2	874,7	1 263	965	942	857,4	18
20	-25,59	470,8	537,0	617,7	809,0	931	1 341	1 025	1 001	912	20
22	-19,56	507,0	573,9	659,2	861,0	990	1 421	1 088	1 062	969	22
24	-13,17	544,9	612,3	702,5	915	1 051	1 506	1 152	1 125	1 029	24
26	6,38	584,5	652,2	747,5	972	1 115	1 594	1 220	1 191	1 090	26
28	0,8	626,0	693,8	794,4	1 030	1 181	1 685	1 290	1 260	1 155	28
30	8,4	669,3	737,1	843,2	1 091	1 250	1 780	1 363	1 331	1 223	30
32	16,5	714,6	782,1	893,9	1 155	1 321	1 879	1 438	1 406	1 291	32
34	25,0	761,8	828,8	947	1 220	1 396	1 982	1 516	1 483	1 364	34
36	33,9	811,1	877,3	1 001	1 289	1 473	2 089	1 600	1 563	1 439	36
38	43,4	862,4	928	1 058	1 360	1 553	2 200	1 684	1 646	1 517	38
40	53,4	916	980	1 117	1 433	1 636	2 315	1 772	1 732	1 597	40
42	63,8	972	1 034	1 178	1 509	1 722	2 435	1 864	1 821	1 681	42
44	74,9	1 030	1 090	1 241	1 588	1 812	2 559	1 959	1 914	1 768	44
46	86,5	1 090	1 148	1 307	1 670	1 904	2 688	2 057	2 010	1 858	46
48	98,7	1 153	1 208	1 375	1 755	2 000	2 822	2 158	2 109	1 951	48
50	111,4	1 218	1 270	1 445	1 842	2 098	2 960	2 264	2 212	2 047	50
52	124,8	1 285	1 334	1 517	1 933	2 201	3 103	2 373	2 319	2 147	52
54	138,8	1 355	1 400	1 592	2 027	2 306	3 252	2 486	2 430	2 250	54
56	153,5	1 428	1 469	1 670	2 124	2 415	3 405	2 603	2 544	2 357	56
58	168,9	1 504	1 539	1 750	2 224	2 528	3 564	2 723	2 663	2 467	58
60	185,0	1 582	1 612	1 832	2 327	2 646	3 729	2 849	2 785	2 581	60
62	201,7	1 663	1 688	1 917	2 434	2 764	3 899	2 978	2 912	2 699	62
64	219,2	1 747	1 765	2 005	2 544	2 888	4 075	3 112	3 043	2 820	64
66	237,5	1 834	1 845	2 095	2 658	3 015	4 257	3 250	3 179	2 945	66
°C	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	°C
with	R123	R134a	R406A	R409A	R22	R407C	R410A	R507A	R404A	R408A	with
Replace	R11	R12			R22			R502			Replace

Regulators & Dewars

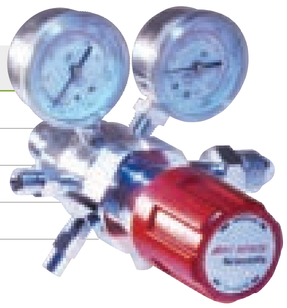
The scientific range of regulators caters for most applications. Should you require a more specialised regulator, we can source it for you.

The scientific range of gas pressure regulators and inlet stems are designed to relevant standards for a variety of special gas mixtures and applications. The regulators are assembled and tested within the requirements of ISO 9001: 2008 Quality Management Standard (certification number 581951/15 from Pricewaterhouse Coopers Inc.).

Due to the safety risks associated with the connection of incompatible components or incorrect customer assembly, the interchanging or replacement of connections and gauges for these regulators is not supported by Afrox.

In the event of a failure of a scientific regulator, customers are urged to return the product to their local Gas & Gear, where the warranty conditions will be honoured provided that the term has not lapsed and there is no evidence of tampering or abuse.

Scientific Regulators & Equipment



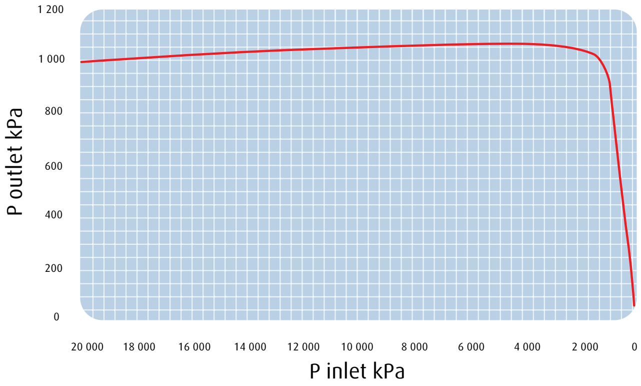
Regulators suitable for: Oxygen, Air, Argon, Helium and Non-Flammable Non-Toxic Mixtures

Item Number	**W019110**	**W019210**
	Single-Stage	**Multi-Stage**
Primary Pressure (bar)	230	230
Outlet Pressure (barg)	0 - 10	0 - 10
Connections: Inlet	5/8" RH male	5/8" RH male
Outlet	3/8" RH*	3/8" RH*
Operating Temperature (°C)	-20 - +65	-20 - +65
Body	Chrome plated brass	Chrome plated brass
Diaphragm	Stainless steel	Stainless steel
Seat	PTFE	PTFE
Seal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow stainless steel valve	2 x quad-flow stainless steel valves
Filtration	316 stainless steel	2 x 316 stainless steel
He Leak Certified	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

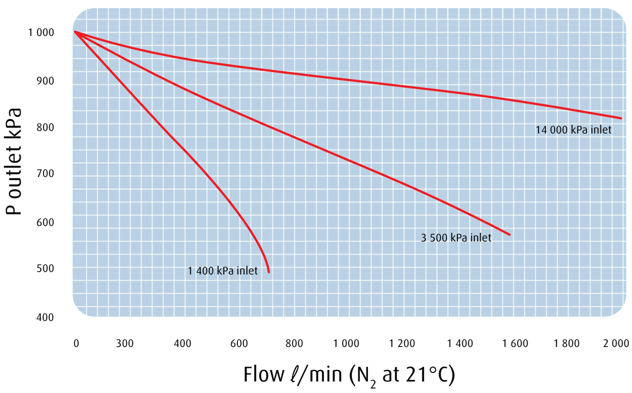
*Connection for nipple and nut

W019110 (Single-Stage)

Output pressure versus cylinder pressure for brass single-stage

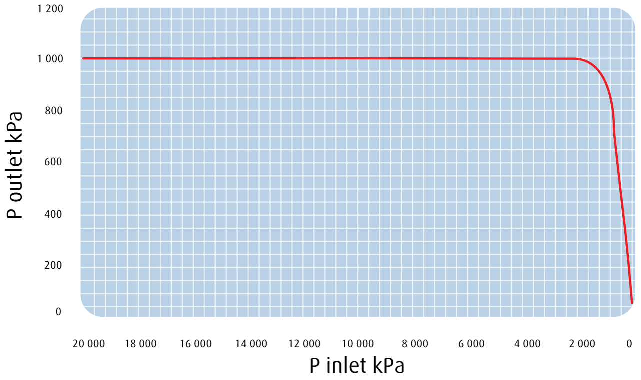


Pressure/flow relationship for brass single-stage

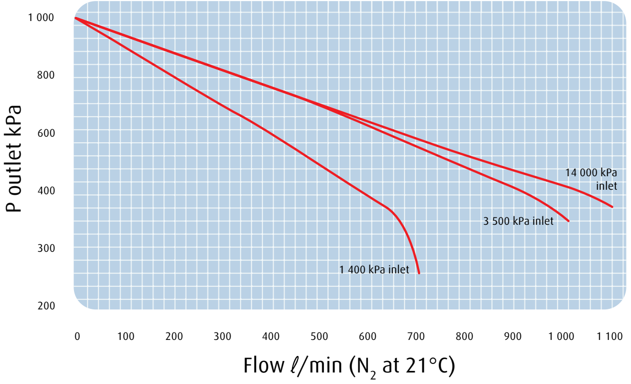


W019210 (Multi-Stage)

Output pressure versus cylinder pressure for brass multi-stage



Pressure/flow relationship for brass multi-stage

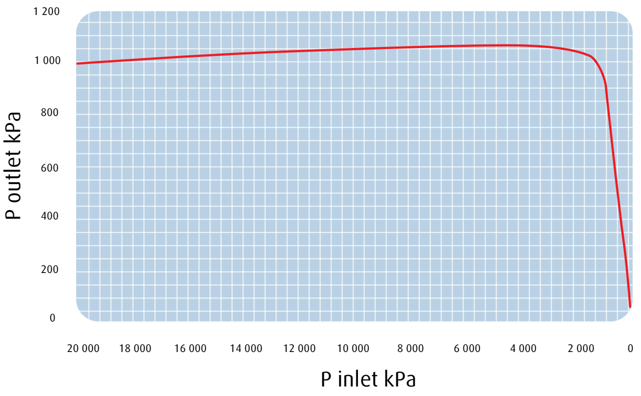


Regulators suitable for: Hydrogen, Carbon Monoxide, P10, Ethylene, Methane and Flammable Toxic Mixtures

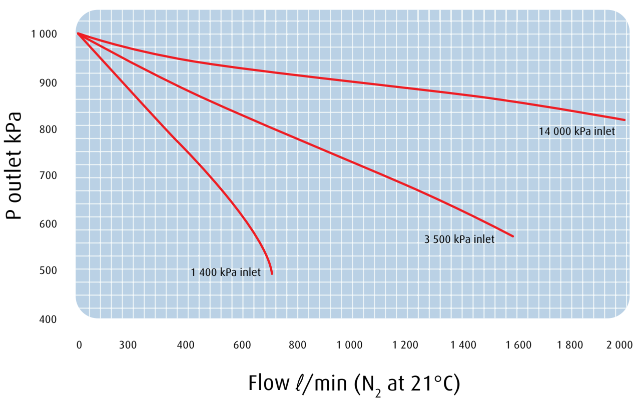
Item Number	**W019120**	**W019220**
	Single-Stage	**Multi-Stage**
Primary Pressure (bar)	230	230
Outlet Pressure (barg)	0 - 10	0 - 10
Connections: Inlet	5/8″ LH male	5/8″ LH male
Outlet	3/8″ LH*	3/8″ LH*
Operating Temperature (°C)	-20 - +65	-20 - +65
Body	Chrome plated brass	Chrome plated brass
Diaphragm	Stainless steel	Stainless steel
Seat	PTFE	PTFE
Seal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow stainless steel	2 x quad-flow stainless steel valves
Filtration	316 stainless steel	2 x 316 stainless steel
He Leak Certified	$<1 \times 10^{-8}$scc/sec	$<1 \times 10^{-8}$scc/sec

W019120 (Single-Stage)

Output pressure versus cylinder pressure for brass single-stage

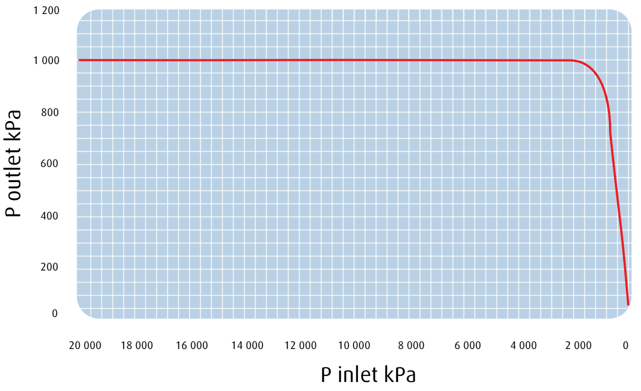


Pressure/flow relationship for brass single-stage

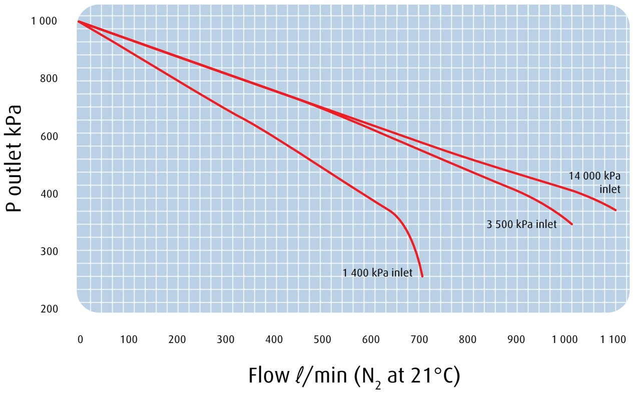


W019220 (Multi-Stage)

Output pressure versus cylinder pressure for brass multi-stage



Pressure/flow relationship for brass multi-stage



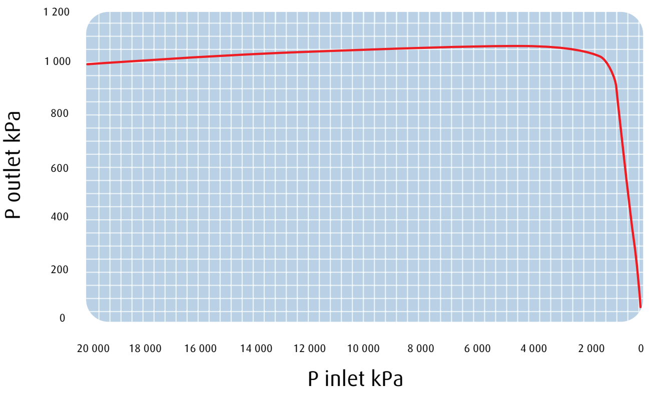
Regulators suitable for: Sulphur Hexafluoride (SF_6)

Item Number	W019141	W019241
	Single-Stage	**Multi-Stage**
Primary Pressure (bar)	230	230
Outlet Pressure (barg)	0 - 10	0 - 10
Connections: Inlet	5/8″ RH female	5/8″ RH female
Outlet	3/8″ RH*	3/8″ RH*
Operating Temperature (°C)	-20 - +65	-20 - +65
Body	Chrome plated brass	Chrome plated brass
Diaphragm	Stainless steel	Stainless steel
Seat	PTFE	PTFE
Seal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow stainless steel	2 x quad-flow stainless steel valves
Filtration	316 stainless steel	2 x 316 stainless steel
He Leak Certified	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

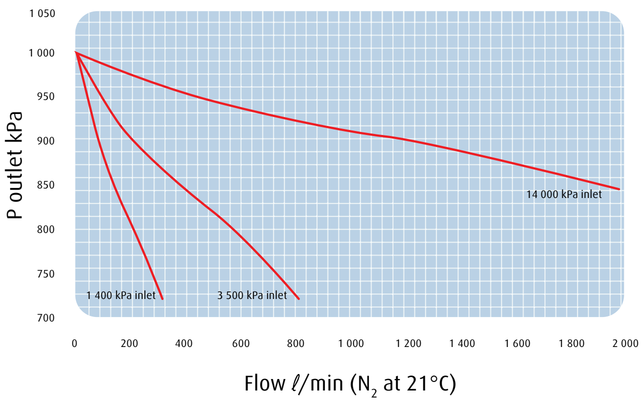
*Connection for nipple and nut

W019141 (Single-Stage)

Output pressure versus cylinder pressure for brass single-stage

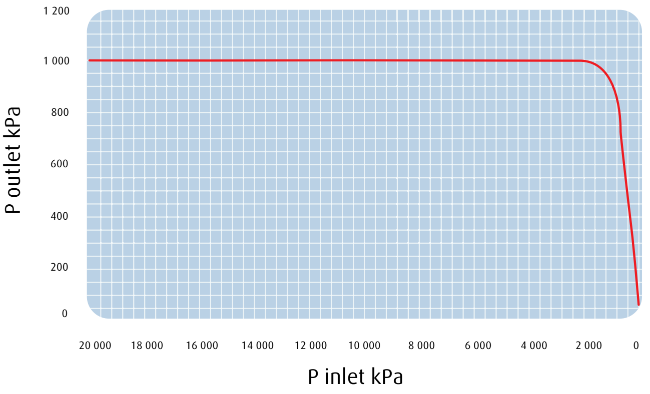


Pressure/flow relationship for brass single-stage

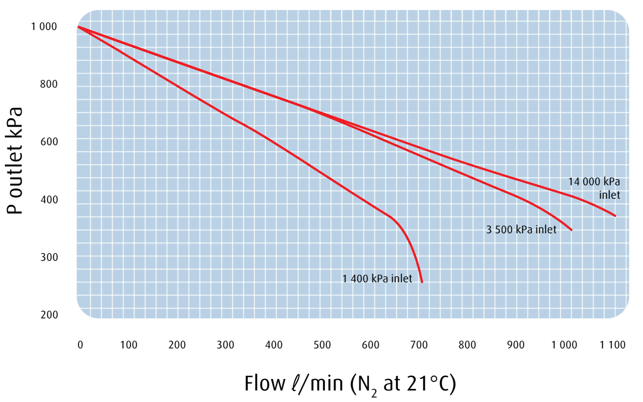


W019241 (Multi-Stage)

Output pressure versus cylinder pressure for brass multi-stage



Pressure/flow relationship for brass multi-stage

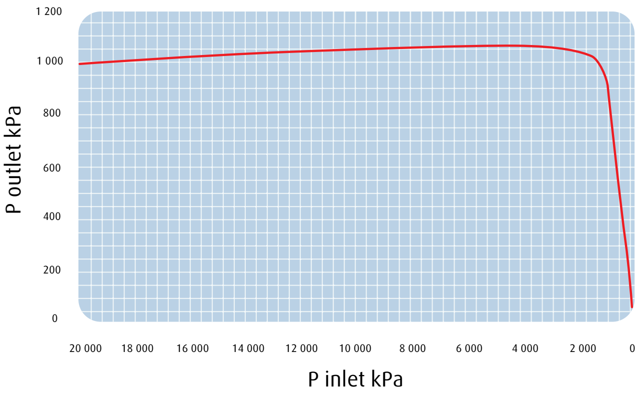


Regulators suitable for: Nitrogen			
Item Number	**W019130**	**W019230**	**W019999**
	Single-Stage	**Multi-Stage**	**Single-Stage**
Primary Pressure (bar)	230	230	230
Outlet Pressure (barg)	0 - 10	0 - 10	35
Connections: Inlet	3/4″ RH male	3/4″ RH male	3/4″ RH male
Outlet	3/8″ RH*	3/8″ RH*	3/8″ RH*
Operating Temperature (ºC)	-20 - +65	-20 - +65	-20 - +65
Body	Chrome plated brass	Chrome plated brass	Chrome plated brass
Diaphragm	Stainless steel	Stainless steel	Stainless steel
Seat	PTFE	PTFE	PTFE
Seal	Metal to metal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow	2 x quad-flow stainless steel valves	Quad-flow
Filtration	316 stainless steel	2 x 316 stainless steel	316 stainless steel
He Leak Certified	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

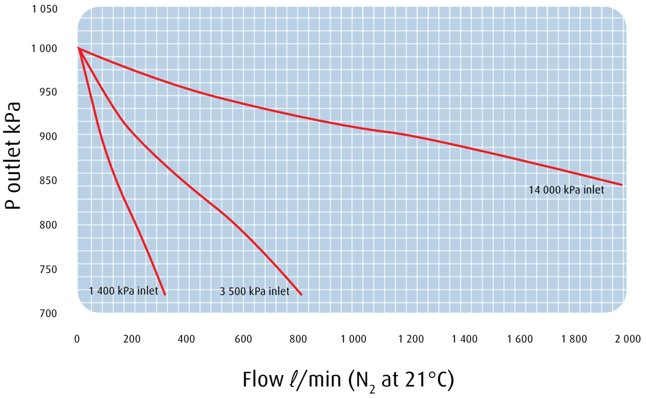
*Connection for nipple and nut

W019130 (Single-Stage)

Output pressure versus cylinder pressure for brass single-stage

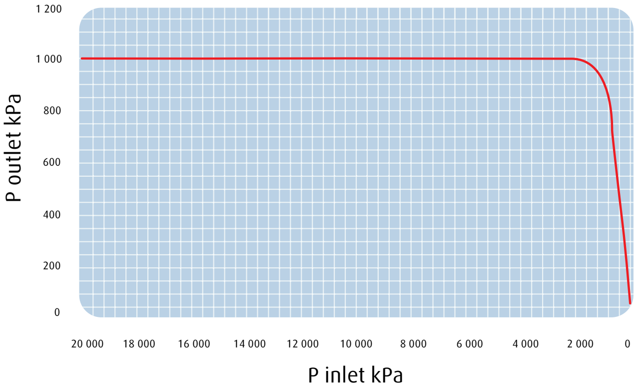


Pressure/flow relationship for brass single-stage

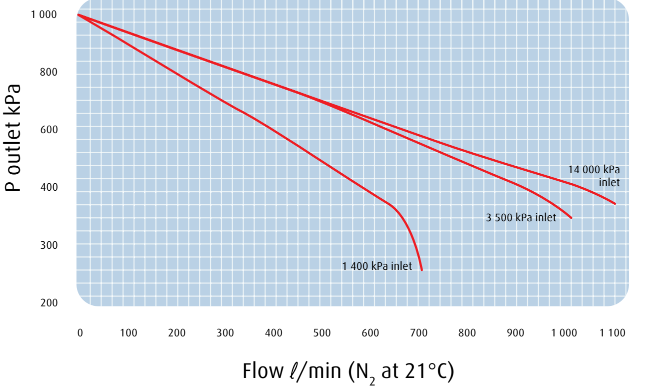


W019230 (Multi-Stage)

Output pressure versus cylinder pressure for brass multi-stage



Pressure/flow relationship for brass multi-stage



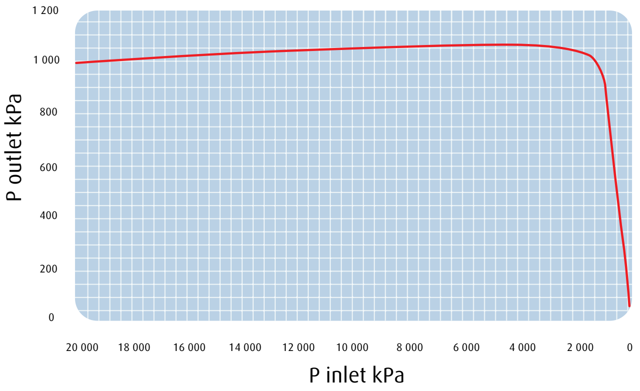
Regulators suitable for: Carbon Dioxide

Item Number	**W019140**	**W019240**
	Single-Stage	**Multi-Stage**
Primary Pressure (bar)	230	230
Outlet Pressure (barg)	0 - 10	0 - 10
Connections: Inlet	5/8″ RH female	5/8″ RH female
Outlet	3/8″ RH*	3/8″ RH*
Operating Temperature (°C)	-20 - +65	-20 - +65
Body	Chrome plated brass	Chrome plated brass
Diaphragm	Stainless steel	Stainless steel
Seat	PTFE	PTFE
Seal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow stainless steel	2 x quad-flow stainless steel valves
Filtration	316 stainless steel	2 x 316 stainless steel
He Leak Certified	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

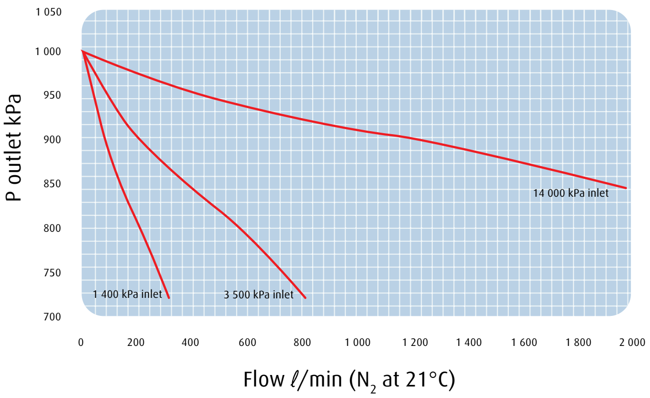
*Connection for nipple and nut

W019140 (Single-Stage)

Output pressure versus cylinder pressure for brass single-stage

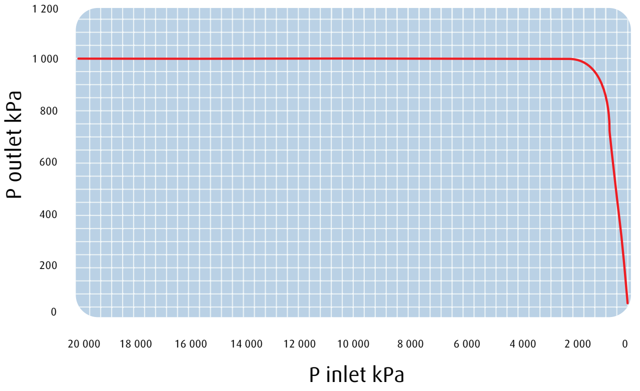


Pressure/flow relationship for brass single-stage

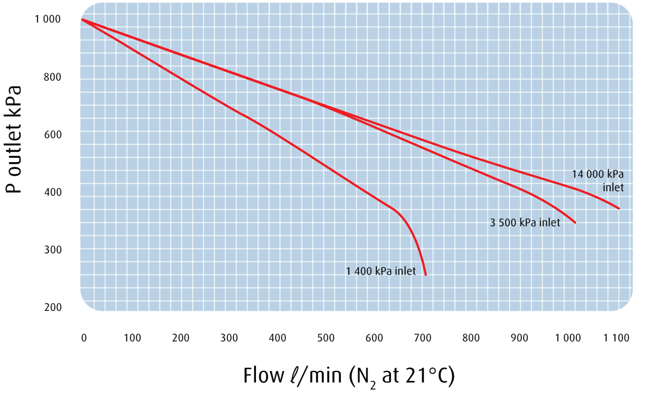


W019240 (Multi-Stage)

Output pressure versus cylinder pressure for brass multi-stage



Pressure/flow relationship for brass multi-stage



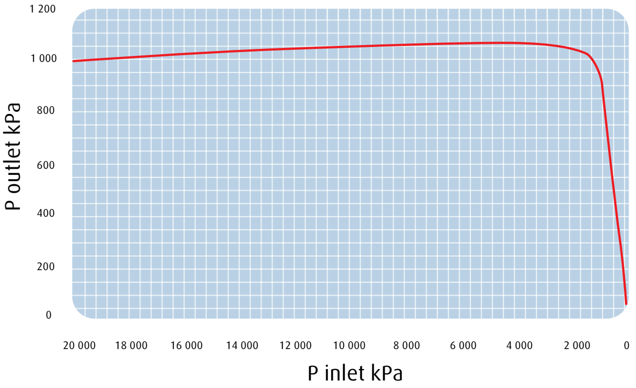
Regulators suitable for: Nitrous Oxide (Non-Medical N_2O)

Item Number	**W019150**	**W019250**
	Single-Stage	**Multi-Stage**
Primary Pressure (bar)	230	230
Outlet Pressure (barg)	0 - 10	0 - 10
Connections: Inlet	11/16" x 20 tpi RH female	11/16" x 20 tpi RH female
Outlet	3/8" RH*	3/8" RH*
Operating Temperature (°C)	-20 - +65	-20 - +65
Body	Chrome plated brass	Chrome plated brass
Diaphragm	Stainless steel	Stainless steel
Seat	PTFE	PTFE
Seal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow stainless steel	2 x quad-flow stainless steel valves
Filtration	316 stainless steel	2 x 316 stainless steel
He Leak Certified	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

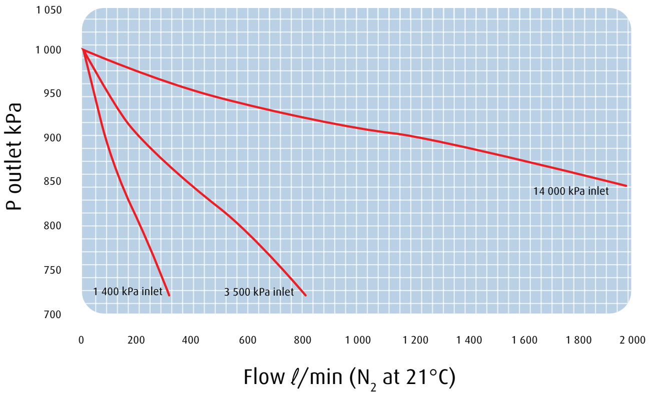
*Connection for nipple and nut

W019140 (Single-Stage)

Output pressure versus cylinder pressure for brass single-stage

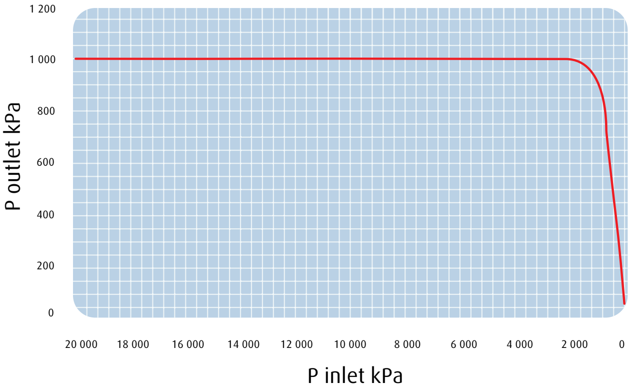


Pressure/flow relationship for brass single-stage

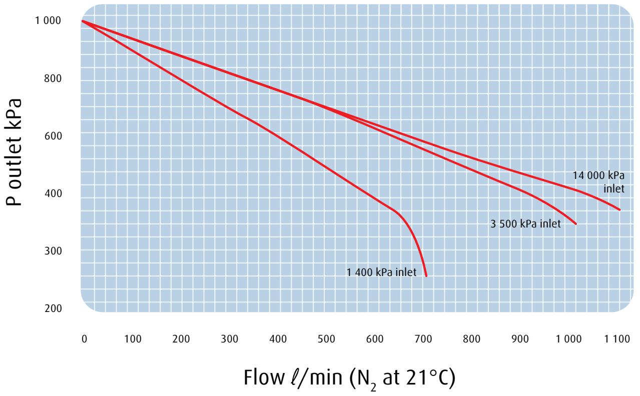


W019240 (Multi-Stage)

Output pressure versus cylinder pressure for brass multi-stage



Pressure/flow relationship for brass multi-stage

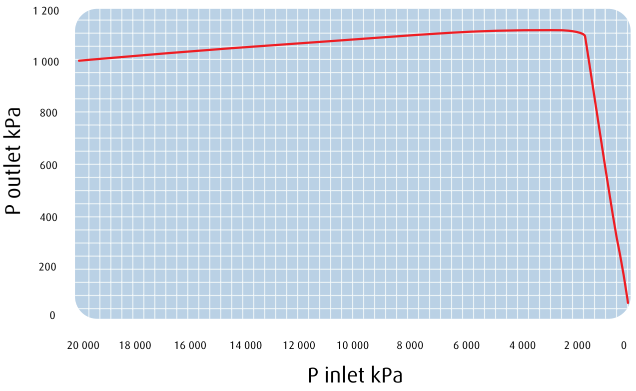


Regulators suitable for: Corrosive Non-Flammable Mixtures			
Item Number		**W020160**	**W020260**
		Single-Stage	**Multi-Stage**
Primary Pressure (bar)		230	230
Outlet Pressure (barg)		0 - 10	0 - 10
Connections:	**Inlet**	3/8″ RH female	3/8″ RH female
	Outlet	3/8″ RH*	3/8″ RH*
Operating Temperature (°C)		-20 - +65	-20 - +65
Body		316 stainless steel	316 stainless steel
Diaphragm		Stainless steel	Stainless steel
Seat		PTFE	PTFE
Seal		Metal to metal	Metal to metal
Encapsulated Valve		Quad-flow stainless steel	2 x quad-flow stainless steel valves
Filtration		316 stainless steel	2 x 316 stainless steel
He Leak Certified		<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

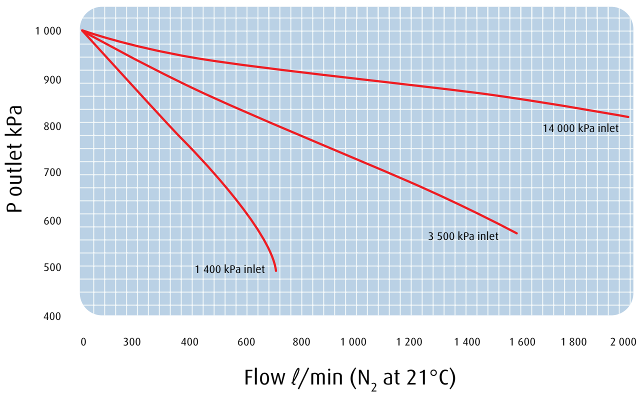
*Connection for nipple and nut

W020160 (Single-Stage)

Output pressure versus cylinder pressure for stainless single-stage

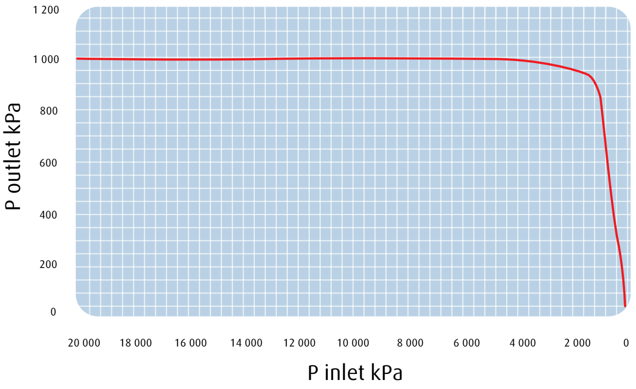


Pressure/flow relationship for stainless single-stage

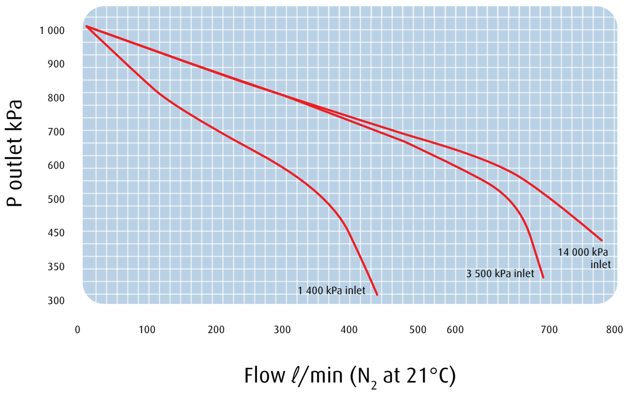


W020260 (Multi-Stage)

Output pressure versus cylinder pressure for stainless multi-stage



Pressure/flow relationship for stainless multi-stage



Regulator suitable for: Sulphur Dioxide (SO_2)

Item Number		**W020121**
		Single-Stage
Primary Pressure (bar)		230
Outlet Pressure (barg)		0 - 1
Connections:	**Inlet**	CGA 240
	Outlet	3/8″ RH*
Operating Temperature (°C)		-20 - +65
Body		316 stainless steel
Diaphragm		Stainless steel
Seat		PTFE
Seal		Metal to metal
Encapsulated Valve		Quad-flow stainless steel
Filtration		316 stainless steel
He Leak Certified		<1 x 10^{-8}scc/sec

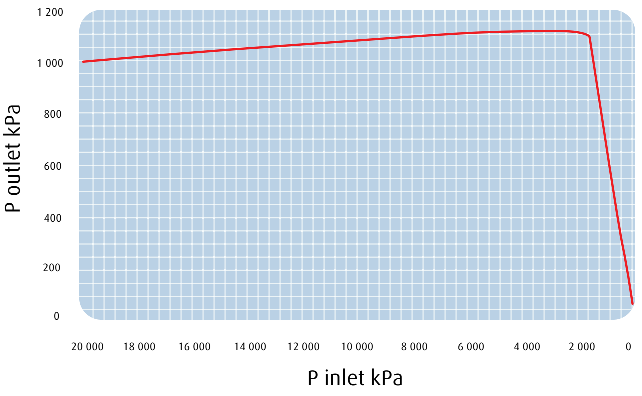
Regulator suitable for: Ammonia (NH_3)

Item Number		**W020120**
		Single-Stage
Primary Pressure (bar)		230
Outlet Pressure (barg)		0 - 10
Connections:	**Inlet**	CGA 240
	Outlet	3/8″ LH*
Operating Temperature (°C)		-20 - +65
Body		316 stainless steel
Diaphragm		Stainless steel
Seat		PTFE
Seal		Metal to metal
Encapsulated Valve		Quad-flow stainless steel
Filtration		316 stainless steel
He Leak Certified		<1 x 10^{-8}scc/sec

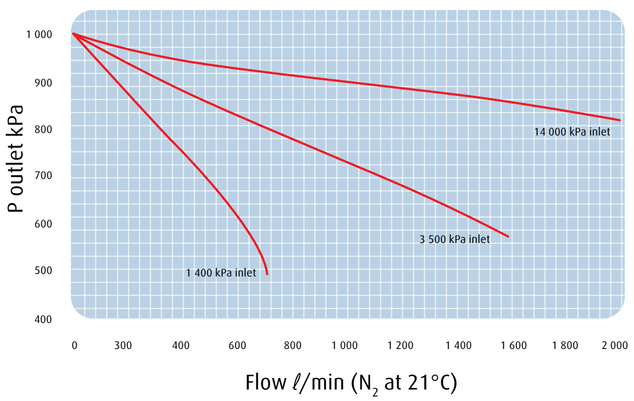
*Connection for nipple and nut

W020121 and W020120

Output pressure versus cylinder pressure for stainless single-stage



Pressure/flow relationship for stainless single-stage



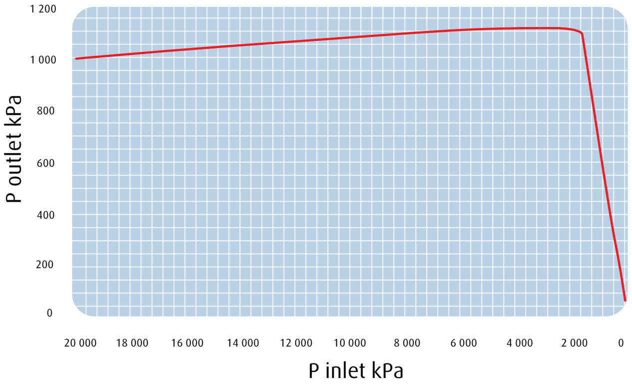
Regulators suitable for: Corrosive, Flammable Mixtures

Item Number	**W020170**	**W020270**
	Single-Stage	**Multi-Stage**
Primary Pressure (bar)	230	230
Outlet Pressure (barg)	0 - 10	0 - 10
Connections: Inlet	3/8″ LH female	3/8″ LH female
Outlet	3/8″ LH*	3/8″ LH*
Operating Temperature (°C)	-20 - +65	-20 - +65
Body	316 stainless steel	316 stainless steel
Diaphragm	Stainless steel	Stainless steel
Seat	PTFE	PTFE
Seal	Metal to metal	Metal to metal
Encapsulated Valve	Quad-flow stainless steel	2 x quad-flow stainless steel valves
Filtration	316 stainless steel	2 x 316 stainless steel
He Leak Certified	<1 x 10^{-8}scc/sec	<1 x 10^{-8}scc/sec

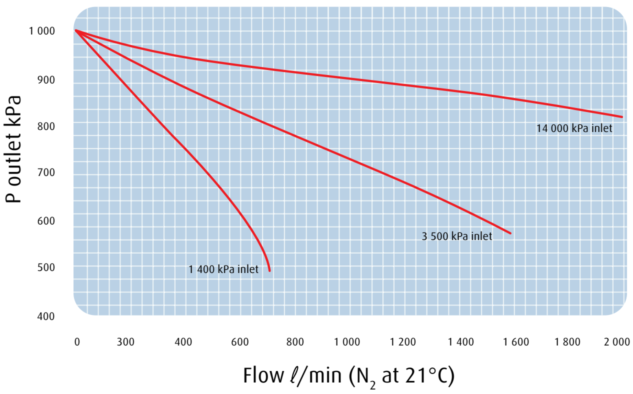
*Connection for nipple and nut

W020170 (Single-Stage)

Output pressure versus cylinder pressure for stainless single-stage

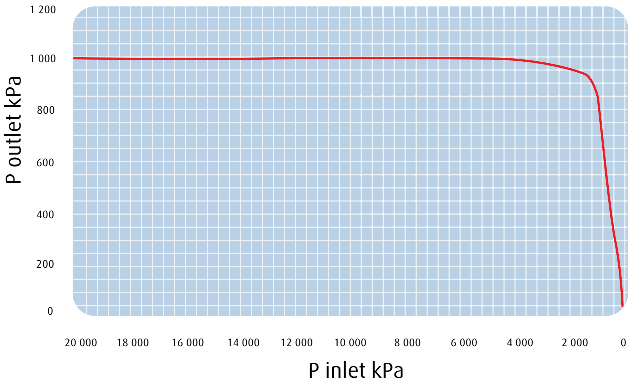


Pressure/flow relationship for stainless single-stage

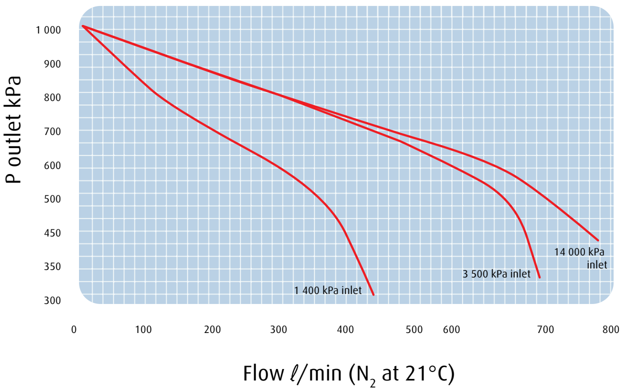


W020270 (Multi-Stage)

Output pressure versus cylinder pressure for stainless multi-stage



Pressure/flow relationship for stainless multi-stage



Cryogenic Equipment

Dewars

Item Number	Product	Capacity (ℓ)	Description	Height (mm)
W011556	Dewar, 5 LD LN_2	5	3,1 kg empty	445
W011563	Dewar, 10 LD LN_2	10	6,6 kg empty	597
W011557	Dewar, 25 LD LN_2	25	10,5 kg empty	655
W011074	Dewar, 25 LD LN_2 Classic	25	8,6 kg empty	582
W011562	Dewar, 50 LD LN_2	50	17,6 kg empty	823
W011214	Hose, transfer, cryogenic 1,8 m long, stainless steel	3/8″ NPT male and CGA female fittings		
W011230	Phase separator (69 mm long)	Fit 3/8″ NPT end of transfer hose		
W011542	Roller base for LD Range dewars			
W011564	Spare neck tube core (lid) for LD Range			

Dewars

Models	LD5	LD10	LD25	Classic 25	LD50
Static Holding Time Delays (ℓ)	6	45	109	119	122
Evaporation Rate (ℓ/days)	0,77	0,22	0,23	0,21	0,41
Liquid Nitrogen Capacity (ℓ)	5	10	25	25	50
Weight Empty (kg)	3,1	6,6	10,5	8,6	17,6
Weight Full (kg)	7,2	14,7	30,8	28,9	58,0
Neck Diameter (mm)	142	51	64	51	64
Overall Height (mm)	445	597	655	582	823
Overall Diameter (mm)	193	290	396	394	475

Ripegas

Ripegas is used for degreening of fruit, by acceleration of the natural ripening process. Ethylene, a naturally occurring hormone, is used in Ripegas. The fruit travels better when it is green and hard, and is ripened quickly and evenly in a controlled manner, near the end of the supply chain. The result is an undamaged, evenly ripened, attractive product. Afrox has two mixtures on the market: Ripegas 5 and Ripegas 10 has to be used with flameproof equipment as it is flammable.

Product Description	Product Mass (kg)	Volume (m^3)	Fill Pressure (bar)	Material Number	Valve Connection	Recommended Regulator
Ripegas 5 (L)	8,15	7,0	150	518705-RC-C	5/8" BSP LH Int	W019120 or W019220
Ripegas 10 (L)	8,30	7,1	150	518710-RC-C	5/8" BSP LH Int	W019120 or W019220

Cylinder Code	Cylinder Description	Water Capacity (ℓ)	Height (m)	Diameter (m)	Empty (kg)	Max Fill Pressure (kPa)
RC	Large Steel Cylinder	47,2	1,46	0,23	68	15 300

Ripegas 5

- Flammable
- 5% ethylene and nitrogen.

Ripegas 10

- Flammable
- 10% ethylene and nitrogen.

Safety Risk

Ripegas 5 & 10 to be used with flameproof equipment, as it is flammable.

Scientific Mixtures

Afrox supplies a wide range of mixtures used in many applications: petrochemical, chemical, pharmaceutical, medical, air monitoring, energy, metal, R&D, automotive, and manufacturing industries. With a database containing over 2 000 mixtures, we are able to meet diverse needs, or new mixtures can be made to suit customer needs. Mixtures are made gravimetrically to a high degree of accuracy. We manufacture these mixtures to ISO 6142 standards in an ISO 9001 facility. Personnel are trained in the latest techniques for making gas mixtures, and are evaluated regularly. Quality control is an important step, and our laboratory has state-of-the-art analytical instrumentation, measuring component levels with an accuracy of better than internationally accepted standards. Certification level depends on application and customer requirements. On a Certificate of Analysis, results are reported to a 95% confidence level. These mixtures are made to order, so please allow for production time.

Each scientific mixture has a unique number, e.g. 802035-NE-A: (500 ppm CO balance Nitrogen (L)). GOC MIX 0259

The NE- denotes the type of cylinder: NE means that it is in a large aluminium cylinder, see table below:

Cylinder Code	Description	Water Capacity (ℓ)	Height (m)	Diameter (m)	Empty Mass (kg)	Max Fill Pressure (kPa)
NE	Large Aluminium Cylinder	40	1,51	0,23	52	20 000
IJ	Small Aluminium Cylinder	10	0,68	0,18	16	20 000
SE	Large Steel Cylinder	50	1,54	0,23	70	20 000
RC	Large Steel Cylinder	47,2	1,46	0,23	68	15 300
IE	Small Steel Cylinder	10	0,60	0,18	18	20 000
SO	Other Cylinder (Usually imported)	Various Sizes				

Code	Certificate
A	Certificate of Analysis
C	Certificate of Conformance
G	Gravimetric Certificate
N	Uncertified
Higher traceability available on imported mixtures, on request	

Type/Level	Blending Tolerance	Analytical Tolerance
% Components	+/-10	+/-2 (95% confidence)
PPM Components	+/-20	+/-5 (95% confidence)
Imported	Narrower blending and analytical tolerances on request	

The purity of a gas component is depicted by a value, e.g. 5.0 or (N5.0)

The ‘5’ equals the number of 9s in the % purity:

5.0 = 99,999% pure (0,001% or 10 ppm maximum impurities)

4.5 = 99,995% pure (0,005% or 50 ppm maximum impurities)

2.8 = 99,8% pure (0,2% or 2 000 ppm maximum impurities)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ARC EQUIPMENT & PROCESSES

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WELDING PROCESSES

MMA Process

Manual Metal Arc (MMA) welding is an electric arc welding process in which the arc is struck between a covered metal electrode and the workpiece. The central metal electrode or core wire is consumable to provide the filler metal for the weld. Shielding of the weld pool is provided by the decomposition of some components of the electrode covering.

- MMA welding is the most flexible and one of the most widely used arc welding processes
- The process uses an electric arc to fuse joint areas
- The consumable electrode consists of a metal core wire covered in a concentric clay-like mixture
- The process may be operated with an AC or DC power source
- This process requires highly skilled welders to produce good quality welds
- The process does not require a separate shielding gas.

Engine driven generators can be used in the field as well as in the workshop, and in remote areas where mains power is not available, thereby extending MMA welding's versatility.

With MMA welding, only a limited amount of weld metal can be deposited from one electrode. This means electrodes have to be replaced frequently, making it a less productive process than other welding methods.

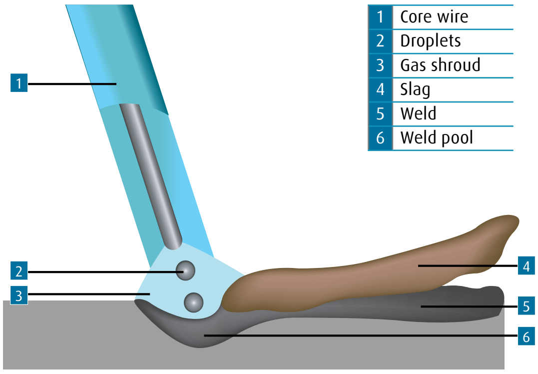
Operation

MMA is a fusion welding process that uses the heat generated by an electric arc to fuse metal in the joint area, the arc being struck between a covered consumable electrode and the workpiece.

The process consists of a welding power source that may provide either an AC, DC or DC and AC electric current. Connected to this power source is an electrode holder into which the electrode is placed. The circuit is completed with an earth return cable fixed between the power source and the workpiece.

When the arc is struck between the tip of the electrode and the workpiece, the core wire begins to melt, and the coating provides a protective gas and slag covering to the weld.

As the core wire melts, the operator must maintain a constant arc length – distance between the end of the electrode and the workpiece – to prevent the arc extinguishing. Parent metal in the immediate area of the arc is also melted and this combines with molten metal from the electrode to form a weld pool.



Schematic of MMA process in operation

Applications

The MMA process can be used to weld:

- Most steels
- Stainless steels
- Cast irons
- Nickel alloys
- Copper alloys
- Aluminium alloys.

MMA welding is also used for hardfacing, and for gouging, cutting and grooving of ferritic alloys.

Applications for MMA are many and varied:

- General fabrication
- Structural steelwork
- Power plant
- Process plant
- Pressure vessels
- Cryogenic plant
- Pipelines
- Shipbuilding
- Bridge-building
- Offshore fabrication
- Repair and maintenance in a wide variety of industries.

MMA is particularly suited to site and external welding applications such as the repair of agricultural equipment.

MMA Welding Equipment

The equipment used for MMA welding consists of:

- Power source
- Electrode cable
- Electrode holder
- Electrode
- Work clamp
- Return cable.

Whether you work with MIG/MAG welding machines, TIG/MMA welders or plasma machines, Afrox offers a unique and extensive range of arc equipment. From basic DIY welders to advanced capabilities and superior functionality, to lightweight portable plasma cutting systems, Afrox gives you unprecedented choice and quality. With a full complement of accessories, spares and welding consumables, the professional welder has everything at hand from a single and trusted supplier.

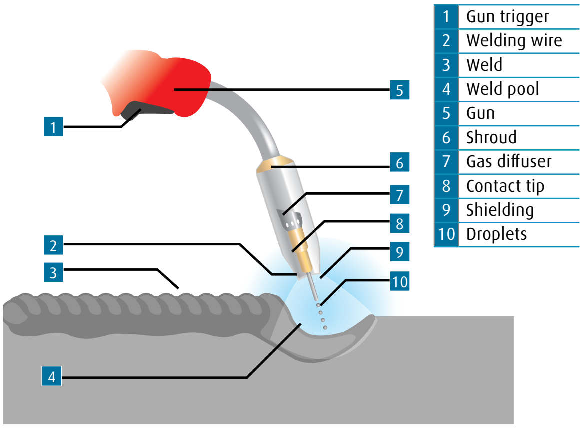
MIG Process

Gas Metal Arc Welding (GMAW)

GMA – commonly referred to as Metal Inert Gas (MIG) – welding embraces a group of arc welding processes in which a continuous electrode (the wire) is fed by powered feed rolls (wire feeder) into the weld pool. An electric arc is created between the tip of the wire and the weld pool. The wire is progressively melted at the same speed at which it is being fed and forms part of the weld pool. Both the arc and the weld pool are protected from atmospheric contamination by a shield of inert (non-reactive) gas, which is delivered through a nozzle that is concentric with the welding wire guide tube.

Operation

MIG welding is usually carried out with a handheld gun as a semi-automatic process. The MIG process can be suited to a variety of job requirements by choosing the correct shielding gas, electrode (wire) size and welding parameters. Welding parameters include the voltage, travel speed, arc (stick out) length and wire feed rate. The arc voltage and wire feed rate will determine the filler metal transfer method.



This application combines the advantages of continuity, speed, comparative freedom from distortion and the reliability of automatic welding with the versatility and control of manual welding. The process is also suitable for mechanised set-ups, and its use in this respect is increasing.

MIG welding can be carried out using solid wire, flux cored, or a copper-coated solid wire electrode. The shielding gas or gas mixture may consist of the following:

- Argon
- Carbon dioxide
- Argon and carbon dioxide mixtures
- Argon mixtures with oxygen or helium mixtures.

Afrox recommends Afrox shielding gas mixtures.

Each gas or gas mixture has specific advantages and limitations. Other forms of MIG welding include using a flux cored continuous electrode and carbon dioxide shielding gas, or using self-shielding flux cored wire, requiring no shielding.

Flux Cored Arc Welding (FCAW)

How It Works

Flux Cored Arc Welding (FCAW) uses the heat generated by a DC electric arc to fuse the metal in the joint area, the arc being struck between a continuously fed consumable filler wire and the workpiece, melting both the filler wire and the workpiece in the immediate vicinity. The entire arc area is covered by a shielding gas that protects the molten weld pool from the atmosphere.

FCAW is a variant of the MIG process and, while there are many common features between the two processes, there are also several fundamental differences.

As with MIG, direct current power sources with constant voltage output characteristics are normally employed to supply the welding current. With flux cored wires, the terminal that the filler wire is connected to depends on the specific product being used (some wires run electrode positive and others run electrode negative). The work return is then connected to the opposite terminal. It has also been found that the output characteristics of the power source can have an effect on the quality of the welds produced.

The wire feed unit takes the filler wire from a spool, and feeds it through the welding gun, to the arc at a predetermined and accurately controlled speed. Normally, special knurled feed rolls are used with flux cored wires to assist feeding and to prevent crushing the consumable.

Unlike MIG, which uses a solid consumable filler wire, the consumable used in FCAW is of tubular construction, an outer metal sheath being filled with fluxing agents plus metal powder. The flux fill is also used to provide alloying, arc stability, slag cover, de-oxidation and, with some wires, gas shielding.

In terms of gas shielding, there are two different ways in which this may be achieved with the FCAW process:

- Additional gas shielding supplied from an external source, such as a gas cylinder
- Production of a shielding gas by decomposition of fluxing agents within the wire (self-shielding).

Gas shielded wires are available with either a basic or rutile flux fill, while self-shielded wires have a broadly basic type flux fill. The flux fill dictates the way the wire performs, the properties obtainable, and suitable applications.

Gas Shielded Operation

Many cored wire consumables require an auxiliary gas shield in the same way that solid wire MIG consumables do. These types of wire are generally referred to as ‘gas shielded’.

Using an auxiliary gas shield enables the wire designer to concentrate on the performance characteristics, process tolerance, positional capabilities and mechanical properties of the products.

In a flux cored wire, the metal sheath is generally thinner than that of a self-shielded wire. The area of this metal sheath surrounding the flux cored wire is much smaller than that of a solid MIG wire. This means that the electrical resistance within the flux cored wire is higher than with solid MIG wires and it is this higher electrical resistance that gives this type of wire some of its novel operating properties.

One often quoted property of flux cored wires is their higher deposition rates in comparison to solid MIG wires. What is often not explained is how they deliver these higher values and whether these can be utilised. For example, if a solid MIG wire is used at 250 A, then exchanged for a flux cored wire of the same diameter, and welding power source controls are left unchanged, then the current reading would be much less than 250 A, and perhaps as low as 220 A. This is because of Ohm's Law, which states that as the electrical resistance increases (and if the voltage remains stable) then the current must fall.

To bring the welding current back to 250 A, it is necessary to increase the wire feed speed, effectively increasing the amount of wire being pushed into the weld pool to make the weld. It is this effect that produces the 'higher deposition rates' that the flux cored wire manufacturers claim for this type of product. Unfortunately, in many instances, the welder has difficulty in utilising this higher wire feed speed and must either increase the welding speed or increase the size of the weld. Often in manual applications, neither of these changes can be implemented and the welder simply reduces the wire feed speed back to where it was and the advantages are lost. However, if the process is automated in some way, then the process can show improvements in productivity.

It is also common to use longer contact tip to workplace distances with flux cored arc welding than with solid wire MIG welding, which has the effect of increasing the resistive heating on the wire further accentuating the drop in welding current. Research has also shown that increasing this distance can lead to an increase in the ingress of nitrogen and hydrogen into the weld pool, which can affect the quality of the weld.

Flux cored arc welding has a lower efficiency than solid wire MIG welding, because part of the wire fill contains slag forming agents. Although the efficiency varies by wire type and manufacturer, it is typically between 75 and 85%.

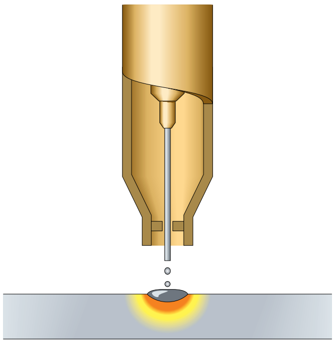
Flux cored arc welding does, however, have the same drawback as solid wire MIG in terms of gas disruption by wind, and screening is always necessary for site work. It also incurs the extra cost of shielding gas, but this is often outweighed by gains in productivity.

Self-Shielded Operation

There are also self-shielded consumables designed to operate without an additional gas shield. In this type of product, arc shielding is provided by gases generated by decomposition of some constituents within the flux fill. These types of wire are referred to as 'self-shielded'.

If no external gas shield is required, then the flux fill must provide sufficient gas to protect the molten pool and to provide de-oxidisers and nitride formers to cope with atmospheric contamination. This leaves less scope to address performance, arc stabilisation and process tolerance, so these tend to suffer when compared with gas shielded types.

Wire efficiencies are also lower, at about 65%, in this mode of operation than with gas shielded wires. However, the wires do have a distinct advantage when it comes to site work in terms of wind tolerance, as there is no external gas shield to be disrupted.



Extended self-shielded flux cored wire nozzle

When using self-shielded wires, external gas supply is not required and, therefore, the gas shroud is not necessary. However, an extension nozzle is often used to support and direct the long electrode extensions that are needed to obtain high deposition rates.

Metal Cored Arc Welding (MCAW)

How It Works

Metal Cored Arc Welding (MCAW) uses the heat generated by a DC electric arc to fuse metal in the joint area, the arc being struck between a continuously fed consumable filler wire and the workpiece, melting both the filler wire and the workpiece in the immediate vicinity. The entire arc area is covered by a shielding gas, which protects the molten weld pool from the atmosphere.

As MCAW is a variant of the MIG welding process, there are many common features between the two processes, but there are also several fundamental differences.

As with MIG, direct current power sources with constant voltage output characteristics are normally employed to supply the welding current. With metal cored wires, the terminal that the filler wire is connected to depends on the specific product being used. (Some wires are designed to run on electrode positive, while others run on electrode negative, and some run on either.) The work return lead is then connected to the opposite terminal. Electrode negative operation will usually give better positional welding characteristics. The output characteristics of the power source can have an effect on the quality of the welds produced.

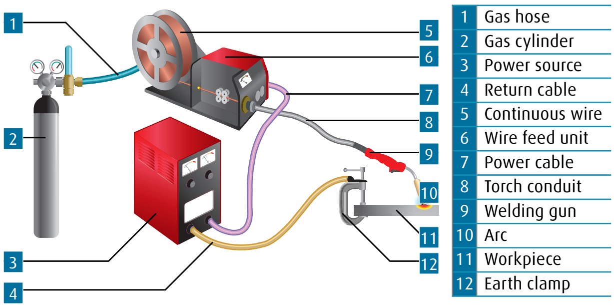
The wire feed unit takes the filler wire from a spool or bulk pack, and feeds it through the welding gun to the arc at a predetermined and accurately controlled speed. Normally, special knurled feed rolls are used with metal cored wires to assist feeding and to prevent crushing the consumable.

Unlike MIG, which uses a solid consumable filler wire, the consumable used in MCAW is of tubular construction, an outer metal sheath being filled entirely with metal powder, except for a small amount of non-metallic compounds. These are added to provide some arc stability and de-oxidation.

MCAW consumables always require an auxiliary gas shield in the same way that solid MIG wires do. Wires are normally designed to operate in argon-carbon dioxide or argon-carbon dioxide-oxygen mixtures or carbon dioxide. Argon-rich mixtures tend to produce lower fume levels than carbon dioxide.

As with MIG, the consumable filler wire and the shielding gas are directed into the arc area by the welding gun. In the head of the gun, the welding current is transferred to the wire by means of a copper alloy contact tip, and a gas diffuser distributes the shielding gas evenly around a shroud which then allows the gas to flow over the weld area. The position of the contact tip relative to the gas shroud may be adjusted to limit the minimum electrode extension.

Modes of metal transfer with MCAW are very similar to those obtained in MIG welding, the process being operable in both 'dip transfer' and 'spray transfer' modes. Metal cored wires may also be used in pulse transfer mode at low mean currents, but this has not been widely exploited.



Process schematic diagram for MIG/FCAW and MCAW

Modes of Metal Transfer

The mode or type of metal transfer in MIG welding depends upon the current, arc voltage, electrode diameter and type of shielding gas used. In general, there are four modes of metal transfer.

Modes of metal transfer with FCAW are similar to those obtained in MIG welding, but here the mode of transfer is heavily dependent on the composition of the flux fill, as well as on current and voltage.

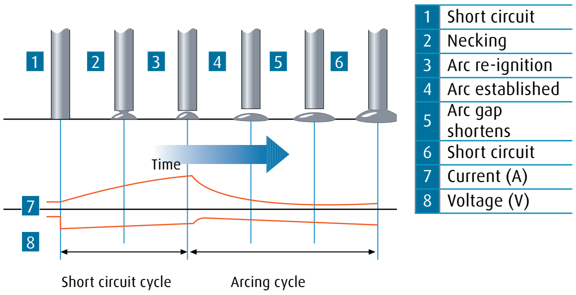
The most common modes of transfer in FCAW are:

- Dip transfer
- Globular transfer
- Spray transfer.

Pulsed arc transfer operation has been applied to flux cored wires but, as yet, is not widely used because the other transfer modes are giving users what they require in most cases.

Dip Transfer

Also known as short-circuiting arc or short-arc, this is an all-positional process, using low heat input. The use of relatively low current and arc voltage settings cause the electrode to intermittently short-circuit with the weld pool at a controlled frequency. Metal is transferred by the wire tip actually dipping into the weld pool and the short-circuit current is sufficient to allow the arc to be re-established. This short-circuiting mode of metal transfer effectively extends the range of MIG welding to lower currents so thin sheet material can readily be welded. The low heat input makes this technique well-suited to the positional welding of root runs on thick plate, butt welds for bridging over large gaps and for certain difficult materials where heat input is critical. Each short-circuit causes the current to rise and the metal fuses off the end of the electrode. A high short-circuiting frequency gives low heat input. Dip transfer occurs between ±70–220 A, 14–23 arc volts. It is achieved using shielding gases based on carbon dioxide and argon.

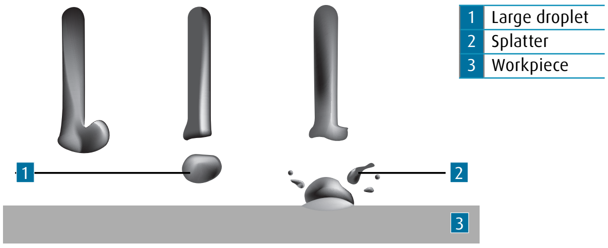


Schematic of dip transfer

Metal cored wires transfer metal in dip mode at low currents, just like solid MIG wires. This transfer mode is used for all positional work with these types of wire.

Globular Transfer

Metal transfer is controlled by slow ejection, resulting in large, irregularly-shaped 'globs' falling into the weld pool under the action of gravity. Carbon dioxide gas drops are dispersed haphazardly. With argon-based gases, the drops are not as large and are transferred in a more axial direction. There is a lot of spatter, especially in carbon dioxide, resulting in greater wire consumption, poor penetration and poor appearance. Globular transfer occurs between the dip and spray ranges. This mode of transfer is not recommended for normal welding applications and may be corrected when encountered by either decreasing the arc voltage or increasing the amperage. Globular transfer can take place with any electrode diameter.



Schematic formation of globular transfer

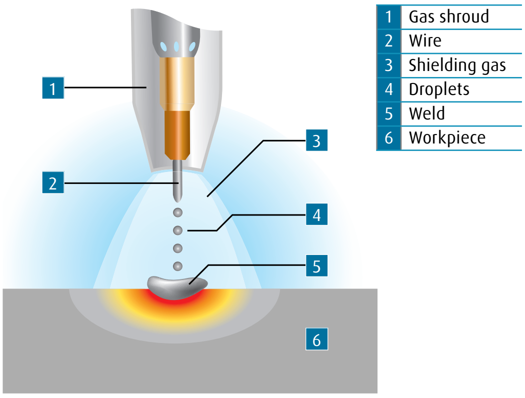
Basic flux cored wires tend to operate in a globular mode or in a globular-spray transfer mode, where larger than normal spray droplets are propelled across the arc, but they never achieve a true spray transfer mode. This transfer mode is sometimes referred to as non-axial globular transfer.

Self-shielded flux cored wires operate in a predominantly globular transfer mode, although at high currents the wire often 'explodes' across the arc.

Spray Transfer

In spray transfer, metal is projected by an electromagnetic force from the wire tip in the form of a continuous stream of discrete droplets approximately the same size as the wire diameter. High deposition rates are possible and weld appearance and reliability are good. Most metals can be welded, but the technique is limited generally to plate thicknesses greater than 6 mm. Spray transfer, due to the tendency of the large weld pool to spill over, cannot normally be used for positional welding. The main exception is aluminium and its alloys where, primarily because of its low density and high thermal conductivity, spray transfer in position can be carried out.

The current flows continuously because the high voltage maintains a long arc and short-circuiting cannot take place. It occurs best with argon-based gases.



Schematic of spray transfer

In solid wire MIG, as the current is increased, dip transfer passes into spray transfer via a transitional globular transfer mode. With metal cored wires there is virtually a direct transition from dip transfer to spray transfer as the current is increased.

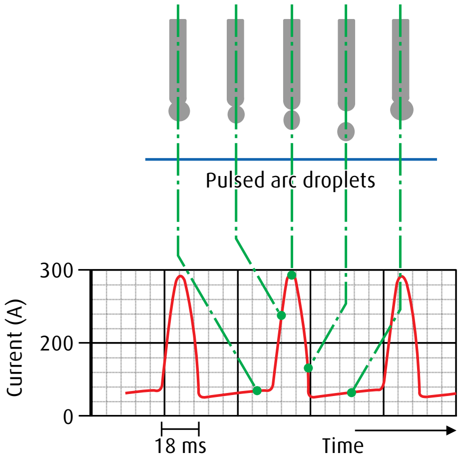
For metal cored wire, spray transfer occurs as the current density increases and an arc is formed at the end of the filler wire, producing a stream of small metal droplets. Often the outside sheath of the wire will melt first and the powder in the centre flows as a stream of smaller droplets into the weld pool. This effect seems to give much better transfer of alloying elements into the weld.

In spray transfer, as the current density increases, an arc is formed at the end of the filler wire, producing a stream of small metal droplets. In solid wire MIG, this transfer mode occurs at higher currents. Flux cored wires do not achieve a completely true spray transfer mode, but a transfer mode that is almost true spray may occur at higher currents and can occur at relatively low currents depending on the composition of the flux.

Rutile flux cored wires will operate in this almost-spray transfer mode at all practicable current levels. They are also able to operate in this mode for positional welding. Basic flux cored and self-shielded flux cored wires do not operate in anything approaching true spray transfer mode.

Pulsed Transfer

Pulsed arc welding is a controlled method of spray transfer, using currents lower than those possible with the spray transfer technique, thereby extending the applications of MIG welding into the range of material thickness where dip transfer is not entirely suitable.The pulsed arc equipment effectively combines two power sources into one integrated unit. One side of the power source supplies a background current which keeps the tip of the wire molten. The other side produces pulses of a higher current that detach and accelerate the droplets of metal into the weld pool. The transfer frequency of these droplets is regulated primarily by the relationship between the two currents. Pulsed arc welding occurs between ±50–220 A, 23–35 arc volts, and only with argon and argon-based gases. It enables welding to be carried out in all positions.



Schematic of pulse transfer

Process	Dip Transfer	Globular Transfer	Spray Transfer	Pulsed Transfer
Metal Inert Gas (MIG)	●		●	●
Flux Cored (Rutile Type)	●	●	Not True Spray	
Flux Cored (Basic Type)	●	●		
Metal Cored	●		●	●

TIG Process

The Gas Tungsten Arc Welding – commonly referred to as Tungsten Inert Gas (TIG) – process uses the heat generated by an electric arc struck between a non-consumable tungsten electrode and the workpiece to fuse metal in the joint area and produce a molten weld pool. The arc area is shrouded in an inert or reducing gas shield to protect the weld pool and the non-consumable electrode. The process may be operated autogenously (without filler), or filler may be added by feeding a consumable wire or rod into the established weld pool.

- The addition of filler is optional
- Only inert or reducing gases can be used as the shielding gas
- TIG welding is a high quality, versatile and commonly used process
- TIG is suitable for welding ferrous and non-ferrous materials
- The TIG process can be run on DC-, DC+, or AC.

The TIG process is capable of producing very high quality welds in a wide range of materials and in thicknesses up to about 8 or 10 mm. It is particularly suited to welding of sheet material and for putting in the root run of pipe butt welds.

The process tends to be very clean, producing little particulate fume, although it is capable of generating ozone in appreciable amounts and is not regarded as a high-productivity process.

Operation

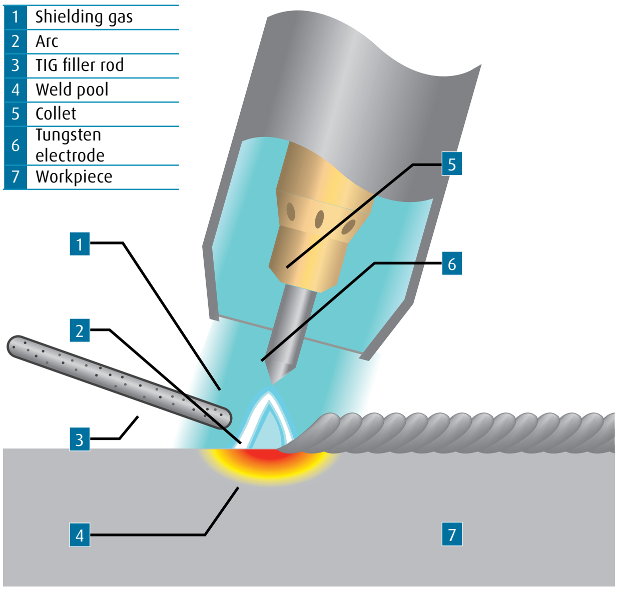
Direct or alternating current power sources with constant current output characteristics are normally employed to supply the welding current. For DC operation, the tungsten may be connected to either output terminal, but is most often connected to the negative pole. The output characteristics of the power source can have an effect on the quality of the welds produced. Shielding gas is directed into the arc area by the welding torch, and a gas lens within the torch distributes the shielding gas evenly over the weld area. In the torch, the welding current is transferred to the tungsten electrode from the copper conductor. The arc is then initiated by one of several methods between the tungsten and the workpiece.

Operating Modes

The TIG process may be operated in one of the following modes:

- Direct Current Electrode Negative (DCEN)
- Direct Current Electrode Positive (DCEP)
- Alternating Current (AC).

The mode used is largely dependent on the parent material being welded.



Schematic of the TIG welding process

DC Electrode Negative (DCEN)

In this mode the tungsten electrode is the negative pole in the welding circuit, the workpiece being the positive pole.

DC Electrode Positive (DCEP)

In this mode the tungsten electrode is the positive pole in the welding circuit, the workpiece being the negative pole.

Alternating Current (AC)

In this mode the polarity of the tungsten electrode and the workpiece alternate between negative and positive at the frequency of the applied welding current.

Process Variants

There are three main variations of the TIG process designed to improve productivity:

- Orbital TIG
- Hot-wire TIG
- Narrow-gap TIG
- Cold-wire TIG.

Application

The TIG process is very versatile and may be used to weld any metal or alloy system over a wide range of thicknesses, but is usually restricted to 10 mm and under for economic reasons. It is particularly suited to welding sheet materials and for the root run in pipe butt welds.

DCEN is the most common mode of operation and is widely used for welding all carbon, alloy and stainless steels, as well as nickel and titanium alloys. Copper alloys, with the exception of those containing aluminium in significant amounts, can also be welded with this polarity.

DCEP is used for aluminium alloys when welding, with pure helium as the shielding gas, since this polarity has a strong cathodic cleaning effect capable of removing the tenacious aluminium oxide film from the surface. It may also be used for TIG welding magnesium alloys.

AC polarity is used most commonly when welding aluminium and its alloys with pure argon or argon-helium mixtures to take advantage of the combination of the cyclic heating and cleaning action. It is also suitable for welding magnesium alloys and aluminium bronze.

Hot-wire TIG is used predominantly for steel and nickel alloys where the electrical resistance of the wire can be used to increase productivity.

Applications

- High quality fabrications in stainless steel
- Aluminium, copper and nickel alloys
- Welding reactive and refractory metals such as titanium, tantalum and zirconium.

The process is used extensively in the nuclear and aerospace industries and in the construction and maintenance of chemical and cryogenic process plant and pipework. It is also used for fabrication of tube heat exchangers in petrochemical and power-generation plant, and for brewing and food-processing vessels.

Orbital TIG welding is used in the nuclear, pharmaceutical, semi-conductor and food industries for the installation of pipework – especially where high quality standards are required.

Specialist equipment for tube and tube-plate welding for heat exchangers has been developed. These systems may operate from the outside or inside, depending on tube diameter and the size of the welding head.

TIG Welding Equipment

The equipment used for TIG welding consists of:

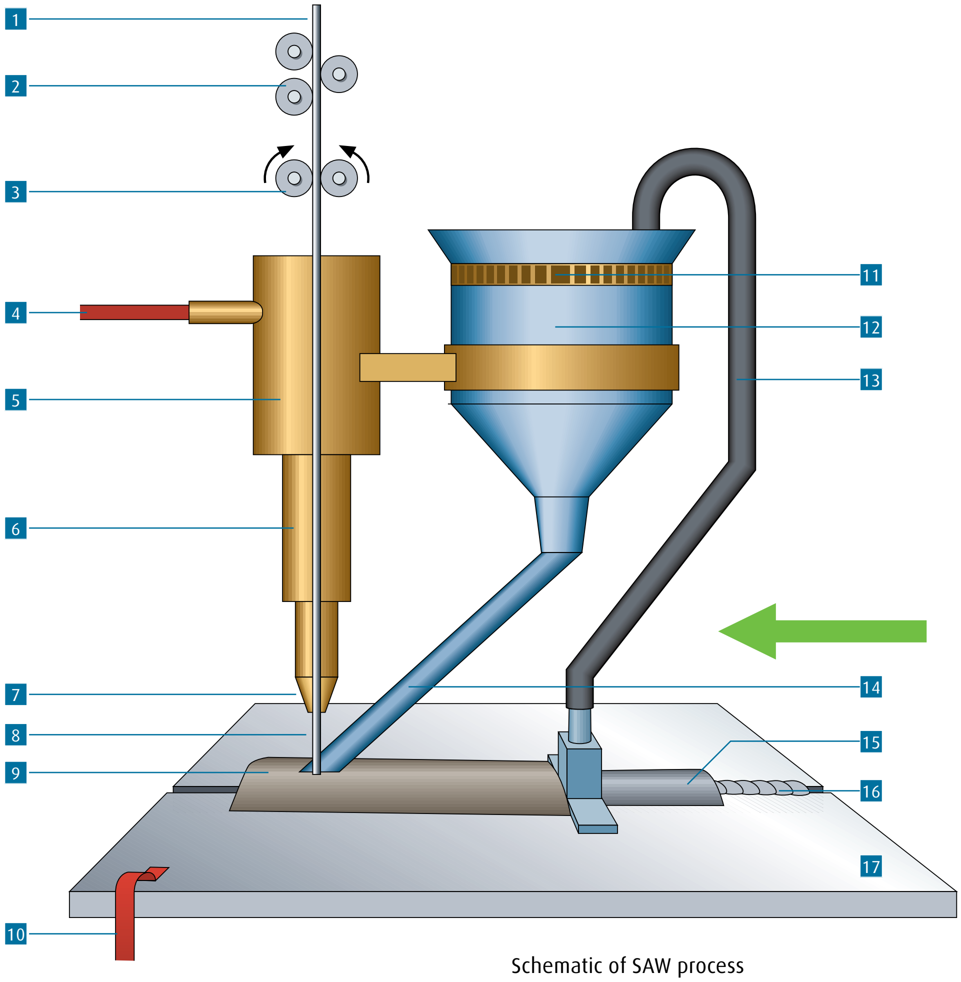
- Power source
- Welding torch
- Tungsten electrode
- Leads and connectors
- Gas supply system
- Arc and re-ignition system.

Submerged Arc Welding (SAW)

How It Works

SAW uses the arc struck between a continuously fed electrode and the workpiece to melt the metal in the joint area and provide additional filler metal under a blanket of granular flux. This arc is completely submerged under the molten flux, which protects the molten metal from the atmosphere. There is no visible arc, spatter or fume during the welding operation. The continuous electrode may be a solid or cored wire.

The solid wires are normally copper coated. The cored wires may contain either metallic materials or a mixture of metallic and flux materials. Flux cored wires affect the welding characteristics and metallurgical quality of the deposited weld metal. On surfacing applications, a strip electrode can be used instead of a wire.



1	Submerged arc wire
2	Straightening rollers
3	Feed rollers
4	Power lead
5	Contact tube
6	Extension tube
7	Electrode guide
8	Electrode
9	Flux bed
10	Lead to earth
11	Slag sieve
12	Flux hopper
13	Excess flux recovery system
14	Flux delivery tube
15	Slag
16	Weld bead
17	Workpiece

Schematic of SAW process

A wide range of flux compositions is used with submerged arc welding. Generally speaking, fluxes with the best welding characteristics give inferior weld metal mechanical properties. These fluxes are known as acid fluxes. Neutral fluxes generally give a good all round performance. While basic fluxes give the best metallurgical results, they possess inferior welding characteristics. The normal approach is to select the flux with the best running characteristics that will meet the metallurgical requirements comfortably.

SAW may be carried out using either DC or AC power sources. The best all round welding conditions are normally obtained with DC electrode positive. DC electrode negative will give higher deposition rates, but fusion characteristics are reduced so that this mode of transfer is mainly used on weld surfacing applications. AC welding may also be used, but arc control is not as good as on DC electrode positive. This means that many fluxes are developed primarily for DC operation and will not operate satisfactorily on AC.

Operating Parameters

SAW is capable of operating at high welding currents. Welding current is the parameter that controls weld deposition rate. It also controls the depth of weld penetration and the amount of base metal melted. Arc voltage controls the arc length and this has a major influence on the shape of the weld and its exterior appearance. Raising the arc voltage increases the arc length and this, in turn, increases the weld width. Lowering the arc voltage has the opposite effect.

The travel speed controls the heat input into the joint area. Increasing travel speed reduces the heat input and supplies less filler metal per unit length of weld, resulting in less weld reinforcement. Increasing travel speed reduces weld penetration but can cause undercut. Reducing travel speed provides time for the gases to escape from the molten metal and thus porosity may be reduced.

Electrode 'stick out', the distance between the contact tube and the arc, has a major affect on weld penetration and deposition rate. Increasing the stick out increases deposition rate and reduces weld penetration. However, to maintain optimum process control, the electrode stick out is normally maintained between 25–35 mm unless special nozzle adaptors are fitted.

Application

SAW is widely used for welding carbon, carbon manganese, alloy and stainless steels. It is also used for joining some nickel based alloys.

The ability to produce high quality, defect-free welds at high deposition rates and with deep weld penetration makes the SAW process highly suitable for all mechanised and automatic welding and surfacing applications.

Typical Welding Applications

With welding longitudinal and spiral welded pipes, the longitudinal welds are carried out using a two-pass welding procedure. A welding station located inside the pipe deposits the inside weld and the joint is completed by another station with a single weld on the outside of the pipe. Spiral welded pipes are produced from a continuous coil of strip that is folded into a spiral. One welding head deposits a single weld on the inside and another completes the joint from the outside.

In shipbuilding, the process is used to produce butt welds with a two pass welding procedure depositing a single run on each side of the joint. Stiffeners are produced using single and twin fillet welding procedures. Major shipyards carry out this operation using panel lines where large sections are produced prior to transfer to the construction berth.

Submerged arc welding is widely used on general structural steel welding applications, including mass production of repetitive short welds. Single side welding procedures using a copper backing system are often used on applications such as propane cylinder production.

Typical Surfacing Applications

Roll resurfacing is carried out as a continuous operation. Circumferential bead welds are deposited on the roll surface. When a weld is completed around the roll, the welding head is automatically adjusted to produce the next bead adjacent to the previous one. This process is continued until the complete roll has received one layer of surfacing deposit. The head is then repositioned to produce a second and further layers of weld metal as required.

Submerged arc welding is widely used for cladding carbon and alloy steels with stainless steel and nickel alloy deposits. This process is usually carried out using strip electrodes and alloy bearing fluxes which compensate for alloy losses in the arc.

Afrox offers a range of accessories for submerged arc welding.

Welding Process Comparisons

Weld costs, productivity, weld positions, weld materials and welder skill are all criteria to be considered when selecting welding processes and their appropriate equipment and consumables. These factors will significantly affect the quality of the weld and the overall process costs.

MMA Comparisons

MIG to MMA

- MMA is an intermittent, low-productivity process with electrode replacement necessary at regular intervals
- MMA is predominantly a manual process, whereas MIG can be used manually, automatically and robotically
- MMA electrodes are available primarily for ferrous materials and nickel alloys, but electrodes can be tailored to suit the composition of the parent material. MIG covers a wider range of standard materials, but all grades are not always available
- MMA requires no shielding gas
- MMA is ideally suited to outside and site work; MIG suffers from draughts affecting the gas shield
- Consumable wastage levels in MMA are high
- MMA requires the slag to be removed, as MIG doesn't create a slag cover
- Welding speeds are much quicker with MIG, so joint completion times are much lower
- With MMA, only about 65% of the consumable weight is converted into weld metal, compared to about 98% for MIG.

TIG to MMA

- MMA is predominantly a manual process, but TIG is used both manually and for the automatic orbital welding of pipe
- MMA electrodes are available primarily for ferrous materials and nickel alloys, but electrodes can be tailored to suit the composition of the parent material. TIG covers a wide range of both ferrous and non-ferrous materials
- MMA requires no shielding gas
- MMA is ideally suited to outside and site work, while TIG suffers from draughts affecting the gas shield
- Consumable wastage levels in MMA are high
- MMA requires the slag to be removed, as TIG doesn't create a slag cover
- Welding speeds are higher with MMA, but with clean-up added there can be little difference between the processes
- TIG welding power sources are normally capable of being used for MMA welding

- Both processes require good operator technique to produce high quality welds.

FCAW to MMA

- MMA is predominantly a manual process, whereas FCAW can be used manually, automatically and robotically
- MMA electrodes and flux cored wires cover very similar ferrous, nickel and hardfacing materials
- MMA requires no shielding gas. Some types of cored wire require a shielding gas but others don't
- MMA is ideally suited to outside and site work, as are gasless cored wires
- Consumable wastage levels in MMA are high compared to cored wires
- Welding speeds are much quicker with cored wires, so joint completion times are much faster
- With MMA, only about 65% of the consumable weight is converted into weld metal, compared to about 80% for FCAW.

MIG Comparisons

MMA to MIG

- MIG is a high-productivity continuous process requiring little downtime
- MIG can be used manually, automatically and robotically, whereas MMA is predominantly a manual process
- MIG covers a wide range of standard materials. MMA electrodes are available primarily for ferrous materials and nickel alloys, but electrodes can be tailored to suit the composition of the parent material
- MIG requires a shielding gas, which is often different for different materials. MMA requires no shielding gas
- MIG suffers from draughts affecting the gas shield. MMA is ideally suited to outside and site work because it doesn't require a shielding gas
- There is little wastage associated with MIG welding. Consumable wastage levels in MMA are high
- MIG doesn't create a slag cover, but MMA requires the slag to be removed
- Welding speeds are much quicker with MIG, so joint completion times are much lower
- With MIG, about 98% of the consumable weight is converted into weld metal compared to about 65% for MMA.

TIG to MIG

- MIG and TIG welding can both be carried out either manually or automatically
- Skill levels for MIG welding are lower than those required for TIG
- Welding speeds for MIG are generally about double those for TIG
- Weld costs per unit length are much higher in TIG welding
- It is generally considered that defect levels in TIG welds are lower than those for MIG.

FCAW to MIG

- Both MIG and FCAW can be used manually, automatically and robotically
- MIG wires are available for a wide range of ferrous and non-ferrous materials. FCAW is limited to steel and some types of stainless steels
- Positional welding can be easier using some flux cored wires than with MIG
- MIG requires a shielding gas. Some types of cored wire require a shielding gas but others don't
- MIG is predominantly a workshop process, but gasless cored wires are designed for site work
- Flux cored wires are much less efficient. With MIG, about 98% of the consumable weight is converted into weld metal compared to about 80% for basic and rutile FCAW, and 65% for gasless cored wires
- Welding speeds are very similar between MIG and FCAW
- MIG doesn't create a slag cover, but FCAW requires the slag to be removed
- Weld costs per unit length are generally higher with FCAW than with MIG.

TIG Comparisons

MMA to TIG

- TIG can be used manually or automatically, whereas MMA is predominantly a manual process
- TIG can be used for all metals and alloys, whereas MMA electrodes are available primarily for ferrous materials, stainless steels and nickel alloys
- TIG can be used to weld refractory metals because of its inert gas shield. MMA is not suited to welding these materials
- TIG filler compositions are restricted, but MMA electrodes can be tailored to suit the composition of the parent material
- TIG requires a shielding gas, but MMA does not
- TIG can suffer from drafts disrupting the gas shield. MMA is ideally suited to outside and site work because it doesn't require a shielding gas
- There is very little consumable wastage with TIG welding, almost all of it being converted into weld metal. Consumable wastage levels in MMA are high, with only approximately 65% ending up as weld metal
- TIG doesn't create a slag cover and needs little post weld cleaning, but MMA requires the slag to be removed.

MIG to TIG

- TIG and MIG welding can both be carried out either manually or automatically
- Skill levels for TIG welding are much higher than those required for MIG
- Welding speeds for TIG are generally about half those for MIG, with the exception of hot-wire TIG
- Weld costs per unit length are much higher in TIG welding compared with MIG

- Less defects are normally detected in TIG than MIG welds.

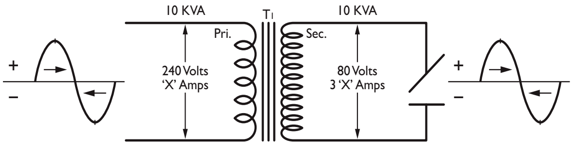
Plasma to TIG

- TIG and plasma welding can both be carried out either manually or automatically
- The arc in plasma welding is hotter than that for TIG
- Plasma can weld greater thicknesses in a single pass than TIG by using the keyhole welding technique
- TIG has a greater tolerance to fit-up of components than plasma.

Welding Power Sources

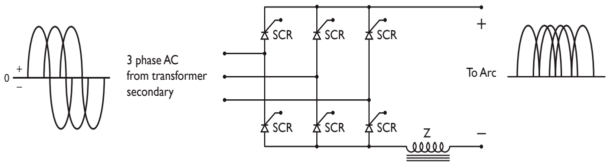
AC Transformers

AC transformers convert the electrical supply voltage and amperage to a safer, usable welding amperage and voltage. These units are suited to applications where external magnetic fields cause magnetic arc blow and the alternating current output eliminates the effect of the magnetic field.



DC Rectifiers

DC rectifiers offer a more stable welding output, particularly where the highest possible welding standards are required. The direct current output makes these units suitable for a wider range of welding electrodes and applications. DC rectifiers afford easier arc initiation, better out-of-position weld pool control, and they also generate less spatter.



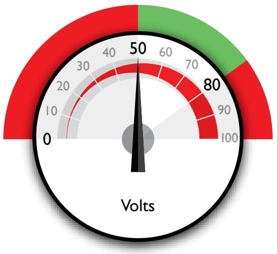
AC/DC Power Sources

These are power sources that have the option of selecting AC or DC power output. They provide the user with the advantage of using processes requiring either an AC transformer or DC rectifier. Good performance is achievable across the spectrum of welding applications.

Open Circuit Voltage

The open circuit voltage (OCV) is the voltage measured at the output of a welding transformer when the output is not under load. The open circuit voltage supports arc initiation, and it is important to establish that the welding transformer has sufficient voltage to initiate the arc, particularly when AC transformers are used, less so with DC power sources.

Restrictions on OCV



MMA Process

Poor Welding	Unsafe
Min. OCV is ± 50 V AC	Max OCV is 80 V AC
For good arc striking	For safety reasons
For good arc stability	

The Need for OCV

Electrode manufacturers specify a minimum OCV requirement for their electrodes.

General Purpose	Low Hydrogen
50 V AC Min	70 V AC Min

Voltage Reduction Devices

VRD is an abbreviation for voltage reduction devices, or more commonly known as voltage reducers. When a VRD is fitted to a welding machine it reduces the potentially unsafe maximum OCV across the output terminals of the welding machine to a safer voltage. When attempting to strike an arc the VRD will sense this and switch the welding machine to full output whereupon normal welding can commence.

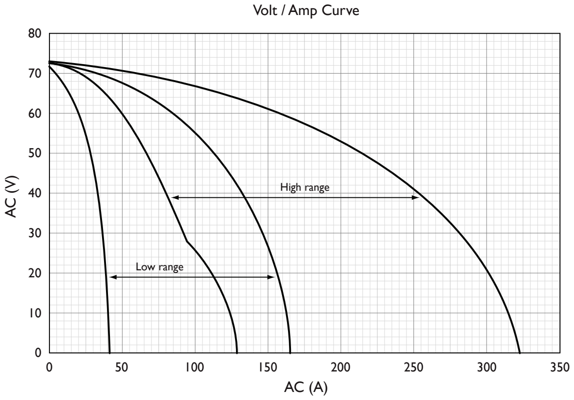
Voltage reducers are devices that are typically connected to constant current welding power sources for use with the MMA process.

It is in most cases not a requirement to fit a VRD for the TIG or MIG processes.

Voltage reducers are typically connected to the secondary (welding output) side of the power source and may be either internally or externally mounted.

Volt-Ampere Characteristics

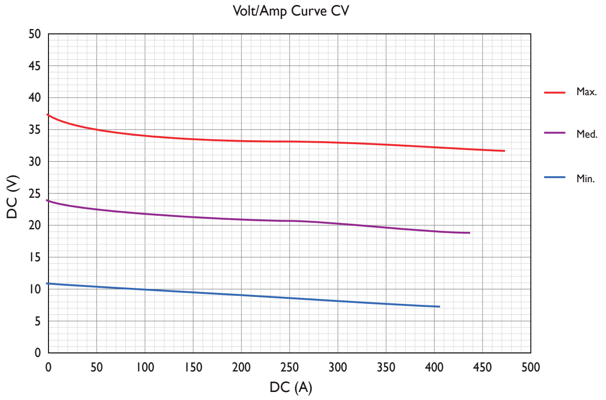
Constant Current



The above volt-ampere (V–A) curve illustrates how welding current changes when arc voltage changes and power source settings remain unchanged. This drooping characteristic is common for MMA and TIG power sources and for processes that utilise voltage-sensing feeders.

A large change in arc voltage will only result in small changes to the current. Arc voltage is affected by arc length, process parameters such as electrode type, shielding gas and arc current. Generally, less skilled welders will prefer the current to stay near constant if the arc length should change with MMA and TIG welding.

Constant Voltage



The above graph illustrates the typical volt-ampere relation in constant voltage machines. This V-A characteristic is suitable for maintaining constant arc length in constant-speed processes such as MIG, SAW and flux cored welding. A slight change in arc length (voltage) causes a large change in the welding current. This automatically increases or decreases the electrode melting rate to regain the desired arc length. This effect is called self-regulation.

Method of Output Control

It is important to select a welding transformer with an output control suited to the application. Stepped output control is less costly, but limits the welder to between fixed amperage or voltage options. Welding applications that require precise output require more accurate control. Moving shunt, moving coil, mag amp and thyristor control provide the welder with the capability to adjust the machine to deliver the precise amperage necessary for high quality welding. The voltage should meet the requirement as stipulated by the electrode manufacturer.

All power sources used for MIG and MAG welding have a DC output, while flux cored wire welding may use either a DC or AC power source, depending on the type of wire in question. Semi-automatic power sources display the following main controls: switches or potentiometers for selection of open circuit/arc voltage, inductance control and burn-off control.

Voltage Selection

A suitable voltage is selected by a switch or switches on the power source. These switches, in effect, select a number of windings of the primary side of the transformer. Potentiometers set phase angles. The selection of a suitable OCV also determines the amperage that the machine is capable of delivering. This is, however, controlled precisely by the wire feed speed when welding is commenced.

Inductance

A rise in current to above normal in any electrical circuit results in the melting of the wire at some point. To avoid damage to the circuit, a fuse is installed at a convenient point. In the event of a current rise as a result of a short-circuit, the fuse wire will melt off and break the circuit. Inspecting a 'blown' fuse can indicate, to a certain extent, what the cause of the overload has been. If the wire in the fuse has only just parted with a small globule of metal on one strand, it indicates a slow, gradual overloading of the circuit. If, however, the wire has 'blown' violently and bits of fuse wire have been flung all over the inside of the capsule, the cause of the overload was certainly a serious short-circuit.

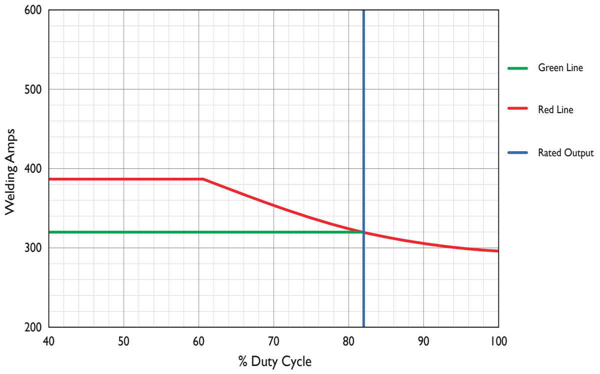
Consider dip transfer (short-circuiting arc) in action. Before the wire strikes the workpiece, there is no flow of current and the voltage has maximum value (i.e. OCV). When the wire strikes the workpiece, one creates what is known as a 'dead short'. This short-circuit causes the current to rise rapidly and burn off the wire violently. This rapid melt flings about metal globules as it takes place.

These globules settle on the workpiece and welding torch in the form of 'spatter'. To control the rate of rise of short-circuiting current, a choke (or inductor) is fitted in series with the welding power cable. This inductor thus 'chokes' the rate of rise of current and ensures a smooth arc condition.

Inductance controls the rate of rise of short-circuiting current. It becomes evident that inductance must be a function of time and current, since it controls the time taken for the current to rise to the pre-set value. Hence an increase in inductance results in less frequent short-circuiting. Fewer short-circuits imply that the arc is present for a longer duration of time. Increased 'arc-on' time means increased heat input.

On heavier plate, where more heat is required to ensure good fusion, more inductance would contribute immensely. Conversely, on thinner sections, less inductance would lead to a decrease in 'arc-on' time, and consequently a 'cooler' arc that enables thin materials to be welded with ease.

Duty Cycle

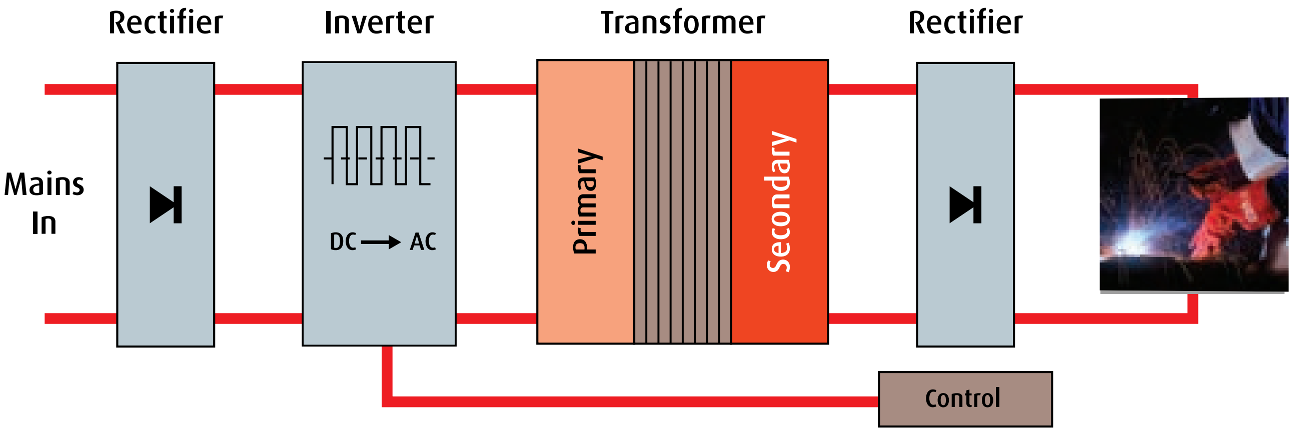


Duty cycle is defined as the ratio of arc on time to total time. For a welding machine it is normal to consider a 10 minute time period. In the above example, the duty cycle of the machine is 82% at 320 A. The duty cycle for other amperages can be calculated by using the following equation:

$$\%\ \text{Duty Cycle} = \frac{(\text{Rated Current})^2}{(\text{Load Current})^2} \times (\text{Rated Duty Cycle})$$

Furthermore by using the following equation it is possible to determine the amperages at any given duty cycle:

$$\text{Amps (Req)} = \sqrt{\frac{\text{Amps}^2\ (\text{Given}) \times \text{Duty Cycle (Given)}}{\text{Duty Cycle (Req)}}}$$



Inverter Technology

The primary rectifier-inverter circuits (often referred to as 'inverters' in welding power source literature) allow the advantages of electronic control to be obtained more economically. This type of circuit is common in low power domestic applications such as television and computer power supplies.

It is a type of power source that became viable when relatively high power switching devices became available. The AC mains input is first rectified, then the high voltage DC output of the rectifier is fed to an inverter which converts the DC to high frequency alternating current by a variety of semiconductor switching circuits. The high voltage-high frequency AC is reduced to a safe level suitable for welding by a transformer and finally rectified to produce a DC output. Control is achieved by pulse width modulation or mark-space control of the switching devices.

This apparently complex circuit is justified by the effect of the increased AC frequency on the transformer. The size, weight and cost of a transformer depends on its frequency, as the operating frequency increases, the size is reduced. AC frequencies of 100 kHz are achievable with commercially available semi-conductors. A transformer operating at this frequency is dramatically smaller than the normal 50 Hz mains transformer. In addition, regardless of whether a single or three-phase mains input is used, the 'inverter' transformer is a single-phase device.

Conventional and Inverter Transformers

The influence on transformer size, shown above, is where a conventional three-phase 200 A transformer is compared with a 20 kHz, 200 A transformer. The reduction in copper windings and iron laminations, in addition to the reduced labour content involved in its construction, significantly reduce the transformer cost. The electrical efficiency is also reduced due to the absence of a magnetising current drain in the transformer.

The effect on the final power source size is quite dramatic. A typical 150 A inverter power source will only weigh 5-8 kg, compared to between 20 and 50 kg for a conventional transformer power source.

Typical Dimensions of Inverter versus Conventional Power Sources

Dimensions	Conventional Power Source (mm)	Inverter Power Source (mm)
Height	290	250
Width	215	123
Length	370	305

As the cost of the electronic power devices has reduced and reliability of the designs has improved, the primary rectifier-inverter has become competitive for a wide range of welding power source applications.

The power switching devices used in the inverter stage vary depending on the design and the manufacturer. They must be specifically rated for the high switching frequencies and voltages present, but devices such as asymmetrical SCRs (ASCRs), Field-Effect Transistors (FETs) and Metal-Oxide Semiconductor Field-Effect Transistors (MOSFETs) are among the components successfully used.

Welding Power Source Comparisons

A summary of power source types and their capabilities is given below:

Power Source Type	Output Characteristics	Electrical Efficiency	Physical Characteristics	Relative Cost	Applications
Motor generator – (mains powered electric motor driven)	Variable – slow response rate	Poor	Large and noisy, subject to mechanical wear	Expensive	MMA, SAW
Engine driven generator – (petrol, diesel, gas engine driven)	Variable – relatively slow response rate	N/A	Wide range – small petrol to large diesel	High	Field welding, MMA, MIG where no mains power available
Conventional tapped transformer-rectifier, moving iron, variable inductor, magnetic amplifier, etc.	Fixed at design stage, slow response rate, no mains voltage stabilisation	Fair – but magnetising current and thermal losses in transformer	Relatively heavy and industrial duty units are large but robust and reliable	Cheap	MIG, MMA and TIG. Hobby units and general purpose fabrication
SCR phase control	Electronically variable within response limits of switching system. Mains stabilised but high ripple especially at low output	Fair	May be more compact than conventional design due to reduction in size of magnetic (wound) components	High	Manual and mechanised MIG/TIG and manual MMA. Medium to high quality fabrications
Transistor series regulator	Very fast response, flexible control, waveform control, accurate, ripple free, repeatable	Poor	Fairly large, may be water-cooled	Very expensive	High quality mechanised and automated MIG and TIG. Precision engineering and R&D
Hybrid and secondary chopper	Fast response, variable output, stable and repeatable	Good	Medium size, air-cooled	High	Medium to high quality manual and automated, multiprocess
Primary rectifier-inverter	Fast response, variable output, stable and repeatable	Very good	Compact – electronically complex	Medium	Medium to high quality manual and automated, multiprocess

The most common industrial units remain the tapped transformer-rectifier and primary inverter rectifier types. Selection is usually based on cost and fitness for purpose.

Health and Safety

Welding power sources are electrical devices which often operate at high voltages. Electric shock is a common hazard in welding and cutting operations.

There are several essential rules related to the safe installation and operation of this type of equipment which must be observed if electric shock injury is to be avoided:

- Equipment should always be installed by competent, qualified personnel
- Equipment must not be operated with protective casework removed
- Equipment should be regularly maintained and tested (eg. for insulation resistance)
- Equipment should comply with national standards
- The class of protection (IP number) should meet working environment requirements.

Due to the potential severity of the hazard, the following is a guide on what to do before any MIG welding is started to reduce the risk of an electrical accident:

- Only qualified personnel should be allowed to install MIG equipment
- Whoever does install the equipment must ensure that it complies with national standards, any local regulations, the manufacturer's instructions and workpiece 'earthing' requirements
- All equipment should be tested to ensure it is operating correctly and safely before being put into service.

ARC EQUIPMENT

Afrox Industrial Range

Highlights

Delivers superior performance - These single- and three-phase machines are ideal for welding carbon steel, stainless steel and aluminium. They offer high arc stability and clean weld finish.

Simplistic front panel design - User-friendly layout makes setting voltage, wire speed and inductance easy. For segregated (remote) wire feeder-machine combinations, adjusting welding parameters can be done from the wire feeder.

Polarity change for cored wires

Protection from grime - improved tunnel design keeps dust and grime away from electronic parts and maximises cooling.

Gas purge - ensures weld defects are minimised by clearing the line after changing cylinders or when the machine has not been used for a period of time.

Advantages

Infinite voltage, wire speed and inductance settings - The infinite control over voltage wire speed and inductance ensures you can fine tune settings for optimum results.

Easy-grip handles - Ergonomically designed soft feel handles make moving the power source and wire feeders easy.

Low slung cylinder tray - The design includes a lowered cylinder tray to ensure heavy cylinders can be placed onto the machine safely and with ease.

Abbreviations

CC	= Constant Current
CV	= Constant Voltage
MIG	= Metal Inert Gas Welding
TIG	= Tungsten Inert Gas Welding
FCAW	= Flux Cored Arc Welding
MCAW	= Metal Cored Arc Welding

Applications

CC	= MMA & TIG
CV	= MIG, FCAW & MCAW

MIG Power Sources

Afrox Industrial MIG 251C

Item Number	W500251

The Afrox Industrial MIG 251C is a 230 V single-phase DC compact machine for the medium and light industrial sectors. It features inductance control, close loop current control, arc spot timer and burn back control. Power source is capable of producing welds with the MMA, Lift-TIG and MIG processes. The Afrox Industrial MIG 251C comes standard with digital volt and amp meter display, built-in VRD, 2-roll wire feeding system, 18 kg spool capacity and undergear with integrated cylinder rack.

Package includes:
* Afrox Industrial MIG 251C DC compact power source
* 4 m earth cable and clamp

Optional extras:

W500063	Transarc® OHE410 Auto Darkening Helmet
W500252	MIG Kit: MIG 251C
W500255	MMA Kit: Afrox Industrial Compact MIG
W500256	TIG Kit: Afrox Industrial Compact MIG

Afrox Industrial MIG 251C DC Compact power source is backed by a two-year warranty and is subject to the terms and conditions stipulated in the owner's manual.

W500252 MIG Kit

MIG 251C includes:
1 x W032003 MIG Gun – BZL – MB 25 AK A/C MIG Gun 4 m
2 x W053033 Skull Cap with Back Flap
1 x W033980 MIG Accessories – Noryl Basket Adaptor
1 x W003037 Shieldmaster® Flowmeter 30 LPM CO_2 /AR
1 x W051023 Classic Blue and Yellow Welding Gauntlet
1 x 6 m Inert Gas Hose 5 mm with Fittings for Shieldmaster® Flowmeter + 1 x 5 mm O-Clip Loose

W500255 MMA Kit

Afrox Industrial Compact MIG includes:
1 x Suhan Jaw Type Electrode Holder 300 A + 4 m Grey PVC Welding Cable 300 A 35 mm² with Male Dinse Plug (50 – 70)
1 x W051021 Classic Red Welding Gauntlet

W500256 TIG Kit

Afrox Industrial Compact MIG includes:
1 x TWP 26 V 3,8 m 200 A A/C TIG Torch with Male Dinse Plug (50 – 70)
1 x W031012 Witstar TIG Tungsten Pack 2,4 mm
1 x W031160 TIG Spares – Nozzle 10 mm #6
1 x W031152 TIG Spares – Collet 2,4 mm
1 x W031156 TIG Spares – Collet Body 2,4 mm
1 x W051024 TIG Welders' Glove

Afrox Industrial MIG 313C

Item Number	W500313

The Afrox Industrial MIG 313C is a 380 V three-phase DC compact machine for the medium and light industrial sectors. It features inductance control, close loop current control, arc spot timer and burn back control. Power source is capable of producing welds with the MMA, Lift-TIG and MIG processes. The Afrox Industrial MIG 313C comes standard with digital volt and amp meter display, built-in VRD, 2-roll wire feeding system, 18 kg spool capacity and undergear with integrated cylinder rack.

Package includes:
* Afrox Industrial MIG 313C DC Compact power source
* 4 m earth cable and clamp

Optional extras:

W500063	Transarc® OHE410 Auto Darkening Helmet
W500253	MIG Kit: MIG 313C
W500255	MMA Kit: Afrox Industrial Compact MIG
W500256	TIG Kit: Afrox Industrial Compact MIG

Afrox Industrial MIG 313C DC Compact power source is backed by a two-year warranty and is subject to the terms and conditions stipulated in the owner's manual.

W500253 MIG Kit

MIG 313C includes:

1 x W032004 MIG Gun – BZL – MB 36 KD A/C MIG Gun 4 m
2 x W050533 Skull Cap with Back Flap
1 x W033980 MIG Accessories – Noryl Basket Adaptor
1 x W003037 Shieldmaster® Flowmeter 30 LPM CO_2 /AR
1 x W051023 Classic Blue and Yellow Welding Gauntlet
1 x 6 m Inert Gas Hose 5 mm with Fittings for Shieldmaster® Flowmeter + 1 x 5 mm O-Clip Loose

W500255 MMA Kit

Afrox Industrial Compact MIG includes:

1 x Suhan Jaw Type Electrode Holder 300 A + 4 m Grey PVC Welding Cable 300 A 35 mm^2 with Male Dinse Plug (50 – 70)
1 x W051021 Classic Red Welding Gauntlet

W500256 TIG Kit

Afrox Industrial Compact MIG includes:

1 x TWP 26 V 3,8 m 200 A A/C TIG Torch with Male Dinse Plug (50 – 70)
1 x W031012 Witstar TIG Tungsten Pack 2,4 mm
1 x W031160 TIG Spares – Nozzle 10 mm #6
1 x W031152 TIG Spares – Collet 2,4 mm
1 x W031156 TIG Spares – Collet Body 2,4 mm
1 x W051024 TIG Welders' Glove

Afrox Industrial MIG 403C

Item Number	W500403

The Afrox Industrial MIG 403C is a 380 V three-phase DC compact machine for the medium industrial sectors. It features inductance control, close loop current control, arc spot timer and burn back control. Power source is capable of producing welds with the MMA, Lift-TIG and MIG processes. The Afrox Industrial MIG 403C comes standard with digital volt and amp meter display, built-in VRD, 4-roll wire feeding system, 18 kg spool capacity and undergear with integrated cylinder rack.

Package includes:
* Afrox Industrial MIG 403C DC Compact power source
* 4 m earth cable and clamp

Optional extras:

W500063	Transarc® OHE410 Auto Darkening Helmet
W500254	MIG Kit: MIG 403C
W500255	MMA Kit: Afrox Industrial Compact MIG
W500256	TIG Kit: Afrox Industrial Compact MIG

Afrox Industrial MIG 403C DC Compact power source is backed by a two-year warranty and is subject to the terms and conditions stipulated in the owner's manual.

W500254 MIG Kit

MIG 403C includes:

1 x W032007 MIG Gun – BZL – MB 40 KD A/C MIG Gun 4 m
2 x W050533 Skull Cap with Back Flap
1 x W033980 MIG Accessories – Noryl Basket Adaptor
1 x W003037 Shieldmaster® Flowmeter 30 LPM CO_2 /AR
1 x W051023 Classic Blue and Yellow Welding Gauntlet
1 x 6 m Inert Gas Hose 5 mm with Fittings for Shieldmaster® Flowmeter + 1 x 5 mm O-Clip Loose

W500255 MMA Kit

Afrox Industrial Compact MIG includes:

1 x Suhan Jaw Type Electrode Holder 300 A + 4 m Grey PVC Welding Cable 300 A 35 mm^2 with Male Dinse Plug (50 – 70)
1 x W051021 Classic Red Welding Gauntlet

W500256 TIG Kit

Afrox Industrial Compact MIG includes:

1 x TWP 26 V 3,8 m 200 A A/C TIG Torch with Male Dinse Plug (50 – 70)
1 x W031012 Witstar TIG Tungsten Pack 2,4 mm
1 x W031160 TIG Spares – Nozzle 10 mm #6
1 x W031152 TIG Spares – Collet 2,4 mm
1 x W031156 TIG Spares – Collet Body 2,4 mm
1 x W051024 TIG Welders' Glove

TIG Power Sources

Afrox Industrial TIG 185 AC/DC CC Package

Item Number	W035186

Single-phase 230 VAC +-15%, 50/60 Hz. Rated at 185 A, 35% duty cycle.

A lightweight AC/DC inverter power source that provides a consistent welding arc for the TIG and MMA processes. Power source comes standard with frequency, post flow and down slope control.

Applications include; DIY and light maintenance for welding of aluminium, carbon steel and stainless steel applications.

Package includes:
- Afrox Industrial TIG 185 AC/DC CC power source
- Air-cooled CK HF-TIG torch kit
- Electrode holder and welding cable
- Earth clamp and welding cable
- S6000 Regulator 40ℓ CO_2/Argon
- 3 m inert gas hose and fittings

Please note:
- Shielding gas and welding consumable requirements are excluded from above packages and should be selected according to customer requirements.
  - Please refer to the Shielding Gases and Welding Consumables section for detailed product specification and description.

Afrox Industrial TIG 201P 230 V

Item Number	W500201

Single-phase 230 VAC +-15%, 50/60 Hz. Rated at 200 A, 60% duty cycle.

A lightweight DC inverter power source that provides a consistent welding arc for the TIG and MMA processes. Power source comes standard with high frequency, pulsating feature, post flow and down slope control. Remote capabilities

Applications include; DIY and light maintenance for welding of carbon steel and stainless steel applications.

Power source includes:
- 2 x male dinse plugs

Optional extras:

W031186	TWP 26 HF TIG Kit
W030911	RFCS-14HD foot Control
W030912	RHC-14 Hand Control
W030913	RCC-14 Finger Tip Control

Please note:
- Shielding gas and welding consumable requirements are excluded from above packages and should be selected according to customer requirements.
  - Please refer to the Shielding Gases and Welding Consumables section for detailed product specification and description.

Afrox Industrial TIG 303PU 380 V

Item Number	W500303

Three-phase 380 VAC +-15%, 50/60 Hz. Rated at 300 A, 60% duty cycle.

Inverter based TIG/MMA power source which incorporates high frequency ignition, line voltage protection and a built-in voltage reduction device. Includes USB data logging of welding parameters. DC TIG/MMA. Remote capability.

Applications include; DIY and light maintenance for welding of carbon steel and stainless steel applications.

Power source includes:
- 2 x male dinse plugs

Optional extras:
W031186 TWP 26 HF TIG Kit
W030911 RFCS-14HD Foot Control
W030912 RHC-14 Hand Control
W030913 RCC-14 Finger Tip Control

MMA Power Sources

Afrox Industrial 220i 220 V DC Inverter

Item Number	W046223

The Afrox Industrial 220i is a 230 V single-phase DC MMA/Lift DC TIG machine. Rated at 220 A, 80% duty cycle.

A lightweight, durable industrial inverter power source, backed by a two-year warranty, subject to terms and conditions stipulated in the owner's manual. Afrox Industrial 220i power source comes standard with digital amp meter and built-in voltage reduction device.

Applications including medium and light industrial sectors. It is particularly suitable for the mining industry.

Power source includes:
- 2 x male dinse plugs

Optional extras:
W500063 Transarc® OHE410 Auto Darkening Helmet
W051021 Classic Red Welding Gauntlet
W051024 TIG Welders' Glove
W053102 Welding Cable PVC 300 A 35 mm² Grey/metre
W054146 Earth Clamp 300 A Crocodile
W053011 Cable Lugs Crimping 35 x 12 mm
W053090 Suhan Jaw Type 300 A Electrode Holder
W053095 Optimus Type 300 A Electrode Holder
W031263 TIG Torches – TWP 26 V 3,8 m 200 A A/C
(Consumables sold separately)
W003037 Shieldmaster® Flowmeter 30 LPM CO_2/AR

Afrox Industrial MMA 221S

Item Number	W500221

The Afrox Industrial MMA 221S is a 230 V single-phase DC MMA machine for the medium and light industrial sectors. Rated at 220 A. 60% duty cycle. It features DIG (arc force), anti-stick and adjustable hot start functions. Power source is capable of producing welds with the MMA and Lift-TIG processes. The Afrox Industrial MMA 221S comes standard with digital amp meter display and built-in voltage reduction device.

Power source includes:
* 2 x male dinse plugs

Afrox Industrial 221S DC CC Inverter power source is backed by a two-year warranty and is subject to the terms and conditions stipulated in the owner's manual.

Optional extras:
W500063 Transarc® OHE410 Auto Darkening Helmet
W051021 Classic Red Welding Gauntlet
W051024 TIG Welders' Glove
W053102 Welding Cable PVC 300 A 35 mm² Grey/metre
W054146 Earth Clamp 300 A Crocodile
W053011 Cable Lugs Crimping 35 x 12 mm
W053090 Suhan Jaw Type 300 A Electrode Holder
W053095 Optimus Type 300 A Electrode Holder
W031263 TIG Torches – TWP 26 V 3,8 m 200 A A/C
(Consumables sold separately)
W003037 Shieldmaster® Flowmeter 30 LPM CO_2/AR

Afrox Industrial MMA 323S

Item Number	W500323

The Afrox Industrial MMA 323S is a 380 V/525 V three-phase DC MMA machine for the medium and light industrial sectors. It is particularly suitable for the mining industry. It features DIG (arc force), anti-stick and adjustable hot start functions. Power source is capable of producing welds with the MMA and Lift-TIG processes. The Afrox Industrial MMA 323S comes standard with digital amp meter display, built-in VRD, close loop current control for accurate current setting and line voltage protection to compensate for electrical spikes from input supply. Rated at 320 A, 60% duty cycle.

Power source includes:
* 2 x male dinse plugs

Afrox Industrial 323S DC CC Inverter power source is backed by a two-year warranty and is subject to the terms and conditions stipulated in the owner's manual.

Optional extras:
W500063 Transarc® OHE410 Auto Darkening Helmet
W051021 Classic Red Welding Gauntlet
W051024 TIG Welders' Glove
W053102 Welding Cable PVC 300 A 35 mm² Grey/metre
W053103 Welding Cable PVC 400 A 50 mm² Grey/metre
W054148 Earth Clamp 600 A Crocodile
W053012 Cable Lugs Crimping 50 x 12 mm
W053096 Electrode Holder – TRC – 400 A Optimus Type
W054201 Electrode Holder – AOX – 400 A Jaw Type
W054202 Electrode Holder – AOX – 400 A Twist Lock
W031263 TIG Torches – TWP 26 V 3,8 m 200 A A/C
(Consumables sold separately)
W003037 Shieldmaster® Flowmeter 30 LPM CO_2/AR

Afrox Industrial 320i 380 V/525 V DC Inverter

Item Number	W046321

Three-phase 380 V/525 VAC +- 15%, 50/60 Hz. Rated at 320 A, 80% duty cycle.

The Afrox Industrial 320i 380 V/525 V inverter power source with its dual power option is suitable for various work environments. Applications include; medium to heavy maintenance, fabrication and manufacturing of mining and construction equipment where three-phase 380 V - 525 V is a requirement.

Power source includes:
* 2 x male dinse plugs

Optional extras:
W500063 Transarc® OHE410 Auto Darkening Helmet
W051021 Classic Red Welding Gauntlet
W051024 TIG Welders' Glove
W053102 Welding Cable PVC 300 A 35 mm² Grey/metre
W053103 Welding Cable PVC 400 A 50 mm² Grey/metre
W054148 Earth Clamp 600 A Crocodile
W053012 Cable Lugs Crimping 50 x 12 mm
W053096 Electrode Holder – TRC – 400 A Optimus Type
W054201 Electrode Holder – AOX – 400 A Jaw Type
W054202 Electrode Holder – AOX – 400 A Twist Lock
W031263 TIG Torches – TWP 26 V 3,8 m 200 A A/C
(Consumables sold separately)
W003037 Shieldmaster® Flowmeter 30 LPM CO_2/AR

Multiprocess Power Sources

Afrox Industrial 453M

Item Number	W500453

Three-phase 380/525 VAC +-15%, 50/60 Hz. Rated at 450 A, 60% duty cycle.

The Afrox Industrial 453M 380 V/525 V Multiprocess inverter power source is capable of delivering high integrity welds and its dual input power option can accomodate various input power requirements.

Applications include: Medium to heavy maintenance, engineering, fabrication and manufacturing of mining and construction equipment.

Power source includes:
- Built-in voltage reducer for MMA/TIG
- 2 x male dinse plugs

Optional extras:
W500400 Afrox Industrial 4-Roll Wire Feeder Base
W500401 Afrox Industrial 4-Roll Wire Feeder Deluxe
Undercarriage, wire feeder and cylinder rack available on request from Afrox Service Engineering Department.

Afrox Industrial 4-Roll Wire Feeder Base

Item Number	W500400

Wire feeder includes:
- 1,0 mm/1,2 mm V-groove drive rolls
- 5 m air-cooled interkon kit for Afrox Industrial 453M Power Source

Afrox Industrial 4-Roll Wire Feeder Deluxe

Item Number	W500401

- The Afrox Industrial 4-Roll Wire Feeder Deluxe is compatible only with the Afrox Industrial 453M power source
- V-knurled and U-groove drive rolls available on request from Afrox Service Engineering Department

Wire feeder includes:
- 1,0 mm/1,2 mm V-groove drive rolls
- 5 m air-cooled interkon kit for Afrox Industrial 453M Power Source

Afrox Transarc® Range

Transarc® 180P PortaMIG DC CV Package

Item Number	W034181

Single-phase 230 VAC +-15%, 50/60 Hz. Rated at 180 A, 35% duty cycle.

The Transarc® 180P offers a compact (built-in wire feeder) inverter technology power source with infinitely variable voltage, amperage and inductance control for easy setting of welding parameters.

Applications include; DIY, light maintenance and engineering.

Package includes:
- Afrox Transarc® 180P PortaMIG DC CV power source
- PortaMIG trolley
- Portashield gas cylinder
- Drive roll kit:
  - *Double-sided V-Groove 0,6 mm & 0,8 mm, 0,8 mm & 1,0 mm, 1,0 mm & 1,2 mm
  - *Single-sided V-Knurled 0,9 mm
- **Binzel MB 15 AK MIG gun
- S6000 Regulator 40ℓ CO_2/Argon
- Noryl basket adaptor
- 3 m inert gas hose and fittings

* Drive roll kit comprises one drive roll per pack
**Binzel MIG gun includes liner, tip adaptor/gas diffuser, contact tip and gas shroud.

Please note:
- Welding consumable requirements are excluded from above package and should be selected according to customer requirements.
  - Please refer to the Welding Consumables section for detailed product specification and description.

Plasma Power Sources

Transarc® Plasma Cut 40 Power Source

Item Number	W036440

Single-phase 230 VAC +-15%, 50/60 Hz. Rated at 40 A, 35% duty cycle.

The Transarc® Plasma Cut 40 offers a lightweight (weighs only 8 kg) inverter technology plasma power source for the cutting of various metals. Plasma Cut 40 requires air at 4 bar input pressure and features a post flow selector switch and air control connector.

Applications include; art sculptures, hobby and DIY enthusiasts Cutting thickness; carbon steel 9 mm, stainless steel 8 mm, aluminium 4 mm

Package includes:
- Afrox Transarc® Plasma Cut 40 power source
- *PT-31 plasma torch
- Air control connector
- Earth clamp and cable

*Plasma torch supplied with first set of consumables

Please note:
- Gas requirements are excluded from above package and should be selected according to customer requirements.
  - Please refer to the Compressed Gases section for detailed product specification and description.

*Plasma torch supplied with first set of consumables
W036441 Transarc® Plasma 40 Torch
W036443 Transarc® Plasma 40 Electrode PT-31
W036444 Transarc® Plasma 40 Cutting Tip PT-31
W036445 Transarc® Plasma 40 Shield Cup PT-31
W036446 Transarc® Plasma 40 Switch PT-31
W036447 Transarc® Plasma 40 Diverter PT-31

Miller Range

MIG Packages

Miller MigMatic® 320i

Item Number	W034338

Miller MigMatic® 320i, 320 A, 30 V at 35% duty cycle, 400 V, three phases (50/60 Hz) power source only.

Miller MigMatic® 320i synergic MIG/MAG system featuring a heavy duty drive mechanism capable of consistent and precise wire feeding regardless of your choice of wire. The machines are quick to set up and the graphical user interface makes it easy to achieve those perfect weld parameters with very limited training required. The MigMatic® 320i is the perfect workshop tool and ideal for both solid and flux core wires.

Accessories not included.

Miller MigMatic® 400ip

Item Number	W034337

Miller MigMatic® 400ip, 400 A, 34 V at 80% duty cycle, 400 V, three phases (50/60 Hz) package.

Miller MigMatic® S400iP synergic pulsed MIG/MAG system offers full flexibility. All modules are bespoke to the system and designed for trouble-free, high productivity welding. Never before has it been so easy and straightforward to achieve excellent welding performance. Enjoy full control at all times.

Package includes power source, interconnecting cable air, feeder and undergear. (Water cooler sold separately).

Accessories sold separately.

Miller XPS 450 Deluxe Package

Item Number	W034450

Three-phase 380 VAC +-15%, 50 Hz. Rated at 450 A, 45% duty cycle, 320 A 100% duty cycle.

The Miller XPS 450 with a segregated (remote) wire feeder provides greater flexibility for the operator. This industrial heavy duty package comes standard with a rugged deluxe four-drive-roll wire feeder that features an adjustable run-in control that allows for optimal arc starting. The Miller XPS 450 comes standard with 40 voltage step selection for exceptional arc stability. Additional features include trigger latch option, gas purging and burn back control and multiple inductance selection ports.

Applications include; medium to heavy engineering, fabrication and manufacturing of mining and construction equipment, with the use of the MIG, FCAW and MCAW process.

Package includes:

- Miller XPS 450 DC CV power source
  - Power source supplied with undergear cylinder and vertical cooler rack
- Drive roll kit:
  - *Double-sided V-Groove 1,0 mm & 1,2 mm
- **Binzel MB 40 KD MIG gun (W032007)
- Earth clamp and welding cable
- Shieldmaster® flowmeter regulator CO_2/Argon (W003037)
- Noryl basket adaptor (W033980)
- 3 m inert gas hose and fittings

* Drive roll kit comprises 4 drive rolls, inlet and intermediate guides

** Binzel MIG gun includes liner, tip adaptor/gas diffuser, contact tip and gas shroud.

Please note:

- Shielding gas and welding consumable requirements are excluded from above packages and should be selected according to customer requirements.
  - Please refer to the Shielding Gases and Welding Consumables section for detailed product specification and description.

TIG Power Sources

Miller Maxstar 161 STH Package

Item Number	W052151

Single-phase 50/60 Hz. Rated at 160 A 20% duty cycle, 110 A 100% duty cycle. High frequency TIG (GTAW), pulsed TIG (GTAW-P), MMA.

Ideal for light industrial applications. Built-in voltage reduction device.

Package includes:
- Maxstar 161 power source
- 2 m power cable (no plug)
- X-CASE provides protection in transport and storage
- RCCS-6M remote finger tip control (W195184)
- Weldcraft A-150 (WP-17) 3,8 m TIG torch with connector
- Stick electrode holder with 4 m cable
- Earth clamp with 3 m cable
- Shieldmaster® flowmeter with gas hose
- AK2C accessory kit
- Handle/shoulder strap

Miller Maxstar 280 DX 208 V-575 V CPS

Item Number	W030151

Auto-line 208 V - 575 V 50/60 Hz. Rated at 235 A, 60% duty cycle. High frequency DC TIG, pulsed TIG, stick (SMAW) and air carbon capability.

Applications include; fabrication, petrochemical aerospace, food/beverage industry and shipyards.

Power source includes:
- 2,5 m power cable
- Cooler power supply
- 2 x male dinse plugs

Optional extras:
- W031186 TWP 26 HF TIG Kit
- W030911 RFCS-14 HD Foot Control
- W030912 RHC-14 Hand Control
- W030913 RCC-14 Finger Tip Control
- Weldcraft TIG Torches
- Wireless Remote Controls

Miller Dynasty® 210 DX 120 V - 480 V CPS

Item Number	W030200

Auto-line 120 V-480 V 50/60 Hz. Rated at 210 A. 60% duty cycle.

The Miller Dynasty® 210 DX with its AC balance and frequency control makes welding of aluminium an easy task.

Applications include; DIY, precision, heavy fabrication, pipe and tube fabrication and aerospace.

Process capabilities:
- AC/DC TIG (GTAW)
- Pulsed TIG (GTAW-P)
- Stick (SMAW)

Power source includes:
- 2 x male dinse plugs

Optional extras:
W031186 TWP26 HF TIG Kit
W030911 RFCS-14 HD Foot Control
W030912 RHC-14 Hand Control
W030913 RCC-14 Finger Tip Control

Available from Afrox Service Engineering Department:
- Weldcraft TIG torches
- Wireless remote controls
- Coolmate 1,3 Cooler

Dynasty® 400 TIGRunner

Item Number	W700001

Dynasty® 400 TiGRunner; 300 A at 32 V, 60% duty cycle, 3–400 A, 208–575 V, 3- or single-phase power auto line technology.

The Dynasty® AC/DC TIG machine has been designed for ease of use without compromising on the weld performance. Allows for any input voltage hook up (208–575 V) with no manual linking, providing convenience in any job setting. Ideal solution for dirty or unreliable power.

Blue Lightning™ high-frequency (HF) arc starter for non-contact arc initiation provides more consistent arc starts and greater reliability compared to traditional HF arc starters.

Programme memory features nine independent programme memories that maintain/save your parameters.

AC Waveforms

Advanced squarewave, fast freezing puddle, deep penetration and fast travel speeds.

Soft squarewave for a soft, buttery arc with maximum puddle control and good wetting action.

Sine wave for customers that like a traditional arc. Quiet with good wetting.

Triangular wave reduces the heat input and is good on thin aluminum. Fast travel speeds.

Including power source, water cooler and running gear. Accessories sold separately.

Syncrowave® 300 TIGRunner

Item Number	W700002

Syncrowave® 300 TIGRunner; 300 A at 22 V, 30% duty cycle, 5-300 A, max OCV 60 VDC.

The Syncrowave® AC/DC TIG machine has been designed for ease of use without compromising on the weld performance. The machine can be set for AC TIG, DC TIG or MMA in no time. The simple and clean control panel reduces the set up time and improves productivity.

400 V, 50/60 Hz, incl. power source, water cooler and running gear. Accessories sold separately.

Syncrowave® 400 TIGRunner

Item Number	W700003

Syncrowave® 400 TIGRunner; 400 A at 26 V, 30% duty cycle, 5-400 A, max OCV 70 VDC.

The Syncrowave® AC/DC TIG machine has been designed for ease of use without compromising on the weld performance. The machine can be set for AC TIG, DC TIG or MMA in no time. The simple and clean control panel reduces the set up time and improves productivity.

400 V, 50/60 Hz, incl. power source, water cooler and running gear. Accessories sold separately.

MMA Power Sources

Miller Blue-Thunder Series

The Miller Blue-Thunder MMA (stick) welding power sources with electromagnetic shunt control combine good welding performance with practicality.

The Afrox range comprises two models; Blue-Thunder 443 and Blue-Thunder 343.

Applications include; mining fabrication, structural fabrication, trailer fabrication, maintenance and repair.

Miller Blue-Thunder 443 DC CC Power Source

Item Number	W052420

Three-phase 380/525 VAC +-15%, 50/60 Hz. Rated at 420 A, 45% duty cycle.

Package includes:
- Miller Blue-Thunder 443 DC CC power source
  - Power source supplied with running gear

Optional equipment:
- Earth clamp and welding cable
- Electrode holder and welding cable
- External voltage reducer

Miller STi 203 DC CC Power Source

Item Number	W034094

Three-phase 380 VAC +-10%, 50/60 Hz. Rated at 200 A, 40% duty cycle.

Miller STi 203 DC inverter-based power source provides superb welding performance with the MMA and Lift-arc TIG processes.

This power source features a remote control port for remote amperage control, arc force (dig) control and adaptive hot start for difficult-to-weld electrodes.

Applications include; petrochemical, process piping, maintenance and light fabrication.

Package includes:
- Miller STi 203 DC CC power source

Optional equipment:
- Earth clamp and welding cable
- Electrode holder and welding cable

Please note:
- Arc accessories and welding consumable requirements are excluded from above packages and should be selected according to customer requirements.
  - Please refer to the Arc Accessories and Welding Consumables section for detailed product specification and description.

Miller STR 500 DC CC Power Source

Item Number	W034085

Available on request

Three-phase 380 VAC +-10%, 50/60 Hz. Rated at 500 A, 35% duty cycle.

Miller STR 500 DC is an electronically controlled stick electrode power source. This power source features Lift-arc TIG, gouging and remote control options.

Applications include; superior performance in maintenance, pipe welding and building applications.

Package includes:
- Miller STR 500 DC CC power source
  - Power source supplied with running gear

Optional equipment:
- Earth clamp and welding cable
- Electrode holder and welding cable

Multiprocess Power Sources

Miller XMT 350 DC CC/CV Power Source

Item Number	W034305

Auto-line 208 – 575 VAC +-10%, 50/60 Hz. Rated at 350 A, 60% duty cycle.

This power source features multiprocess selection. By simply changing accessories an operator can select between the MMA, MIG, FCAW, MCAW and TIG processes. Miller XMT 350 comes standard with wind tunnel technology, adaptive hot start and line voltage compensation. Auto-line is a standard feature on the XMT 350 that allows input voltage selection from single- to three-phase power supplies.

Applications include; petrochemical, construction, shipbuilding, railroad, truck/trailer manufacturing, fabrication and power generation plants.

Package includes:
- Miller XMT 350 DC CC/CV power source

Miller XMT 350 MPa CC/CV Power Source

Item Number	W035350

Auto-line 208 – 575 VAC +-10%, 50/60 Hz. Rated at 350 A, 60% duty cycle, 300 A, 100% duty cycle.

This power source features multi-process selection. Processes include MIG, pulsed MIG, Stick, TIG (DC-lift), flux cored, air carbon arc cutting and gouging (CAC-A). Auto-line power management technology allows for any input voltage hook-up (2018 – 575 V). 115 VAC auxiliary power provides 10 A of circuit-breaker-protected power for water circulations, etc.

Package includes:
- Miller XMT 350 MPa CC/CV power source W/aux power
- Miller S-74 MPa Plus Wire Feeder (no euro adapter)
- Extension cable 24 VAC 14 pin 25 ft (7,6 m)
- 1,2 mm V-Groove drive roll kit X 1
- 1,2 mm U-Groove drive roll kit X 1

Miller Dimension Rectifier Series

The Miller Dimension series features rugged multiprocess power sources capable of producing welds with the MIG, FCAW, MCAW, scratch-start TIG and MMA processes with the addition of the air carbon arc gouging process. Power sources come standard with hot start and line voltage compensation.

The Afrox range comprises three models; Miller Dimension 562, Miller Dimension 812 and the Miller Dimension 1250.

Applications include; fabrication and construction, heavy manufacturing, maintenance, repair, pressure vessel fabrication, pipe welding, shipbuilding and earth-moving equipment manufacturing.

Miller Dimension 650 Power Source

Item Number	W052650

Dimension 650; 650 A at 44 VDC,100% duty cycle, three-phase power 380/460 V, 50/60 Hz power source only.

An unbeatable combination of durability, output, efficiency and capability — all in a smaller, easier-to-handle package. Inside its tough, corrosion-resistant, all-aluminum case is big power for heavy welding jobs and carbon arc gouging. In addition to excellent stick and Lift-Arc™ TIG, the Dimension 650 also has excellent short-arc MIG characteristics for precise thin metal welding performance.

Remote control of the power source without a cord. ArcReach® technology uses the existing weld cable to communicate welding control information between the feeder or remote and power source. This technology eliminates the need for control cords, and their associated problems and costs.

Miller SubArc DC 1250 Digital

Item Number	W034983

Available on request:
- Three-phase 380 V, 1 000 A, 100% duty cycle

Processes:
- Submerged arc (SAW)
- Electro slag (ESW)
- Air carbon arc cutting and gouging (CAC-A)

Heavy industrial applications include railcar, shipbuilding, heavy fabrication, pipe manufacturing and pressure vessels.

Optional extras:
- W054024 Locally manufactured undergear
- W054025 Locally manufactured cylinder and vertical cooler rack
- W054026 Locally manufactured single cylinder rack

Engine Driven Power Sources

Miller Blue Star 185 DC CC Power Source

Item Number	W052185

Petrol engine driven power source. Rated at 185 A, 20% duty cycle. Auxiliary voltage 230 VAC, 7,5 kVA peak and 5,5 kVA continuous output, 50 Hz.

Miller Blue Star 185 is a DC petrol engine driven welding power source capable of producing welds with the MMA and scratch-TIG process.

Applications include; maintenance, repair, farm applications, construction and as a stand-alone generator.

Package includes:
- Miller Blue Star 185 DC CC engine driven power source
  - Power source supplied with 230 VAC auxiliary plug

Optional extras:
- Miller Running Gear #301246
- Miller Lifting Eye #195353
- Miller Protective Cover #301245
- Miller Spectrum 375 X-TREME #907529

Above available on request from Afrox Service Engineering Department (SED)

Miller Bobcat 260 Series Engine Driven Power Sources

Miller Bobcat 260 Petrol CC/AC CC/DC CV/DC Power Source

Item Number	W052250

The Bobcat 260 series features rugged multiprocess engine driven power sources capable of producing welds with stick (SMAW), MIG (GMAW)*, flux-cored (FCAW)*, DC TIG (GTAW), non-critical AC TIG (GTAW), air carbon arc (CAC-A) cutting and gouging (3/16 in. carbons), air plasma cutting and gouging with optional Spectrum® models. *With wire feeder.

Applications include; maintenance, repair, work trucks, farm applications, fabrication, structural steel work and as a stand-alone generator.

CC/AC - Stick/TIG, 40–260 A, 225 A at 25 V, 100% duty cycle/260 A at 25 V, 60% duty cycle
CC/DC - Stick/TIG1, 40–260 A, 260 A at 25 V, 100% duty cycle
CV/DC - MIG/FCAW, 17–28 V, 0 A at 28 V, 100% duty cycle/275 A at 25 V, 60% duty cycle

Package includes:
- Miller Bobcat 260 Petrol CC/AC CC/DC CV/DC engine driven power source

Optional extras:
- Locally manufactured 2-wheel trailer (W052082)

Miller Big Blue Series Engine Driven Power Sources

The Miller Big Blue series features rugged diesel engine driven power sources capable of producing welds with the MMA, TIG and FCAW processes with the addition of the air carbon arc gouging process.

The Afrox range comprises three models; Miller Big Blue 400 X, Miller Big Blue 500 X and the Miller Big Blue 600 X power sources.

Applications include; maintenance, repair, farm applications, construction and as a stand-alone generator.

Miller Big Blue 400X PRO

Item Number	W052400

Diesel engine driven welder. Rated at 400 A at 24 VDC, 100% duty cycle. Low OCV Stick (VRD) reduces the open-circuit. Voltage to 15 V when the power source is not in use. Auxiliary voltage 230 VAC, 12 kVA peak and 10 kVA continuous output, 50 Hz

Package includes:
- Miller Big Blue 400 X CC/CV engine driven power source

Miller Big Blue 500 X CC Power Source

Item Number	W052500

Diesel engine driven power source. Rated at 500 A, 40% duty cycle CC/DC. Auxiliary voltage 230 VAC, 5,5 kVA peak and 4 kVA continuous output, 50 Hz

Package includes:
- Miller Big Blue 500 X CC engine driven power source

Miller Big Blue 600 X CC Power Source

Item Number	W052601

Diesel engine driven power source. Rated at 600 A, 40% duty cycle CC/DC. Auxiliary voltage 230 VAC, 5,5 kVA peak and 4 kVA continuous output, 50 Hz

Package includes:
- Miller Big Blue 600 CX CC engine driven power source

Optional extra:
- Locally manufactured trailer (W052086)

Miller Big Blue 800 X Duo Air Pak

Item Number	W052090

Diesel engine driven welder. Rated at 800 A, 38 V, 100% duty cycle paralleled (combined). Rated at 400 A, 36 V CC/DC, 34 V CV/DC, 100% duty cycle, separate (dual outputs).

Generator power output:

- Three-phase: 27 kVA peak and 20 kVA continuous
- Single-phase: 15 kVA peak and 12 kVA peak and 12 kVA continuous

The most powerful line-up of diesel welder/generator in the industry. Ideal for dual-operator applications on labour intensive jobsites or jobsites with limited space. All-in-one welder/generator eliminates the need for an auxiliary air compressor. The industrial Ingersoll Rand screw-type air compressor is ideal for gouging and running pheumatic tools. International model comes with 400 volt three-phase power ArcReach® and vandalism lockout kit.

Optional extras:

- Miller supplied or locally manufactured trailer
- Miller Suitcase Wire Feeders
- Miller Dynasty 210 Series
- Miller Spectrum 375 X-TREME
- Miller Spectrum 875 X-TREME
- Stick/TIG Remote Controls

Accessories available from Afrox Service Engineering Department (SED)

Miller Trailblazer® 325D

Item Number	W052325

Output range DC stick 20–325 A MIG/flux-cored 15–40 V DC TIG 20–325 A.

Trailblazer® welder/generators deliver unbeatable arc performance providing the smoothest, most stable arc in the industry. The Trailblazer® exclusive technologies – Auto-Speed™ and optional Excel™ power – deliver superior runtimes, increased fuel efficiency, and improved welder/generator performance. No other compact machine in the 300-amp class delivers more welding power or more auxiliary power with better fuel efficiency and less noise — for productive, profitable, quieter jobsites.

Miller Spectrum Plasma Cutting Power Sources

Miller Spectrum 375 120-240 VAC

Item Number	W006001

Miller Spectrum 875 Auto-line 208-575 V

Item Number	W006002

Genuine Miller Accessories

Miller Wire Feeders

Miller Wire S-74S Wire Feeder

Item Number	W034070

70 Series, S-74 S Wire Feeder 4-Roll has input power of 24 VAC, 10 A, 50/60 Hz. 3m 14 pin interconnecting cord for connecting to any Miller 14 pin power source. Interconnecting cord is attached internally to wire feeder.

Drive rolls and drive roll kits sold separately.

S -74 MPa Plus, dual feeders available on request.

Drive Roll Kits – S – 74 S 4-Roll Feeder

0,9 mm V-Groove	W034228
1,2 mm V-Groove	W034227
1,6 mm V-Groove	W034226
1,2 mm U-Groove	W034225
1,2 mm V-Knurled	W034291
2,0 mm V-Knurled	W034220
2,4 mm V-Knurled	W034219

Drive Roll Kits – 20 Series 4-Roll Feeder including Miller MigMatic 380

0,9 mm V-Groove	W034638
1,2 mm V-Groove	W034639
1,6 mm U-Groove	W034644
1,2 mm V-Knurled	W034651
1,6 mm V-Knurled	W034652

NB: Interkon kits made on request.

NB: All other drive roll requirements available on request from Afrox Service Engineering Department.

NB: 20 Series Wire Feeders available on request
- 22 A
- 24 A
- ST-24

Miller ArcReach® SuitCase® 12 Roll Feeder

Item Number	W034012

Voltage sensing wire feeder, 14-48 VDC operating voltage.

The Suitcase wire feeder provides wire feed speed that is accurate and consistent from the start of the weld to the finish and from one weld to the next.

Plastic case design, potted PC board and double-fitted as valve ensures Suitcase withstands the harshest industrial environments. Drive rolls and drive roll kits sold separately.

Drive Roll Kits – Miller ArcReach® 12 Roll Feeder

1,2 mm V-Groove	W034610
1,6 mm V-Groove	W034612
1,2 mm U-Groove	W034613
1,2 mm V-Knurled	W034292

Remote Controls

Miller RFCS – 14 HD Foot Control

Item Number	W030911

Miller RHC – 14 Hand Control

Item Number	W030912

Miller RCC – 14 Finger Tip Control

Item Number	W030913

Wireless remote control available on request from Afrox Service Engineering Department.

Miller Spool Gun - 220/250 DX

Spool gun with auto-detect provides reliable and economical welding of aluminium. Supplied with euro adaptor and amphenol remote plug

Item Number	W034089

Optional Extras

Miller Coolmate 3 115 V Horizontal

Item Number	W034735

Miller Hydracool 2 115 V Horizontal

Item Number	W034093

Miller Hydracool 1 115 V Vertical

Item Number	W034733

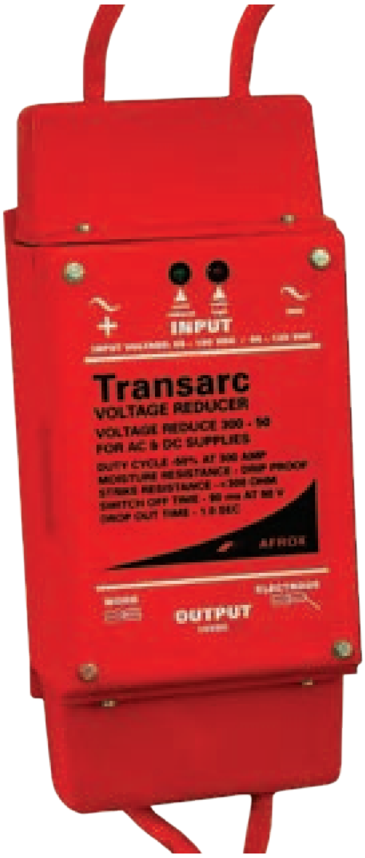
Afrox Voltage Reducers

VRD is an abbreviation for voltage reduction devices, or more commonly known as voltage reducers. When a VRD is fitted to a welding machine it reduces the potentially unsafe maximum OCV across the output terminals of the welding machine to a safer voltage. When attempting to strike an arc the VRD will sense this and switch the welding machine to full output whereupon normal welding can commence.

Voltage reducers are devices that are typically connected to constant current welding power sources for use with the MMA process.

It is in most cases not a requirement to fit a VRD for the TIG or MIG processes.

Voltage reducers are typically connected to the secondary (welding output) side of the power source and may be either internally or externally mounted.



Afrox 600 A AC/DC Voltage Reducer

Item Number	W052060

Package includes:
Afrox 600 A AC/DC Voltage Reducer

Please note:

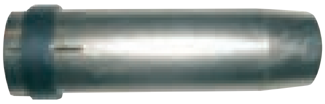
- Voltage reducers should only be fitted by authorised and competent personnel.
- Afrox Services Engineering Department (SED) should be consulted regarding fitment and accessories required.
- Internal voltage reducers available on request

MIG Torches & Consumables

MB 15 AK A/C MIG Gun 3 m

180 A @ 60% duty cycle air-cooled

Item Number	W032001



Shroud Taper MB 15

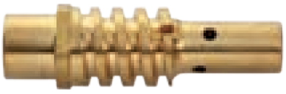
Item Number	W032011

Swan Neck MB 15

Item Number	W032017

Neck Spring MB 15

Item Number	W032013



Tip Holder MB 15

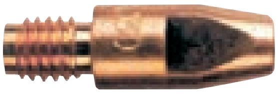
Item Number	W032014

Insulator MB 15

Item Number	W032015

Insulator Sleeve MB 15

Item Number	W032016



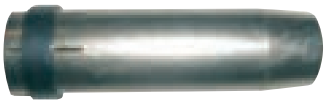
Contact Tip

Description	Item Number
M6 MB 15 0,6 mm	W032021
M6 MB 15 0,8 mm	W032022
M6 MB 15 1,0 mm	W032024
M6 MB 15/2 1,2 mm	W032041

MB 25 AK A/C MIG Gun 4 m

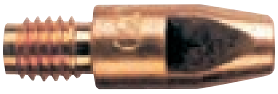
230 A @ 60% duty cycle air-cooled

Item Number	W032003



Shroud

Description	Item Number
Conical MB 25	W032030
Taper MB 25	W032031
Cylinder MB 25	W032032



Contact Tip

Description	Item Number
M6 0,9 mm	W032023
M6 MB 25/36 0,8 mm	W032025
MB 25/36 0,9 mm	W032026
M6 MB 25/36 1,0 mm	W032027
M6 HD M 1,0 mm	W032028
M6 MB 25/36 1,2 mm	W032029

TIP Adaptor MB 25

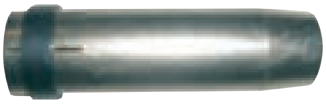
Item Number	W032034

Neck Spring MB 25

Item Number	W032035

Swan Neck MB 25

Item Number	W032036



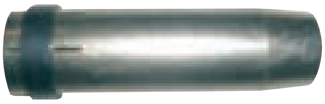
Tip

Description	Item Number
HD M6 MB 25/37 1,2 mm	W032040
HD M6 MB 25 1,0 mm	W032144
HD M6 MB 25 1,2 mm	W032145

MB 36 KD A/C MIG Gun 4 m

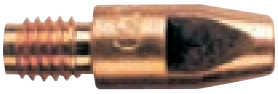
300 A @ 60% duty cycle air-cooled

Item Number	W032004



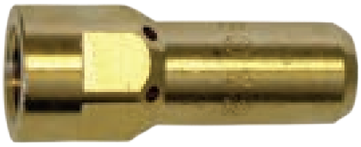
Shroud Conical

Description	Item Number
Conical MB 36	W032050
Taper MB 36	W032051
Cylinder MB 36	W032052



Tip

Description	Item Number
M8 MB 36/40/501 0,9 mm	W032042
M8 MB 36/40/501 1,0 mm	W032043
M8 MB 36/40/501 1,2 mm	W032044
M8 HD MB 36/40/5 1,2 mm	W032045
M8 HD MB 36/40/5 1,2 mm	W032046
M8 HD MB 36/40/50 1,6 mm	W032047
M8 MB 36/40/501 0,8 mm	W032146



Tip Adaptor

Description	Item Number
M6 MB 36	W032053
M8 MB 36	W032054

Gas Diffuser White MB 36

Item Number	W032055

Swan Neck MB 36

Item Number	W032056

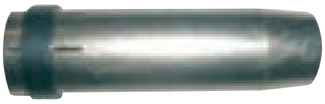
MB 40 KD A/C MIG Gun 4 m

380 A @ 60% duty cycle air-cooled

Item Number	W032007

Gas Diffuser MB 40

Item Number	W032061

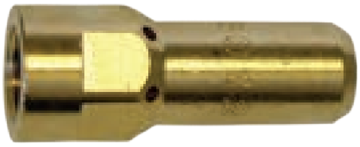


Shroud

Description	Item Number
Conical MB 40	W032057
Taper MB 40	W032058
Cylinder MB 40	W032059

Swan Neck MB 40

Item Number	W032062



Tip Adaptor M8 MB 40

Item Number	W032060

Adaptor Block KZ-2 MB 40

Item Number	W032102

Adaptor Support MB 40 & R

Item Number	W032122

MB 501 D W/C MIG Gun 4 m

500 A @ 100% duty cycle water-cooled

Item Number	W032008

Gas Diffuser White MB 501

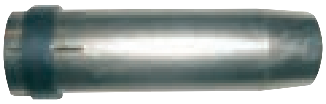
Item Number	W032084

Adaptor Block WZ-2 MB 501

Item Number	W032104

Tip Adaptor M8 MB 501

Item Number	W032085



Shroud

Description	Item Number
Conical MB 501	W032078
Taper MB 501	W032079
Cylinder MB 501	W032080

Insulating Washer MB 501

Item Number	W032086

Adaptor Support MB 501

Item Number	W032123

Swan Neck MB 501

Item Number	W032088

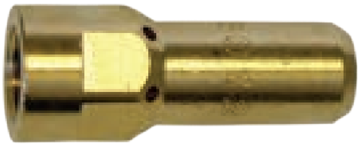
RB 61 HD A/C MIG Gun 4 m

650 A @ 100% duty cycle air-cooled

Item Number	W032009

Adaptor Block RGZ-2 RB 61

Item Number	W032103



Tip Adaptor M10 RB 61

Item Number	W032073

Liner Positioner Nut RB 61

Item Number	W032127

Gas Diffuser RB 61

Item Number	W032074

Swan Neck RB 61

Item Number	W032075

Contact Tips M10 – RB61

Description	Item Number
1,2 mm HD M10	W032067
1,6 mm HD M10	W032068
2,0 mm HD M10	W032069
2,4 mm HD M10	W032070
2,8 mm HD M10	W032071
3,2 mm HD M10	W032072

PP 36 D Straight Neck MIG Gun 8 m

300 A CO_2, 270 A mixed gas 60% duty cycle

Item Number	W032006

Push-Pull welding torches guarantee constant and problem free wire feeding. Push-Pull guns are ideally suited for hard to feed wire like aluminium, thin wire and for extended cable assemblies that allow welding at longer distance from the wire drive unit

Push-Pull torches have become industry standard in shipbuilding, container and tank manufacture and used extensively in the construction of automobiles, railroad cars and rolling stock

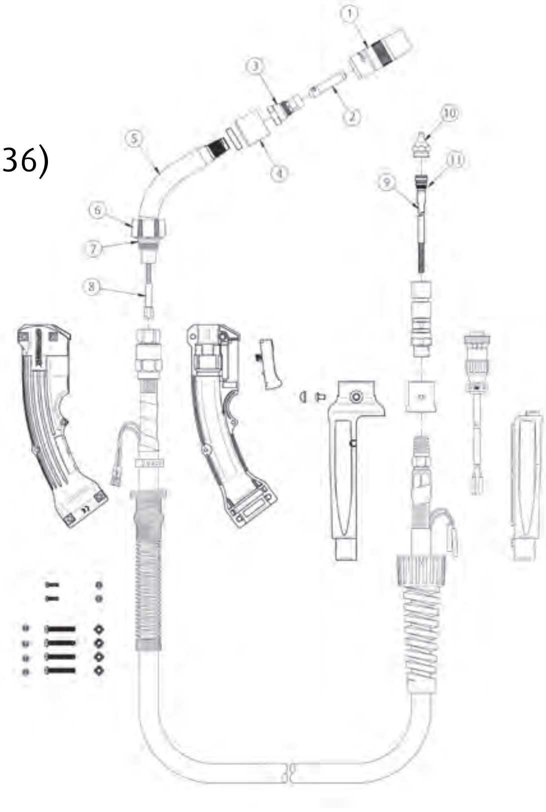
Please note: Bernard® MIG guns available on request from Afrox Service Engineering Department.

General Consumables - MIG Torches

Product	Size	Item Number
Liner Nut		W032020
Plain Liner	1,6 - 2,4 mm 4,0 m	W032076
Plain Liner	2,8 - 3,2 mm	W032077
Liner Blue	0,8 - 0,9 mm 4,0 m	W032018
Liner Red	1,0 - 1,2 mm 4,0 m	W032037
Liner Red	1,0 - 1,2 mm 5,0 m	W032038
Liner Yellow	1,6 mm 5,0 m	W032063
Steel Liner	1,0 - 1,2 mm	W032097
Steel Liner	1,6 mm 4,0 m	W032098
Steel Liner	1,0 - 1,2 mm	W032099
Carbon Teflon Liner	1,6 mm	W032133
Liner Teflon	1,0 - 1,2 mm	W032019
Liner Teflon	1,0 - 1,2 mm	W032039
Liner Teflon	1,6 mm 5,0 m	W032064

Product	Item Number
Plate, Feed Assy	W032039
O-Ring 4XI	W032129
Trigger 2POL	W032126
Ergonomic Handle	W032124
Industrial Handle Complete	W032125
Adaptor Block KZ-2	W032101
Adaptor Support MB 15 - 18	W032121
Shroud Conical MB 15	W032012
Power Cable 3 m MB 15	W032106
Power Cable 4 m MB 25	W032108
Power Cable 4 m MB 40	W032113
Cup Gasket	W031165
Adaptor Nut MB 36/38	W032118

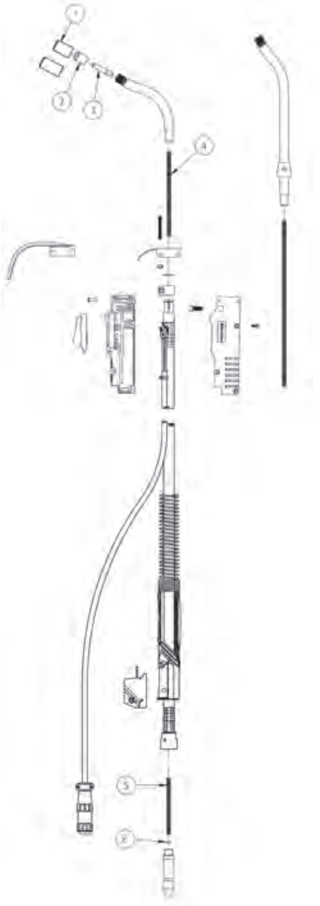
Bernard® Service Parts/Consumables



Pipeworx

MIG Gun Part 195400 - 300 Amp 15 ft Gun (W032336)

Item	Part	Description	Item Number
1	NS-5818C	Centerfire™ Nozzle	W032305
2	T-045	Centerfire™ Contact Tip	W032211
3	DS-1	Centerfire™ Gas Diffuser	W032301
4	4523R	Insulator Cap	W032302
5	QT2-60 (N/A)	Neck	W032309
6	1840057 (N/A)	Q-Neck Cover	W032310
7	1840031	Q-Neck Insulator, Rear	W032308
8	QJL-3545	Jump Liner	W032208
9	L3B-15	Liner	W032304
10	22001351 (N/A)	Power Pin Tip	W032307
11	079974	O-Ring 500 ID Rubber	W032306



Bernard® Dura-Flux™

with Fixed Power Cable Liner (W032336)

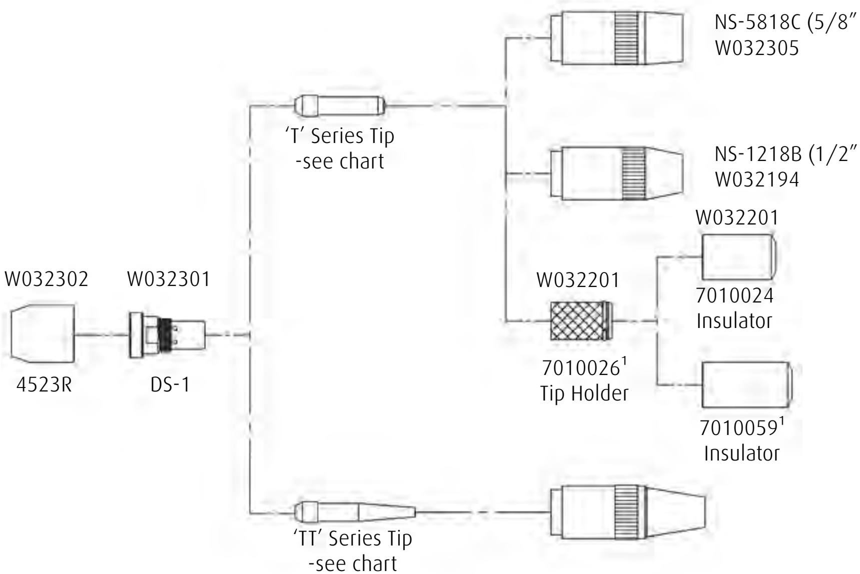
Item	Part #FLX3515AM	Description	Item Number
1	7010024	Insulator Tip	W032201
2	7010026	Tip Holder, Slip-On	W032202
3	T-062	Centerfire™ Contact Tip, 1/16″ (1,6 mm) (Included w/Gun)	W032203
	T-078	Centerfire™ Contact Tip, 5/64″ (2,0 mm) (Included w/Gun)	W032204
	T-094	Centerfire™ Contact Tip, 3/32″ (2,4 mm) (Included w/Gun)	W032205
4	7010031	Neck Liner, 6″ (15,2 cm)	W032226
	7010032	Neck, Liner, 12″ (30,5 cm)	W032225
5	7010035	Liner, Power Pin, Miller	W032227
6	4421P	O-Ring	W032228

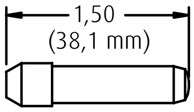
Liners for Bernard®
200, 300, 400 & 500 Amp BTB MIG Guns

Wire Size	Liner Color	10′ (3,05 m)	15′ (4,57 m)	Item Number
.035-.045	White	L3A-10*1 (N/A)	L3A-15*	W032207
.045-1/16	Red	L4A-10**1 (N/A)	L4A-15**	W032224
5/64	Blue	-	L6A-15	W032231

Centerfire™ Consumable Series
for 200, 300, 400 & 500 Amp BTB MIG Guns

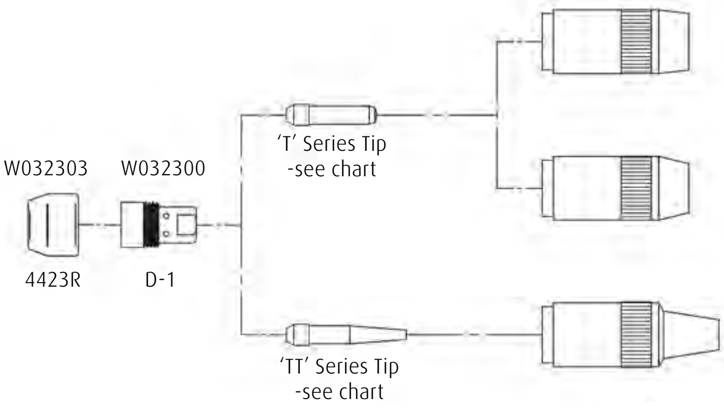
Small Centerfire™ Gas Diffusers and Nozzles

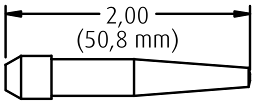




Item	Description	Item Number
T-039	.039″ (1,0 mm)	W032210
T-045	.045″ (1,2 mm)	W032211
T-052	.052″ (1,4 mm)	W032221
T-062	1/16″ (1,6 mm)	W032203
T-078	5/64″ (2,0 mm)	W032204
T-094	3/32″ (2,4 mm)	W032205
T-109	7/64″ (2,8 mm)	W032229
T-125	1/8″ (3,2 mm)	W032230

Large Centerfire™ Gas Diffusers and Nozzles





Item	Description	Item Number
TT-045	.045″ (1,2 mm)	W032209
TT-052	.052″ (1,4 mm)	W032223
TT-062	1/16″ (1,6 mm)	W032222

TIG Torches & Consumables


W031182


W031261/ W031262


W031263/W031264

Product	Description	Item Number
TWP 17V-12-2 CK 150 A 3,8 m	150 A @ 100% duty cycle air-cooled	W031171
TWP 18-25 CK 350 A 7,6 m	350 A @ 100% duty cycle water-cooled	W031182
TWP 26-12-2 CK 200 A 3,8 m	200 A @ 100% duty cycle air-cooled	W031261
TWP 26-25-2 CK 200 A 7,6 m	200 A @ 100% duty cycle air-cooled	W031262
TWP 26V-12-2 CK 200 A 3,8 m	200 A @ 100% duty cycle air-cooled	W031263
TWP 26V-25-2 CK 200 A 7,6 m	200 A @ 100% duty cycle air-cooled	W031264

Torch Body

Description	Item Number
TWP 17V	W031172
26V	W031178
26	W031180
TWP 18	W031183

TIG Remote (Amperage) Controls

Description	Item Number
Miller RFCS-14 Pin Foot Control	W030911
Miller RHC-14 Pin Hand Control	W030912
Miller RCC-14 Pin Finger Tip Control	W030913

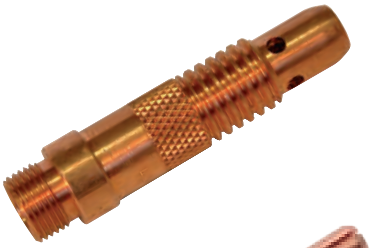

RFCS – 14 HD Foot Control


RHC – 14 Hand Control


RCC – 14 Finger Tip Control

Please note: Weldcraft TIG torches and accessories available on request from Afrox Service Engineering Department.

Product	Size (mm)	Item Number
Collet Body	1,6	W031155
Collet Body	2,4	W031156
Collet Body	3,2	W031157



Product	Size (mm)	Item Number
Collet	1,6	W031151
Collet	2,4	W031152
Collet	3,2	W031153
Collet	4,0	W031154

Product	Size (mm)	Item Number
Nozzle	8,0	W031159
Nozzle	10,0	W031160
Nozzle	11,0	W031161
Nozzle	12,5	W031162

Back Cap Long

Item Number	W031163

Adaptor Power Cable

Item Number	W031166

Back Cap Short

Item Number	W031164

Valve 26 V

Item Number	W031267

3 Series Gas Saver Torch		
Size (mm)	**Product**	**Item Number**
	Gas Saver Collet Body	W031270
	Cup Gasket Gas Saver	W031169
	Back Cap Short	W031164
	Back Cap Long	W031165
	Valve 26 V	W031267
10,0	Gas Saver Nozzle	W031258
11,0	Gas Saver Nozzle	W031259
1,6	Wedge Collet	W031174
2,4	Wedge Collet	W031175
1,6	Gas Screen	W031271
2,4	Gas Screen	W031272

3 Series Gas Lens Torch	
Product	**Item Number**
Cup Gasket Gas Saver	W031169
Heat Shield Gas Lens	W031173
Back Cap Short	W031164
Back Cap Long	W031165
Valve 26 V	W031267

New GYS Plasma Cutting Range

Afrox brings to South Africa a world class product with features and benefits that set global standards. We have the pleasure to introduce our new plasma range fit for any market and sector in South Africa with tough, rigid, durability and quality in mind.

Plasma Power Sources

Plasma CUTTER 45 CT - With Torch

Item Number	W006050

The CUTTER 45 CT is a 45 A plasma cutter equipped with the TPT 40 torch as standard. It offers a clean cutting capacity of 15 mm thick on a multitude of materials. The HF-free arcing system preserves and increases the lifetime of consumables. Designed to be used in difficult environments, it has a very robust mechanics and a user-friendly control panel.

Maximum Productivity
- Faster cutting speed using oxygas
- Cuts all types of steel (mild, stainless, tempered, HLE), aluminium, copper, etc.
- Optimised cooling using the ventilation corridor that helps insulating the electronic components from the dust
- Consumables setting up is easy for maximum productivity
- Duty cycle 41 A at 60% (40°C).

- Flexible voltage hose (85 to 265V), accepts very long network connections (100 m)
- PFC technology, the electrical network is better exploited and allows an energy saving of 30%.

Effective In Every Workplace
- User friendly interface :
  - 3 working modes : plain metal sheet / open metal sheet / locked
  - manual setting of the air pressure using front screen chart
- HF-free ignition to prevent disturbances that could damage nearby electronic equipment
- Compatible with CNC kit for automatic cutting tables
- Disconnectable earth cable for easy storage and replacement.

Designed To Last
- Reinforced metal case and non-slip rubber pads
- IP 23 certified for external use
- Compact and portable.

Performances

Capacity	Max. Thickness
Separation	20 mm
Clean Cut	15 mm
Piercing	8 mm

Plasma CUTTER 70A CT - Torch Included

Item Number	W006051

The CUTTER 70 CT is a 70 A plasma cutter with a cutting capacity of 35 mm thick on a multitude of materials. The HF-free arcing system preserves and increases the lifetime of consumables. Designed to be used in difficult environments, it has very robust mechanics and a user-friendly control panel. It is prewired for use on automatic cutting tables.

Maximum Productivity
- Faster cutting speed using oxygas
- Cuts all types of steel (mild, stainless, tempered, HLE), aluminium, copper, etc.
- Optimised cooling using the ventilation corridor that helps isolate the electronic components from the dust
- Replacement of consumables is fast and easy for maximum productivity
- Duty cycle 70 A at 60% (40°C).

High-Performance Torch
- Premium torch TECMO (leading supplier in Europe)
- Premium cutting quality: the torch is air cooled offering a great arc stability for all types of work
- Consumables compatible with Hypertherm
- Designed to be shock and heat resistant
- Quick connect/disconnection of the torch, no tools required for transport or maintenance
- Easy to use trigger mechanism for added comfort.

Effective In Every Workplace
- User friendly interface :
  - 3 working modes : cutting/mesh/locked
  - manual setting of the air pressure (4,1 < 6,5 bars) using front LED Indicator
- HF-free ignition to prevent disturbances that could interfere with nearby electronic equipment
- Compatible with CNC kit for automatic cutting tables.

Designed To Last
- Reinforced metal case and non-slip rubber pads
- IP 23 protection rated
- Compact and portable.

Performances	
Capacity	**Thickness**
Separation	35 mm
Clean Cut	25 mm
Piercing	15 mm
Capacity	**Removal Rate**
De-gouging	4,8 kg/h

Plasma NEOCUT 125A CT - Torch Included

Item Number	W006052

The NEOCUT 125 is a plasma cutter with a duty cycle of 100% at 125 A for cutting work up to 57 mm thick in industrial environments. It is equipped with an automatic air pressure management, in all modes, offering an optimum cutting quality throughout the lifespan of the consumables. Also connectable to a cutting table, its Marking mode is perfect for tracing and identifying parts.

Synergic Air Pressure

- Automatic management of pressure and air flow independent of the torch length and the operating mode (cutting, gouging and marking)
- Optimised consumable lifespan.

Maximum Productivity

- Duty cycle 100% at 125 A (40°C)
- Marking mode, ideal for tracing and identifying parts
- Cuts most materials (mild, stainless, tempered, HLE), aluminium, copper, etc.
- Optimised cooling design to operate in an industrial environment
- Connectable through one of the 3 optional CNC kits for use on automated cutting table
- Reinforced case IP 23.

Simple To Use

- Ergonomic interface with OLED screen (7 languages)
- 6 working modes: Cutting, Cutting with locked trigger, Gouging, Gouging with locked trigger, Cutting of perforated sheets, Marking
- Counter to follow the wear of the consumables (nozzle and electrode)
- Pneumatic diagnosis (moisture presence test and air pressure control)
- HF-free arc ignition to prevent disturbances that could damage nearby electronic equipment
- Simplified software update via USB cable without any tools or disassembly.

Performances

Cutting	**Fe**	**Al/CrNi**
	25 mm	25 mm
	40 mm	40 mm
	57 mm	57 mm

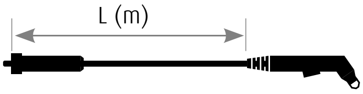
Gouging	**Withdrawal Rate**
	12 kg/h

Plasma Torches & Consumables

Handheld Torches

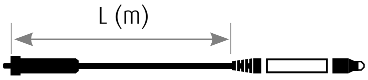
MT Torches

	I (60%)	I (100%)	L (m)	Item Number
MT-70	70 A (50%)	50 A	6	W006055
MT-125	125 A	105 A	6	W006056



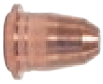
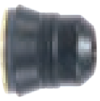
Torches

	I (60%)	I (100%)	L (m)	Consumables	Item Number
TPT 40	40 A	32 A	4	Included	W006086



Consumables

Consumables

										
TPT 40	x1	W006088	x3	W006055	x3	W006089	x1	W006091	Box TPT 40	W006086

Standard Consumables

Consumables Cutting

						
MT-70	20-50 A	W006088	W006061		W006075	W006078
	70A		W006062 (Long)	W006068 W006069 (Long)		W006079 (Long)
MT-125	45 A (Precision cut)	W006093	W006063		W006076	W006081
	45 A					
	65 A					
	85 A					
	105 A	W006065		W006072	W006077	W006082
	125 A					

Consumables Gouging

						
MT-70	70 A	W006088	W006061	W006070	W006075	W006080
MT-125	105 A	W006088	W006063	W006073	W006076	W006081
	125 A			W006074	W006077	W006083

Boxes

MT-70	20-70 A	Box 20-50 A W006059	-
MT-125	45-125 A	-	Box 105/125 A W006060

Compressed Air Cleaning Filter

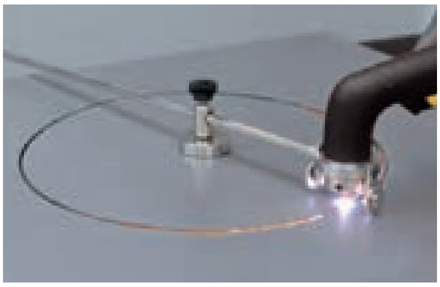
Item Number	W006054

Filter Cartridges (x 4)

Item Number	W006053

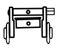
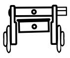
Filter Kit for CUTTER 70 / Neocut 105/125

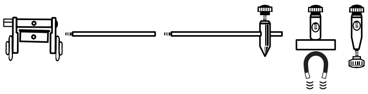
Item Number	W006054



Compass

Compass

	⌀ max	Trolley Included	Torches Compatibility							Item Number
			TPT 25	TPT 40	MT 25K	MT 35K	MT 45	MT 70	MT 125	
	1 540 mm	 W006199	·	·	·	·	·	–	–	W006087
	820 mm	 W006057	–	–	–	–	–	·	·	W006058



Afrox Arc Equipment – RENT OR BUY?

In the construction industry, a general rule of thumb is that if you don't utilise a piece of equipment at least 60 to 70 percent of the time, you should consider renting. Afrox has partnered with Miller to offer tailor-made welding equipment rental packages to the South African market, affording customers the option to rent a selection of premium arc welding machines for short- to medium-term projects. The Afrox equipment rental offer incorporates four models from the Miller range of premium quality welding machines for large industrial applications, and provides customers with the option of selecting equipment for various processes: MMA/Stick, TIG (DC), MIG/FCAW/MCAW and gouging.

For all rental equipment enquiries, email equipment.rental@afrox.linde.com and/or call the Afrox Service Engineering Department (SED) on 011 876 1113.


Miller
PipeWorx 400

ARC ACCESSORIES

9

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Welding Cable & Connectors 295
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Electrode Holders

Afrox offers jaw and twist lock type electrode holders. The electrical capacity of the electrode holder must always be greater than the amperage in use – for instance, to carry 300 A, the electrode holder capacity should be at least 400 A. Damaged electrode holders can cause electric shock and even death and must be carefully maintained. Factors determining choice of an electrode holder:

1. Diameter of the electrode
2. Amperage required
3. Diameter of the cable used
4. Customer preference for jaw type or twist lock.

Electrode Holder - Safegrip Jaw Type

Heat resistant insulation, sturdy copper alloy jaw. Powerful all-position electrode grip allows ultra-quick electrode changes. Heavy duty construction with double ball point cable connections

Description	Item Number
Safegrip Jaw Type 300 A up to 4,0 mm	W054200
Safegrip Jaw Type 400 A up to 5,0 mm	W054201
Safegrip Jaw Type 500 A up to 5,0 mm	W054203
Safegrip Jaw Type 600 A up to 8,0 mm	W054208

Electrode Holder - Jackson Type

Fully insulated electrode holder for a small welding machine. Fully insulated holder, heavy duty heat resistant construction ensures high performance

Description	Item Number
Jackson Type 500 A	W053098

Electrode Holder - Twist

Fully insulated holder made of robust glass fibre material. A well balanced holder, with grub screw fitting that gives positive and easy cable connection. Fully insulated heavy duty heat resistant fibreglass construction ensures high performance under arduous conditions

Description	Item Number
Twist 400 A up to 5,0 mm	W054202
Twist 600 A up to 8,0 mm	W054204

Electrode Holder - Suhan Jaw Type

A fully insulated holder where smaller electrodes are used on portable small machines. For use in light to medium fabrication

Description	Item Number
Suhan Jaw Type 300 A 1,6 - 4,0 mm	W053090
Suhan Jaw Type 500 A up to 5,0 mm	W053092

Electrode Holder - Optimus

Heat resistant insulation, copper jaw electrode allows quick electrode changes. Heavy duty construction, powerful all positional electrode allows ultra-quick electrode changes

Description	Item Number
Optimus 300 A 1,6 - 4,0 mm	W053095
Optimus 400 A up to 5,0 mm	W053096

Welding Cable & Connectors

Welding Cable

Afrox welding cable is available with a choice of rubber and PVC insulation. Rubber-insulated cable is recommended for use outdoors and is available in different amperages and duty cycles. PVC-insulated cable is used indoors only and is also available in a range of amperages.

Rated Area (mm^2)	Welding current in amps for duty cycle of:					Colour	Item Number
	100%	85%	60%	30%	20%		
Natural Rubber Selection Guide							
35	165	180	215	305	370	Black/Grey	W053007
50	210	230	275	385	470	Black/Red	W053008
70	265	285	410	580	710	Black/Brown	W053015
PVC Selection Guide							
16	110	120	145	200	250	Green	W053100
25	150	165	195	275	340	Blue	W053101
35	185	200	240	340	415	Grey	W053102
50	230	250	300	420	520	Red	W053103
70	290	315	380	530	650	Brown	W053104
95	355	385	465	650	800	Yellow	W053105

Description	Dimensions	Colour	Item Number
PVC Welding Cable	25 mm x 6 m	Blue	W053107
PVC Welding Cable	35 mm x 6 m	Grey	W053108
PVC Welding Cable	50 mm x 6 m	Red	W053109
PVC Welding Cable	25 mm x 12 m	Blue	W053110
PVC Welding Cable	35 mm x 12 m	Grey	W053111
PVC Welding Cable	50 mm x 12 m	Red	W053113

Classes of Welding	Automatic (Submerged arc, MIG)	Manual (MMA, HG)	Very intermittent (MMA, MIG, MAG, HG)
	Semi-automatic (MIG, MAG, flux cored)		

Cable Connectors

Solid brass camlock-style cable connectors in two sizes connect welding cable quickly and easily with a quarter turn. Will not slip or disconnect if cable is pulled. Hard rubber sheath insulates the connection. Cable connectors are precision machined to provide a very tight connection which greatly improves power flow. Cam action pulls the two halves tightly together. Covers are made from a temperature resistant material which is not susceptible to rust or corrosion.

Cable Connector

Description	Item Number
CC 20 Plug/Socket	W054154
CC 20 Plug	W054155

Cable Connector CC 18 Socket

Item Number	W054152

Cable Connector CC 17 Plug

Item Number	W054151

Plug

Description	Item Number
Male Dinse Plug (50 - 70)	W033718
Male Dinse Plug (10 - 25)	W054489

Cable Lugs

Description	Item Number
200 A 14 mm Fixing Hole	W053021
150 A 13 mm Fixing Hole	W053022
300 A 17 mm Fixing Hole	W053023

Cable Lugs Crimping

Description	Item Number
35 x 12 mm (300 A)	W053011
50 x 12 mm (400 A)	W053012
70 x 12 mm (500 A)	W053013
95 x 12 mm (600 A)	W053014

Female Dinse Plug (50 - 70)

Item Number	W035751

Panel Mount Female Socket

Description	Item Number
Panel Mount Female Socket (10 - 25)	W054488
Panel Mount Female Socket (50 - 70)	W035692

Earth Clamps & Welding Ancillaries

Earth Clamp - 600 A TRC Screw Type

Item Number	W054147

Earth Clamp - 600 A EC Screw Type

Item Number	W054149

Wire Brush 6 Row Stainless Steel

Item Number	W053081

Wire Brush 5 Row Mild Steel

Item Number	W053003

Chipping Hammer

Steel heavy duty long life hammer

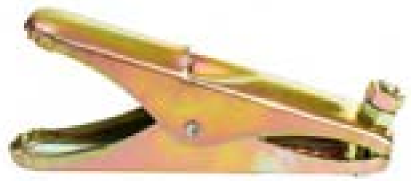
Item Number	W053020

Earth Clamp - 150 A Crocodile

Item Number	W053025

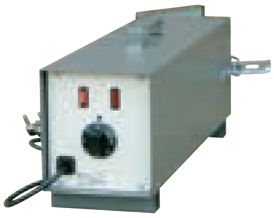
Earth Clamp - 300 A Crocodile

Item Number	W054146



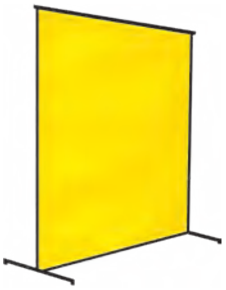
Earth Clamp - 600 A Crocodile

Item Number	W054148



Hot Box

Description	Item Number
220 V Thermostat Controlled	W052005



Welding Screen 2 x 3 m

Flame retardant dipped
Excludes stands

Item Number	W092020

Cleaning & Preparation Products

Penetrant, Developer and Remover

Afrox offers a non-destructive range of testing products. These are used to identify weld defects and clean the affected area before welding.

Penetrant, Developer and Remover

Description	Item Number
NDT - Ardrox HF-P Penetrant 300 g	W033570
NDT - Ardrox HF-P Remover 300 g	W033572
NDT - Ardrox HF-P Developer 300 g	W033571

Anti-Spatter

Afrox offers a variety of anti-spatter to meet customer requirements. We have a non-silicone based anti-spatter as well as a water based version. The latter does not contain hydrocarbons which makes it environmentally friendly.

Anti-Spatter

Description	Item Number
Spatter Off (Water based)	W034009
Spatter Release 640 NO/SI 500 ml	W034010
TRC Spatter Release Aerosol 500 ml	W034015
Anti-Spatter AOX Liquid 500 ml	W034013
Anti-Spatter AOX Liquid Refill 5 ℓ	W034014

Pickling and Passivating Paste

To improve your stainless steel weld quality after welding, apply Afrox's pickling and passivating paste. It forms a thin layer that will protect your welds from corrosion and rust.

Description	Item Number
Passivating Paste AOX 1 ℓ	W053574
Pickling Paste AOX 1 ℓ	W053575

Torch Coolant

Torch coolant is used for plasma cutting to circulate around the electrode and nozzle and prevent it from melting.

Afrox Torch Coolant 5 ℓ

Item Number	W053576

Abrasives

Cutting Discs - Inox (Stainless Steel)

Description	Item Number
Superflex 350x3,4x25,4 Inox Cutting Disc	W053379
Superflex 230x2,5 Inox Ultra Cutting Disc	W053407
Superflex 115x2,4 Inox Ultra Cutting Disc	W053411
Superflex 180x2,5 Inox Ultra Cutting Disc	W053408
Superflex 150x2,5 Inox Ultra Cutting Disc	W053409
Superflex 125x2,4 Inox Ultra Cutting Disc	W053410

Cutting Discs - Carbon Steel (Professional)

Description	Item Number
Superflex 125x2,5 Prof Steel Cutting Disc	W053446
Superflex 115x2,5 Prof Steel Cutting Disc	W053447
Superflex 180x3 Prof Steel Cutting Disc	W053442
Superflex 230x3 Prof Steel Cutting Disc	W053441
Superflex 150x3 Prof Steel Cutting Disc	W053443
Superflex 100x2,5x16 Prof Steel Cutting Disc	W053448

Cutting Discs - Carbon Steel (Professional 2-1 / Stainless & Carbon Steel)

Description	Item Number
Superflex 230x1,9 Prof 2-in-1 Cutting Disc	W053405
Superflex 125x1,0 Prof 2-in-1 Cutting Disc	W053406
Superflex 115x1,0 Prof 2-in-1 Cutting Disc	W053440

Cutting Discs - Carbon Steel (Industrial 2-1 / Stainless & Carbon Steel)

Description	Item Number
Superflex 100x1,0x16 IND 2-in-1 Cutting Disc	W053272
Superflex 115x1,6 2-in-1 Cutting Disc	W053403
Superflex 115x1,0 IND 2-in-1 Cutting Disc	W053273
Superflex 230x1,9 IND 2-in-1 Cutting Disc	W053275
Superflex 115x1,0 IND 2-in-1 Cutting Disc (PO5)	W053402

Cutting & Ginding Disc

Description	Item Number
Superflex 115x2,2 CG-27 Cutting & Grinding Disc	W053263

Cutting Discs - Carbon Steel (Industrial)

Description	Item Number
Superflex 115x3 IND Steel Cutting Disc	W053285
Superflex 230x3 IND Steel Cutting Disc	W053279
Superflex 350x3,6 IND Steel Cutting Disc	W053274

Grinding Discs - Inox

Description	Item Number
Superflex 230x7 Inox Ultra Grinding Disc	W053416
Superflex 115x6 Inox Ultra Grinding Disc	W053436
Superflex 180x7 Inox Ultra Grinding Disc	W053415
Superflex 150x6,5 Inox Ultra Grinding Disc	W053434
Superflex 125x6 Inox Ultra Grinding Disc	W053435
Superflex 100x6x16 Inox Ultra Grinding Disc	W053437

Grinding Discs - Carbon Steel (Professional)

Description	Item Number
Superflex 115x6 Prof Steel Grinding Disc	W053445
Superflex 125x6 Prof Steel Grinding Disc	W053439
Superflex 100x6x16 Prof Steel Grinding Disc	W053444
Superflex 150x6,5 Prof Steel Grinding Disc	W053438

Grinding Discs - Carbon Steel (Industrial)

Description	Item Number
Superflex 115x6 IND Steel Grinding Disc	W053287
Superflex 230x7,2 IND Steel Grinding Disc	W053291

Grinding Discs - Heavy Duty

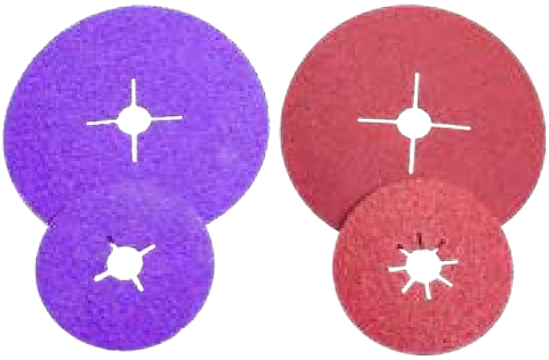
Description	Item Number
Superflex 180x7 Heavy Grinding Disc	W053414
Superflex 230x4,1 Heavy Grind (Back)	W053412
Superflex 230x7 Heavy Grinding Disc	W053413
Superflex 230x5,2 Heavy Duty Back Grind	W053417

Flap Discs

Description	Item Number
Superflex 115x22 AZ60 IND Flap Disc	W053243
Superflex 115x22 AZ80 IND Flap Disc	W053245
Superflex 180x22 AZ60 IND Flap Disc	W053296
Superflex 180x22 AZ80 IND Flap Disc	W053299
Superflex 150x22 AZ60 IND Flap Disc	W053271
Superflex 115x22 AZ40 IND Flap Disc	W053241
Superflex 115x22 AZ120 IND Flap Disc	W053247
Superflex 180x22 AZ40 IND Flap Disc	W053293
Superflex 180x22 AZ120 IND Flap Disc	W053302
Superflex 125x22 AZ60 IND Flap Disc	W053282

Spindle Mounted Flap Wheel

Description	Item Number
Superflex 50x25x6 P320 Flap Wheel	W053229
Superflex 50x25x6 P120 Flap Wheel	W053429
Superflex 50x25x6 P240 Flap Wheel	W053430
Superflex 50x25x6 P80 Flap Wheel	W053428
Superflex 50x25x6 P60 Flap Wheel	W053251



Fibre Discs

Description	Item Number
Superflex Deerfos 125x22 P60 Fibre Disc	W053424
Superflex Deerfos 125x22 P80 Fibre Disc	W053426
Superflex Deerfos 125x22 P100 Fibre Disc	W053427
Superflex P36 115x22 Bora 9 Cer Fibre D	W053423
Superflex P36 178x22 Bora 9 Cer Fibre D	W053425

Wire Wheels

Description	Item Number
Superflex 115x10xM14 1 Row Knotted Wire Wheel	W053253
Superflex 50x25x6 MW912 Mounted Wire Wheel	W053257
Superflex 115x10x22,2 1 Row Knotted Wire Wheel	W053255
Superflex 180x10xM14 1 Row Knotted Wire Wheels	W053259
Superflex 180x10x22,2 1 Row Knotted Wire Wheels	W053265

Mounted Points

Description	Item Number
Superflex A12 HC Ruby Mounted Point	W053421
Superflex A11 Ruby Mounted Point	W053227
Superflex A3 Mini HC Ruby Mounted Point	W053225
Superflex IPDS Point Black	W053420
Superflex A3 Jumbo Ruby Mounted Point	W053419
Superflex A1 Ruby Mounted Point	W053231
Superflex A15 Ruby Mounted Point	W053235

Tungsten Burrs

Description	Item Number
Superflex CP102006-A Cyl Pl Tungsten Burr	W053205
Superflex CR102006-C Cyl Rd Tungsten Burr	W053220
Superflex TP102006-G Pointed Tungsten Burr	W053236
Superflex TR102006-F Round Tungsten Burr	W053242
Superflex TR122506-F Round Tungsten Burr	W053244
Superflex T103006-L Ball Nose Tungsten Burr	W053246
Superflex T123006-L Ball Nose Tungsten Burr	W053249
Superflex CP122506-A Cyl Pl Tungsten Burr	W053210
Superflex CR122506-C Cyl Rd Tungsten Burr	W053232
Superflex TP122506-G Pointed Tungsten Burr	W053238
Superflex CP061606-A Cyl Pl Tungsten Burr	W053200
Superflex CR061606-C Cyl Rd Tungsten Burr	W053215
Superflex TP061606-G Pointed Tungsten Burr	W053234
Superflex TR061606-F Round Tungsten Burr	W053240

Gouging Torches & Electrodes

The Transarc® range of carbon gouge electrodes are designed for the air carbon gouging metal removal process which melts metal with an electric arc, then dynamically removes it with a jet of compressed air. The carbon electrodes contain a precisely formulated blend of carbon and graphite that produces the most efficient metal removal performance.

Features and Benefits

They offer excellent arc stability, superior metal removal rates, resistance to breakage, heat and oxidation, and have a uniform diameter resulting in clean slag-free grooves. Metals that can be gouged with the process include steel, high carbon alloys, stainless steel, copper and cast iron. The air carbon cutting process can also be used for cutting metals that are not readily cut by the oxy-fuel gas cutting process.

Gouging Torches

- Heavy duty with swivel cable 1 000 A
- Heavy duty metal removal applications such as weld preparations in the pressure vessel shops and shipyards
- $^{5}/_{32}$" - $^{1}/_{2}$" round CCDC Electrode (4,0 mm - 9,5 mm)
- $^{3}/_{8}$" - $^{5}/_{8}$" flats (9,5 mm & 15,9 mm)
- Air requirements 80 psi or 5,6 kg/cm³ or 708 ℓ/min

Description	Item Number
Gouging Torch D4000 K4000	W054275
Gouging Torch ArcAir K4000 W/2,13M Cable	W054311
Gouging Parts K4000 Insulator & Screws	W054316
Gouging Parts K4000 Lever & Screw	W054317

All other spares available on request from Afrox SED

Carbon Gouge Electrodes

Description	Item Number
Carbon Gouge TRC 8 x 305 mm (Pack of 50)	W054918
Carbon Gouge TRC 5 x 305 mm (Pack of 100)	W054934
Carbon Gouge Joint TRC 9,5 x 355 mm (Pack of 50)	W054933
Carbon Gouge Joint TRC 13,0 x 355 mm (Pack of 50)	W054926
Carbon Gouge Joint TRC 16 x 355 mm (Pack of 50)	W054922
Carbon Gouge TRC 9,5 x 305 mm (Pack of 50)	W054919
Carbon Gouge TRC 6,4 x 305 mm (Pack of 50)	W054917
Carbon Gouge TRC 4,0 x 305 mm (Pack of 100)	W054915

TIG Tungsten

Zirconiated TIG Electrodes (White tips) - Pack of 10

Description	Item Number
Wolfram 2% Zirconiated 4,0 mm (Pack of 10)	W031005
Wolfram 2% Zirconiated 3,2 mm (Pack of 10)	W031004
Wolfram 2% Zirconiated 2,4 mm (Pack of 10)	W030908
Wolfram 2% Zirconiated 1,6 mm (Pack of 10)	W030907

Zirconiated tungsten electrodes exhibit good performance characteristics in AC welding, especially under high load current. These electrodes can retain a balled end when welding, which results in less tungsten permeation and good corrosion resistance. It balls up well in AC welding and has a more stable arc than pure tungsten. Displays excellent performance in high load AC welding. Not replaceable by any other electrodes. Resists contamination well in AC welding.

Application: Zirconiated tungsten is most commonly used for AC welding of aluminium and magnesium alloys. Preferred when tungsten contamination of weld is intolerable.

The surface condition of zirconiated tungsten electrode is polish grounded. It is bright and tipped with the brown and white colour for its different composition of zirconium in tungsten zirconiated electrode.

Witstar TIG Tungsten (Teal tips) - Pack of 10

Description	Item Number
Witstar TIG Tungsten 3,2 mm (Pack of 10)	W031002
Witstar TIG Tungsten 2,4 mm (Pack of 10)	W031012
Witstar TIG Tungsten 1,6 mm (Pack of 10)	W031014

Witstar TIG electrodes are made from rare earth materials. They are safe to use and not harmful, unlike thoriated tungsten which is radioactive. Witstar TIG electrodes are used for alloyed and non-alloyed metals, alloyed and non-alloyed coppers, nickel and nickel alloys, aluminium and aluminium alloys, magnesium and magnesium alloys, and titanium and titanium alloys.

Transarc® Thoriated TIG Tungsten (Red tips) - Pack of 10

Description	Item Number
Transarc® 2% Thoriated 3,2 mm (Pack of 10)	W031032
Transarc® 2% Thoriated 2,4 mm (Pack of 10)	W031024
Transarc® 2% Thoriated 1,6 mm (Pack of 10)	W031016

Thoriated tungsten electrodes provide excellent resistance against weld pool contamination while at the same time offer the welder easier arc starting capabilities and a more stable arc. Thoriated tungsten electrodes are the most commonly used tungsten material; thoria is low-level radioactive material, but it is was the first to display a significant improvement over pure tungsten.

Application: Thoriated tungsten electrodes are generally used in DC electrode negative or straight polarity applications such as carbon & stainless steels, nickel alloys and titanium, as they operate well even when overloaded with extra amperage, then improving the performance of welding.

GAS EQUIPMENT

10

Section 10 - Gas Equipment 306

Afrox Range 308

Oxy-Fuel Cutting, Welding & Heating Processes 308

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Regulator Spares, Fittings & Attachments 325

Torches & Attachments 327

Nozzles 336

Flashback Arrestors & Quick Release Couplings 343

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IBEDA 365

Flashback Arrestors & Quick Release Couplings 365

Transarc® Gas Equipment 370

AFROX RANGE

Oxy-Fuel Cutting, Welding & Heating Processes

Gas Welding

Combustion can only take place if three conditions are satisfied.

There must be a fuel. A fuel is a material that burns or combusts with oxygen to release energy. The hot gases produced by combustion form a flame. Most, but not all, fuels are hydrocarbons. Oxygen must be present. Oxygen is a chemical element with which most chemical compounds will combine in an exothermic reaction.

Ignition is required for the fuel/oxidant mixture to ignite and produce a flame. The source of ignition may be a pilot flame, an electrical spark, a hot spot or a sudden pressure change. In the process of combustion, ignition causes a fuel to react with oxygen.

The products of complete combustion, in the case of hydrocarbon fuels, are oxides such as carbon dioxide and water, and a large amount of energy in the form of heat and light.

When oxygen and a fuel gas are burned together at the end of a nozzle, a flame is created and it is this flame that is used to melt both the parent and filler material. Of all the fuel gases available, acetylene is the most widely used because of its higher flame temperature and the ease at which the flame can be set.

When equal quantities of acetylene and oxygen are burned, a neutral flame is created and this has two visibly distinct zones within it. In actual fact, there are more than two zones within a neutral flame – there are four.

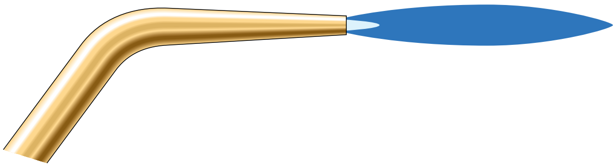
Looking from the nozzle, the first zone is an unburned mixture of oxygen and acetylene. No combustion takes place here because the gases are effectively at room temperature and there is no source of heat.

On the edge of this inner zone is a bright blue-white stationary combustion zone where burning takes place. The reaction within this area can be defined by the equation:

$C_2H_2 + O_2 \geq 2CO + H_2$

The outside of this zone is the hottest point of the flame.

These two zones form what is called the primary zone or primary cone of the flame.



Schematic of the gas welding flame

Further out from the primary zone is the reducing zone. Very little combustion takes place in this zone, as most of the oxygen available was consumed in the previous zone.The outside zone is where the remaining by-products of the initial combustion burn with oxygen from the atmosphere.

Here the reactions are:

$2CO + O_2 \geq 2CO_2 2H_2 + O_2 \geq 2H_2O$

These outside two zones form what is termed the secondary zone or outer envelope.

Flame Types

Although the neutral flame is the most commonly used for gas welding, two other flame types – oxidising flame and carburising flame – are used for different applications.

Neutral Flame

In the neutral flame, the primary zone is sharp and clearly defined.

The neutral flame is used for gas welding:

- Carbon and alloy steels
- Stainless steel
- Cast iron
- Copper.

Oxidising Flame

As the name suggests, in an oxidising flame an excess of oxygen is present. This produces a much shorter, brighter secondary zone. The oxidising flame is also noisier than the other two flame types.

The oxidising flame is primarily used for gas welding brass.

Carburising Flame

The carburising flame is created by having a small excess amount of acetylene present in the flame. This flame is clearly distinguished by a small ‘feather’ of acetylene at the end of the primary zone.

The excess of acetylene in the flame adds carbon into the weld pool and is used predominantly for hardfacing applications.

Application

The application of gas welding is wide and various, both in terms of the thickness range and the materials that can be welded with it. It can also be used to weld in all positions as long as the operator has the skill required to carry out the task.

The industries that use gas welding are varied. The relatively low cost equipment and its flexibility mean that every engineering workshop is likely to have a system on site. Of these systems, oxy-acetylene is by far the most common because it is the only gas combination that can be used to weld all materials.

Gas welding has also become a favourite with the home DIY hobbyist, again because of its flexibility.

The Oxy-Fuel Welding Process

Welding

Welding is using a flame to melt the plate and add filler.

Welding (fusion welding) takes place when a flame is used to heat the edges of the joint to melting temperature. When the metal is in a molten state, the edges flow together. The addition of the welding rod may be required, depending on the type of joint being welded.

Braze Welding

Brazing and braze welding take place at temperatures above 450°C, but below the melting point of the base metal.

Braze welding happens when the edges of the joint to be welded are heated sufficiently to melt the braze welding rod, which then flows onto the joint edges, producing a fillet in the joint. The parent metal does not melt. The process is one of adhesion.

An advantage of braze welding is reduced distortion because of the lower temperatures.

The filler material is an alloy of copper and zinc and may also contain other elements such as silicon, nickel or manganese.

A flux, either coated on or contained within the rod, must chemically clean the surface of the parent metal during heating.

The edges of the joint to be welded are heated sufficiently to melt the braze welding rod which then flows on to the joint edges. The parent metal does not melt.

Comparisons

Advantages of braze welding:

- Less distortion because of lower heat input
- Faster welding speeds because of lower heat input.

Disadvantages

- Weakness of joint at high temperatures
- Mismatch of colour between parent metal and the bronze welded deposit.

Braze welded joints

- Fillet joints
- Lap joint
- Butt joint
- No fusion of the joint edges
- Pronounced build-up of the filler metal.

Brazing

Brazing is the adhesion of one plate to another without melting at temperatures above 450°C but below the melting point of the base metal. The filler material to form the union is non-ferrous.

Features of brazing

- Filler metal in a thin film (0,0254 – 0,0085 mm) between two or more tightly fitted pieces of base metal
- Often referred to as silver brazing or silver soldering
- Fast metal joining is achieved because:
    - Brazing rod has the lowest achievable melting point, which can lead to capillary action
    - Whole joint is raised to the correct temperature (in contrast with localised heat applied in welding)
    - Brazing rod flows by capillary action along joint edges and through to the reverse side of the joint.

Braze joints

- Fillet joints
- Lap joints
- Butt joints – not suitable for brazing.

Fluxes in brazing

Fluxes clean the metal surface.

When fluxes are used to clean the surface chemically, the parent metal does not melt. The cleaning permits a good bond between the parent metal and the brazing welding rod when brazing:

- Mild steel
- Stainless steel
- Cast iron
- Copper.

Removal of fluxes

Removal of fluxes after brazing is important when using aluminium, as the flux residues are very corrosive to aluminium.

Flux not needed

When using the copper phosphor brazing rod to braze with copper, a flux is not needed.

Soldering

Soldering is also adhesion at a lower temperature. Filler metal or solder alloy with a melting temperature of less than 450°C is used. The filler metal wets the parent metal, spreads, makes contact with the joint opening and is drawn into the joint by capillary action.

Filler metals in soldering

- Soldering is another type of adhesion process
- Filler metal or solder alloy with a melting temperature of <450°C is used
- Binary tin-lead alloys are most commonly used
- Some tin-lead filler metals contain a little antimony (up to 3%) to improve the mechanical properties of the soldered joints
- The filler metal wets the parent metal, spreads, makes contact with the joint opening and is drawn into the joint by capillary action.

Fluxes in soldering

- Fluxes consist of either:
    - Various forms of inorganic weak acid solutions and salts
    - Resins dissolved in organic solvents
- Acid and salt fluxes are corrosive and residues must be removed after soldering
- Resin fluxes are not corrosive.

Function of fluxes in soldering

The function of the flux is to prevent, to dissolve or to remove oxide films and other contaminants. It is NOT a function of the flux to clean dirt from the base metal. Pre-cleaning of the joint faces must be done.

Types of joints

The lap joint is best used because it offers maximum strength. The solder alloy must completely fill the gap to prevent moisture getting in and causing corrosion.

Only the correct clearance between the joint faces will enable the solder to enter the joint by capillary action. The filler alloy must be selected for joint gap, as those with a narrow melting range tend to rise higher than those with a wide melting range.

Oxy-Fuel Cutting

Overview

Flame cutting, oxy-fuel cutting, fuel gas cutting and oxygen cutting are terms that are generally used for the same process. Of all the terms used, oxygen cutting best describes how the process operates.

In oxygen cutting, the metal is heated to its ignition temperature and then a jet of pure oxygen is added, which reacts with the metal creating the cut.

The process was originally developed in the beginning of the 20th century and, while the basics haven't really changed over the years, there have been significant improvements in equipment design. The process is very versatile and can be used both manually or built as a machine, with either single or multiple torches for higher operating efficiencies.

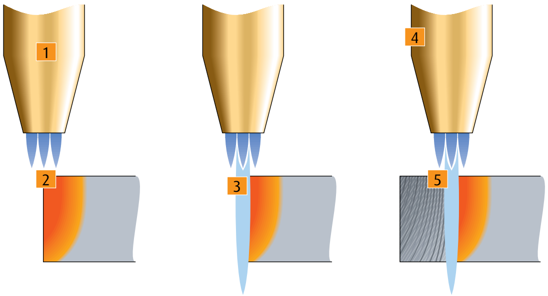
Although a worker can be trained in a short time to make acceptable cuts with the process, considerable skill is necessary to produce cut surfaces suitable for welding. The equipment is also relatively cheap and portable.

Though the equipment for mechanised cutting is more expensive, there is still a high level of skill required by the operator. As profile cutting machines become more programme-controlled, a good understanding of computers is also becoming advantageous.

How It Works

The oxygen cutting process can be considered as a combination of two distinct and separate processes. First the material to be cut must have its temperature increased to the point where it will burn in the presence of oxygen. This is called the ignition temperature of the steel. In oxygen cutting of steel, this is achieved by preheating a localised area until the metal reaches a bright cherry red heat at about 870 – 900°C.

1	Cutting oxygen nozzle
2	Heated steel
3	Cutting oxygen
4	Direction of cut
5	Steel



Schematic of the oxygen cutting process

At this point, a jet of cold oxygen is passed through the centre of the nozzle onto the red-hot steel. This causes a chemical reaction between the steel and the oxygen, generating more heat and melting the steel. This is called an exothermic reaction.

The steel immediately below the oxygen jet is converted to a metal oxide or slag, and is blown away by the jet. If the oxygen stream isn't powerful enough, or if the cutting speed is too quick, the slag will solidify in the cut, and a cut will not be achieved.

As the torch begins to move, more steel is preheated and the oxygen jet burns more of the steel, creating the cut.

Preheat Flame

The preheat flame is formed by the combustion of the pre-heat oxygen and the fuel gas combined either in the torch or the nozzle. It serves three purposes:

- It raises the metal to its ignition temperature
- It counters heat losses due to conduction into the bulk metal
- It shields the cutting oxygen from the effects of entrainment from the surrounding atmosphere.

Although the ignition temperature depends upon the material being cut, the choice of fuel gas has an effect on how quickly the flame will raise the material to the ignition temperature. The higher flame temperature of oxy-acetylene (3,160°C compared to 2,828°C for oxy-propane) will mean that if oxy-acetylene is used, then cutting would commence sooner than for oxy-propane. The thicker the material, the more pronounced this effect becomes.

As cutting begins, it is theoretically possible to turn off the preheat flame as the reaction of the oxygen and steel is exothermic, generating heat. In reality, heat is conducted away from the cut face by the material and the preheat flame is needed to counteract this effect.

The purity of the cutting oxygen stream is very important and the preheat flame acts as a barrier, keeping out the nitrogen in the atmosphere that would react with the cutting oxygen, producing oxides of nitrogen. Should these oxides be produced, they would reduce the cutting speeds and increase oxygen consumption.

Heating

Flame Heating

Flame heating is a method of raising the temperature of components that are usually large and the flame heating process is usually associated with the welding process.

Fabrications may need preheat, interpass temperature control and post heat treatment to follow the welding procedures of critical components and structures or flame heating may be required to simply remove moisture from a weld joint prior to welding.

Flame heating is also used to locally heat components prior to another process such as bending or forming being carried out. Specialised equipment is manufactured for all types of heating applications and may range from a specialist heating equipment and nozzle to an adaptor for a welding or cutting torch.

The process is mobile and all positional, making it ideal for use on large components or structures.

Fuel gas processes, by their nature, use flammable, potentially explosive gases, often in conjunction with oxygen. The gases may be supplied in and used from pressurised gas cylinders and mixed in welding or cutting torches. The main hazards, therefore, are from naked flames, fire and explosion.

Fault Finding Reference Guide

Symptom	Cause	Resolution
A. No gas flows when torch valves are open	1. No gas in cylinder	1. Check contents gauges of both cylinders and refill appropriate cylinder
	2. Cylinder valve not open	2. Crack cylinder valve slowly, open another 1/2 to 1 full turn
	3. Regulator valve not open	3. Set correct pressures on regulator before lighting up
	4. Incorrect flashback arrestors	4. Torch mount arrestors must be fitted on the torch side only. Regulator mount arrestors must be fitted to regulator side only
	5. Flashback arrestors blocked	5. Check inlet filters and replace if necessary
	6. Hoses blocked	6. Blow out hoses with nitrogen or replace hoses if necessary
	7. Nozzle blocked	7. Clean nozzle with approved nozzle cleaner or replace nozzle if necessary
B. Gas won't ignite when torch is opened	1. Oxygen torch valve is open	1. Acetylene is the fuel gas and must be ignited first, with oxygen fully shut
C. Flashbacks occur when acetylene is ignited	1. Pressure not correct for nozzle in use	1. Consult nozzle data chart for the correct pressures for the appropriate nozzles
	2. Flashback occurs	2. Purge each hose separately before use for approximately 2 seconds per 6 m length of hose
D. Flame around nozzle nut when torch is ignited	1. Nozzle nut not tightened	1. Tighten nozzle nut until flame is extinguished
	2. Torch head seat damaged	2. Exchange torch for an Afrox Servex replacement
	3. Nozzle seat damaged	3. Replace nozzles
E. 'Popping' noise heard from torch head	1. Gases mixing in torch head causing small sustained flash-backs	1. Check the nozzle and torch seats, replace if damaged. If not damaged, tighten the nozzle nut
		2. Clean nozzle with approved nozzle cleaner to avoid damage
F. Nozzle not cutting properly or effectively	1. Incorrect nozzle for size and type of material being used	1. Refer to nozzle data chart or Afrox experts for pressure setting and flow rates

Symptom	Cause	Resolution
G. Cutting lever does not produce a cutting stream	1. Incorrect operation procedure (Type 2 torch and Universal®) 2. Oxygen pressure not high enough 3. Torch internally damaged	1. Open oxygen control valve on shank fully. Control preheat flame by oxygen valve on attachment 2. Consult nozzle data chart 3. Trade in torch for an Afrox Servex replacement
H. 'Garlic' or 'fishy' smell occurs when torch is in use	1. Fuel gas (DA/LPG) leaking 2. 'Garlic' smell – Acetylene leaking from gas set 3. 'Fishy' smell – LPG leaking from gas set	1. Test for leaks using Safetest leak detection fluid NB: Oxygen is odourless, colourless and is dangerous when excessive amounts are vented into the atmosphere. Check for leaks regularly on both lines
I. Loud explosion occurs when cutting, welding or heating	1. Flashback has occurred	1. Flashback arrestors must be used to stop back-feeding of gases and quenching of flames
J. Hoses burst after loud explosion	1. Flashback has occurred	1. Flashback arrestors must be used to stop back-feeding of gases and quenching of flames
K. Acetylene cylinder hot	1. Cylinder burning inside	1. Close cylinder valve 2. Evacuate area immediately 3. Hose down with water from a safe distance if possible 4. Call supplier (do not use cylinder again)
L. Acetylene cylinder hot. Paint peeling off or cylinder jumping around	1. Cylinder burning inside and ready to explode	1. All persons evacuate immediately
M. Cylinder/s explode/s	Ensure that your cylinders are always kept in good condition and ensure that flashback arrestors are connected to both the torch and regulator. Ensure that correct nozzles are fitted in accordance with the fuel gas being used as fuel gas/oxygen mixtures vary when using oxy/acetylene and oxy/LPG	

Standards

All gas equipment must comply to the following local/international standards:

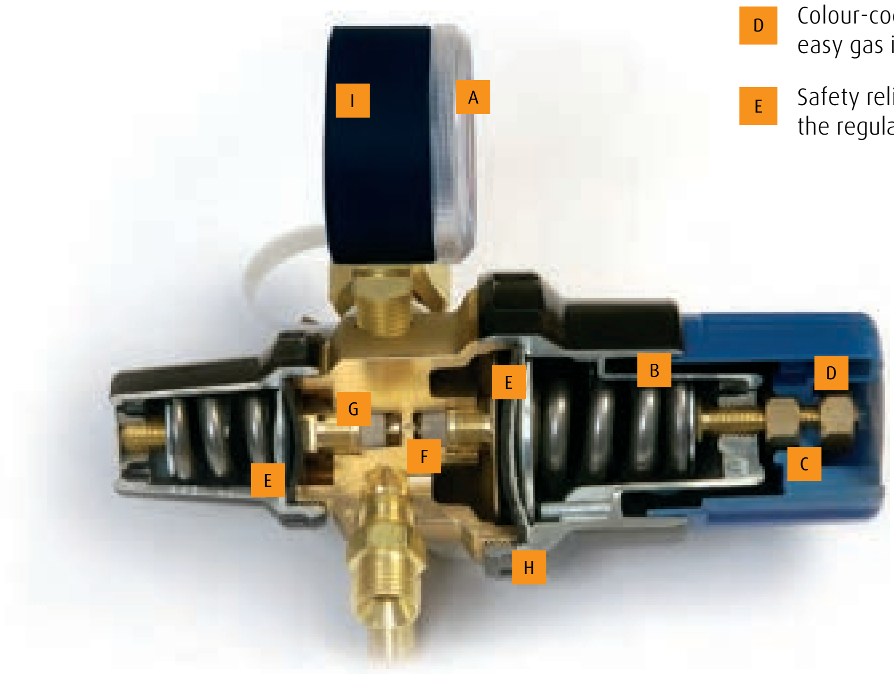
- Regulators: ISO 2503
- Torches: ISO 5172
- Hoses: ISO 3821 for oxygen, acetylene & inert hose
  SANS 1156-2 for LPG
- Hose connections: SANS 3253
- Flashback arrestors: EN 730-1
- Hose assemblies: SANS 8207
- Health & Safety Code of Practice: SANS 10238.

The following guidelines, standards and products are available to assist you and your business:

- ISO approved regulators fitted with encapsulated valves, fit-for-purpose and conforms to ISO 2503 with optional gauge guard, if required
- EN approved regulator mounted flashback arrestors consisting of a temperature activated cut-off valve, flame arrestor, non-return valve and pressure activated cut-off valve on both oxygen and acetylene lines
- Correct length of hoses, fit-for-purpose and ISO approved
- Approved hose connections in accordance with SANS 8207 which include 'O' clips fitted with correct crimping tool
- Suitable hose holders or parallel hose clips fitted in such a way that hoses can be separated easily and do not have any sharp edges
- Flashback arrestors must be fitted to both the regulator and torch
- Approved torches compliant to ISO 5172
- Nozzles: Quality tested for leaks across the seats and quality of performance
- Quality nozzle cleaner to ensure good and consistent quality performing nozzle
- Before light-up, equipment must first be purged. Then leak tested with the correct leak detection solution such as Afrox Safetest (Item Number W012045) which is oil-free. No soapy solutions shall be used on gas equipment
- Only a spark lighter such as the Afrox triple flint lighter (Item Number W012621) shall be used to ignite the gas flowing from the nozzle. Under no circumstances must an open flame be used
- Under no circumstances shall PTFE tape be used on oxy-fuel equipment. Manufacturer uses special oil-free type tape on gauges and for example if spare parts are required for maintenance, equipment will be provided by manufacturer with correct tape attached
- Trolleys to transport oxygen/acetylene cylinders shall be in good working condition. Refrain from using home-made trolleys.
- Correct PPE to be worn at all times
- Wall-mounted posters on light-up and shutdown procedures and other posters and data sheets provided by manufacturer to be visible at all times at every station
- Risk assessments to be conducted on a regular basis. Level to be determined by management
- Flashback arrestors shall be tested or replaced bi-annually. Afrox flashback arrestors can be tested with a WITT test panel (Item Number W012212)
- Never use oil or grease on any gas equipment
- Operators should be trained on the safe use and handling of gas and gas equipment before working on gas equipment
- Training must include product training, correct fitment of equipment and correct safe operating practices (eg. correct light-up and shutdown procedure)
- Never repair gas equipment, although maintenance (eg. replacing a faulty gauge on a regulator) can be done by a qualified operator.

Industrial Regulators & Flowmeters

Afrox Series 8500 regulators are designed to give a constant, precise delivery of the required pressure of gas without the need for continuous readjustment. This is important in applications where an operator works at a distance from the regulator.



A	Working pressure gauges on the regulators are marked 'cut', 'weld' and 'heat' for easy setting
B	Bonnet design protects components from rain and moisture, resulting in longer life and greater durability
C	Captive knob design prevents over-pressurisation and jamming
D	Colour-coded control knob for fine pressure control and easy gas identification
E	Safety relief valves and flexible diaphragm design protects the regulator in the event of over-pressurisation
F	Dual-filtering system reduces contamination, protecting the high-pressure seat from damage
G	Dual-encapsulated valve design delivers exceptional pressure stability, superior accuracy and extended life
H	Forged zinc bonnet for maximum durability and extended life in corrosive environments
I	Blow-out back for added safety

Regulators

A range of both multi-stage and single-stage regulators are available to suit most applications.

Because of their inherent safety features, multi-stage regulators should always be used as the product of choice. Their flat outlet characteristic, irrespective of changes in cylinder pressure, make them the obvious choice.

All regulators are subject to a rise in outlet pressure as inlet pressure drops. This aspect can be minimised by good design in a single-stage but cannot be eliminated. Multi-stage regulators do not display this characteristic!

As the contents of the cylinder reduces, so the outlet pressure on a single-stage regulator rises.

An inexperienced operator will not know to compensate for this and will continue to operate. This rising pressure can cause one gas to feed back against the other in the system and a flashback could result.

When acetylene is mixed with air or oxygen – in concentrations of as little as 2% or as much as 82% – it will explode if ignited. This means there is a substantial risk of an explosion if backfeeding or mixing takes place.

Afrox's multi-stage regulator does not give rise to this situation due to its design.

Therefore, in the hands of less-skilled operators, multi-stage regulators are the preferred choice. This applies very specifically to the mines where low skill levels are used in very dangerous confines, e.g. underground.

Series 8500 Multi-Stage Regulators

Afrox's Series 8500 multi-stage regulator was designed by an international gas welding and cutting equipment team.

The latest technology and materials have been incorporated in the Afrox Series 8500 to maximise the advantages of the tried and tested multi-stage principle.

Two fully encapsulated pressure regulating valves further enhance the safety, quality and durability of the regulator.

As a result, the Afrox Series 8500 is the most reliable regulator on the market. It keeps safety at a premium, and losses in productivity to a minimum.

The Afrox Series 8500 multi-stage regulator is superior to single-stage regulators because:

- It delivers a constant outlet pressure without the need for adjustment
- It allows for much finer control of the outlet pressure
- It provides longer, trouble-free service
- The regulator operates under much lower stresses because the cylinder pressure is first reduced to an intermediate stage and then to the second stage
- Series 8500 regulators meet the ISO 2503 standard, with the high pressure models being suitable for 30 000 kPa (300 bar) inlet pressures in international applications and 23 000 kPa locally.

An Afrox Series 8500 multi-stage regulator remains the professional's choice.

Encapsulated Valves

Afrox has pioneered the development of a fully encapsulated regulator valve whereby the sensitive 'heart' of the device is protected by a sintered metal filter. The complete valve is built with the filter under clean-room conditions, thereby avoiding any chance of foreign particles blocking the valve mechanism.

Encapsulated valves are built into all Afrox regulators. All Afrox multi-stage regulators have a filter built into the first stage valve mechanism and also use the encapsulated valve design in the second stage. The advantages to the user of these innovations are greater reliability, greater safety and greater efficiency.

Hybrid Regulators

Afrox SMOOTHFLO™ Regulators

The SMOOTHFLO™ hybrid gas pressure regulator incorporating "Dynamic Quadflow Stability Control" (DQSC) represents the highest level of development in the global gas pressure regulator arena. Incorporating several world firsts, the SMOOTHFLO™ combines the best of all regulator characteristics worldwide, with innovative features that take the technology to a new level, making this regulator one of the easiest to use. Developed in-house and embodying the Linde spirit of taking the lead, the new SMOOTHFLO™ gas pressure regulator has an innovative and compact design that achieves impressive levels of performance and safety.

Features

- Break-off inlet stem
- Robust cladding
- Unique lever activation technology
- Embedded pressure gauges
- Piston-embedded safety valve
- Piston driven technology
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control

Range

SMOOTHFLO™ regulators are currently available for oxygen and acetylene.

Afrox SMOOTHFLO™ Multi-Stage Regulators

Model	Description	Gas Used	Delivery Pressure	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
Acetylene	Acetylene 150 kPa	Acetylene	0 - 150 kPa	5/8" BSP LH	3/8" BSP LH	2 500 kPa	W003137
Oxygen	Oxygen 1 000 kPa	Oxygen	0 - 1 000 kPa	5/8" BSP RH	3/8" BSP RH	20 000 kPa	W003139

Afrox Saffire® Multi-Stage Medium-Heavy Duty Regulators

Afrox Series 8500 multi-stage regulators are the product of choice for the professional, designed for optimum performance in welding, cutting and heating applications and for circumstances where exceptional safety is required. With its best-in-class flows and control, unique safety features and rugged heavy duty design, the Series 8500 is well suited for use in tough industrial and corrosive environments.

The series comprises a full range of products designed specifically for use in applications using oxygen, acetylene, nitrogen, air and inert gases.

Multi-stage high outlet pressure regulators are suited to heavy duty welding, cutting, gouging, superheating and light lancing applications.

Features

- It delivers constant outlet pressure control without the need of adjustment i.e. 'Set-and-Forget'
- Dual, third generation Quadflo encapsulated valves with sintered metal cup filters ensuring improved filtration and higher flow capacity
- It allows for much finer control of the outlet pressure
- It provides longer, trouble-free service
- The regulator operates under lower stresses because the cylinder pressure is first reduced to an intermediate stage and then to the second stage
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control
- Working pressure gauges are marked 'cut', 'weld' and 'heat' for easy setting
- Manufacturing date stamped on the regulator
- 'Rain protect' bonnet design protecting internal components from rain and moisture.

Afrox Saffire® Multi-Stage Medium-Heavy Duty Regulators							
Model	**Description**	**Gas Used**	**Delivery Pressure**	**Inlet Connection**	**Outlet Connection**	**Max Inlet Pressure**	**Item Number**
S8500 AGM 150 kPa	Multi-stage general purpose pressure regulator with gauges for welding, cutting and heating	Acetylene	0 - 150 kPa	5/8″ LH	3/8″ LH	2 500 kPa	W003851
S8500 OGM 400 kPa	Multi-stage medium duty regulator with gauges for welding and cutting	Oxygen	0 - 400 kPa	5/8″ RH	3/8″ RH	30 000 kPa	W003852
S8500 AVM 150 kPa	Multi-stage general purpose regulator for welding and cutting without gauges. Outlet pressure indicated by a visual indicator on the pressure regulating adjusting knob	Acetylene	0 - 150 kPa	5/8″ LH	3/8″ LH	2 500 kPa	W003853
S8500 OGM 1 000 kPa	Multi-stage pressure regulator with gauges for heavy duty cutting, gouging, superheating and light lancing applications	Oxygen	0 - 1 000 kPa	5/8″ RH	3/8″ RH	30 000 kPa	W003854
S8500 OVM 1 000 kPa	Multi-stage heavy duty pressure regulator without gauges. Outlet pressure indicated by a visual indicator on the pressure regulating adjusting knob	Oxygen	0 - 1 000 kPa	5/8″ RH	3/8″ RH	30 000 kPa	W003855
S8500 NGM 1 000 kPa	Multi-stage high outlet pressure nitrogen regulator, with calibrated cylinder contents and outlet pressure gauges	Nitrogen/ Argon	0 - 1 000 kPa	3/4″ RH	3/8″ RH	30 000kPa	W003856
S8500 HGM 1 000 kPa	Multi-stage high outlet pressure hydrogen regulator, with calibrated cylinder contents and outlet pressure gauges	Hydrogen	0 - 1 000 kPa	5/8″ LH	3/8″ LH	30 000 kPa	W003857

Please Note: For ultimate safety, always use Afrox approved flashback arrestors.

Afrox Saffire® Series 8000 Single-Stage Medium Duty Regulators

Every Afrox Series 8000 regulator incorporates proven global regulator technology – the unique Afrox encapsulated valve – providing superior performance and extended life. This, together with the heavy duty construction, provides longer trouble-free operation – backed by an exceptional five-year conditional warranty.

With flows comparable to many multi-stage regulators in the market, the broad flow and pressure ranges make this an ideal regulator for welding, cutting and heating applications.

The series comprises a range of versatile regulators designed specifically for use in applications using oxygen, acetylene or nitrogen.

The 400 kPa oxygen regulator is suited for general-purpose welding, heating and cutting up to 100 mm. This regulator provides an adequate pressure to run the whole range of welding nozzles and any of the AHT heating nozzles.

Features

- Every Afrox manufactured single-stage regulator meets the ISO 2503 standard and is tested at full service pressure for superior operator safety and control
- Third generation Quadflo encapsulated valve with sintered metal cup filter ensuring improved filtration and higher flow capacity. Suitable for gas welding, cutting and heating applications
- Working pressure gauges are marked ‘cut’, ‘weld’ and ‘heat’ for easy setting
- Manufacturing date stamped on the regulator
- ‘Rain protect’ bonnet design protecting internal components from rain and moisture.

Afrox Saffire® Series 8000 Single-Stage Medium Duty Regulators

Model	Description	Gas Type	Delivery Pressure	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
S8000 AGS 150	Single-stage general-purpose regulator for welding, cutting and heating	Acetylene	0 - 150 kPa	5/8″ LH	3/8″ LH	2 500 kPa	W003801
S8000 OGS 400	Single-stage medium outlet pressure regulator for medium duty welding and cutting	Oxygen	0 - 400 kPa	5/8″ RH	3/8″ RH	30 000 kPa	W003802

Afrox Saffire® Series 5000 PortaPak® Regulators

The Afrox Saffire® two-gauge single-stage PortaPak® regulators are designed to be used with the portable Afrox PortaPak® outfits in light duty, general-purpose non-continuous welding, cutting and heating applications up to 2-bar oxygen working pressure. They are compact, rugged and portable; ideal for mobile operations. Their flow characteristics and compact design make them ideally suited to jobs on the move where space is a constraint – including plumbing and contract engineering.

Features

- Suitable for light duty cutting and welding applications
- Used in PortaPak® outfits
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control
- PortaPak® Oxygen 200 regulator includes a safety regulator valve

Afrox Saffire® Series 5000 PortaPak® Regulators

Model	Description	Gas Type	Delivery Pressure	Outlet Connection	Max Inlet Pressure	Item Number
PortaPak® Oxygen 200	Single-stage regulator suitable for light duty welding and cutting applications	Oxygen	0 - 200 kPa	1/4″ RH	20 000 kPa	W003031
PortaPak® Acetylene 80	Single-stage regulator suitable for light duty welding and cutting applications	Acetylene	0 - 80 kPa	1/4″ LH	2 500 kPa	W003034

Series 6000 Single-Stage Single-Gauge Regulators

The Afrox Saffire® Series 6000 single-gauge LPG regulator is a compact, rugged regulator able to survive in tough working conditions whilst delivering efficient, dependable control of gas. The outlet pressure gauge allows for accurate setting of desired pressures. It incorporates a fully encapsulated Afrox valve for improved performance and precision-engineered components for greater safety.

Features

- Suitable for medium-to-heavy duty cutting and heating applications
- Flow rate is adequate for full range of LPG nozzles
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control.

Afrox Saffire® Series 6000 Single-Stage Single-Gauge Regulators

Model	Description	Gas Type	Delivery Pressure	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
S6000 LGS 400	Single-stage 400 kPa Handigas (LPG) regulator suitable for the full range of Afrox LPG nozzles	Handigas (LPG)	0 - 400 kPa	5/8″ LH	3/8″ LH	2 500 kPa	W010611

Series 6000 Single-Stage Single-Gauge Regulators

The Afrox Saffire® Series 6000 single-gauge regulators are compact, rugged regulators able to survive in tough working conditions whilst delivering efficient, dependable control of gas. The outlet pressure gauge allows for accurate setting of desired pressures. It incorporates a fully encapsulated Afrox valve for improved performance and precision-engineered components for greater safety.

Features

- Suitable for medium duty welding and cutting applications
- Flow rate is adequate for full range of nozzles
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control.

Afrox Saffire® Series 6000 Single-Stage Single-Gauge Regulators

Model	Description	Gas Type	Delivery Pressure	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
S6000 Oxygen	Single-stage 600 kPa Oxygen regulator suitable for the full range of Afrox nozzles	Oxygen	600 kPa	5/8″ LH	3/8″ LH	30 000 kPa	W003903
S6000 Acetylene	Single-stage 600 kPa Acetylene regulator suitable for the full range of Afrox nozzles	Acetylene	150 kPa	5/8″ LH	3/8″ LH	2 500 kPa	W003601

Please Note: For ultimate safety, always use genuine Afrox flashback arrestors.

Flowmeters

Afrox Saffire® Series 6000 Flow-Gauge Regulator

The Afrox Saffire® Series 6000 ArC 40L is a two-gauge single-stage flow-gauge regulator measuring flow of up to 40 litres per minute. It incorporates a fully encapsulated Afrox valve for exceptionally consistent flow characteristics, longer life and improved performance, and precision-engineered components for greater safety.

The ArC 40L is a static flowmeter, where outlet flow is indicated on a suitably calibrated pressure gauge.

Features

- Suitable for general MIG and TIG welding applications where flow indication is not absolutely critical
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control.

Afrox Saffire® Series 6000 Flow-Gauge Regulator

Model	Description	Gas Used	Max Gas Flow	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
S6000 ArC 40L	Combined single-stage regulator and flowmeter, with cylinder contents and flow gauges, for MIG/TIG welding using argon or carbon dioxide. Outlet gauge is calibrated in litres per minute	Argon, Carbon Dioxide	40 ℓ/min	5/8″ RH	3/8″ RH	30 000 kPa	W003610

Afrox Saffire® Integrated Regulator Flowmeter

This precision Afrox Saffire® Shieldmaster® pre-set regulator flowmeter is suitable for critical applications, such as shielding gas control for MIG and TIG welding, where an accurate gas flow needs to be set and maintained.

The integrated regulator flowmeter is a convenient regulator and dynamic flowmeter all in one. It is capable of delivering an adjustable flow from zero to 30 litres per minute.

Features

- MIG/TIG welding applications where an extremely accurate indication of flow is required
- Packaging/blanketing applications where an accurate low flow of gas is needed
- Process control in the technical, food and pharmaceutical industries.

Afrox Saffire® Integrated Regulator Flowmeter

Model	Description	Gas Used	Max Gas Flow	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
Shield-master®	Combined single-stage regulator and flowmeter, with cylinder contents and flow tube for MIG/TIG welding using argon or carbon dioxide. Outlet gauge is calibrated in litres per minute	Argon, Carbon Dioxide	0-30 ℓ/min	5/8″ RH	3/8″ RH	30 000 kPa	W003037

Saffire® 916 Multi-Stage Regulators

Features

- All Saffire® Legend 916 regulators certified to ISO 2503
- The Saffire® Legend 916 regulators are backed by a five-year warranty
- 100% tested at full service pressure for superior operator safety and control
- Unique Quadflo encapsulated valve technology
- 'Rain protect' bonnet protects the internal components from rain and moisture
- The Saffire® Legend 916 range offers multi-stage functionality, delivers constant pressure, even as the cylinder pressure reduces.

Afrox Saffire® Legend 916 Multi-Stage Heavy Duty Regulators

Model	Description	Gas Type	Delivery Pressure	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
Legend 916 OGM 1 000 kPa	Multi-stage, general purpose regulator with gauges	Oxygen	0 - 1 000 kPa	5/8" RH	9/16"	30 000 kPa	W232017
Legend 916 AGM 150 kPA	Multi-stage, general purpose regulator with gauges	Acetylene	0 - 150 kPa	5/8" LH	9/16"	2 500 kPa	W232018
Legend 916 OVM 1 000 kPa	Multi-stage, gaugeless visual indicator	Oxygen	0 - 1 000 kPa	5/8" RH	9/16"	30 000 kPa	W232013
Legend 916 AVM 150 kPa	Multi-stage, gaugeless visual indicator	Acetylene	0 - 150 kPa	5/8" LH	9/16"	2 500 kPa	W232015
Legend 916 OPM 350 kPa	Multi-stage preset gaugeless	Oxygen	350 kPa	5/8" RH	9/16"	30 000 kPa	W232303
Legend 916 APM 80 kPa	Multi-stage preset gaugeless	Acetylene	80 kPa	5/8" LH	9/16"	2 500 kPa	W232304

Regulator Spares, Fittings & Attachments

Afrox Saffire® Regulator Gauges

Acetylene Regulator Gauges

Description	Item Number
Contents Pressure 0 - 4 000 kPa	W003050
Outlet Pressure 0 - 220 kPa	W003054

- Suitable for S8500, S8000 & Legend 916 regulators
- Gauges conform to ISO 5171

PortaPak® Regulator Gauges

Description	Item Number
Pressure Gauges Kit (Contents & Outlet) Acetylene	W003048
Pressure Gauges Kit (Contents & Outlet) Oxygen	W003049

- Suitable for S5000 PortaPak® regulators
- Gauges conform to ISO 5171

Oxygen Gauges

Description	Item Number
Outlet Pressure 0 - 900 kPa	W003051
Contents Pressure 0 - 30 000 kPa	W003052
Outlet Pressure 0 - 1 600 kPa	W003053

- Suitable for S8500, S8000 & Legend 916 regulators
- Gauges conform to ISO 5171

Hydrogen Gauges

Description	Item Number
Contents Pressure 0 - 30 000 kPa	W003057
Outlet Pressure 0 - 1 600 kPa	W003058

- Suitable for S8500 hydrogen regulators
- Gauges conform to ISO 5171

Afrox Saffire® Regulator Fittings

Outlet Connections

Gas Type	Outlet Connection	Item Number
Acetylene	9/16" UNF LH	W003061
Oxygen	9/16" UNF RH	W003062

Inlet Stems & Nuts

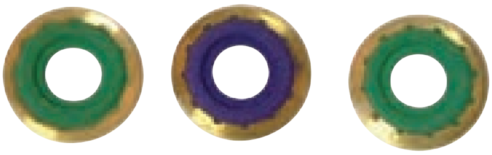
Description	Item Number
Shieldmaster®	W003075
Oxygen/Argon	W003080
Acetylene/LPG/Hydrogen	W003081
Nitrogen	W003082
Nitrogen (Old Style)	W003083
Oxygen (Old Style)	W003084
Acetylene/Hydrogen (Old Style)	W003085

Inlet Stems & Nuts - PortaPak®

Description	Item Number
Kit - Acetylene and Oxygen	W003092

PortaPak® Inlet Stem Seals

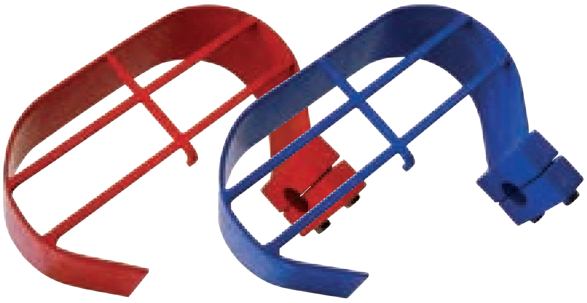
Description	Item Number
Acetylene - Purple x one Oxygen - Green x two	W003077



Afrox Regulator Attachments

Gauge Guard

Description	Item Number
Red - Acetylene - Saffire®	W003201
Blue - Oxygen - Saffire®	W003202
Red - Acetylene - Legend	W003206
Blue - Oxygen - Legend	W003205



- W003201 and W003202 suitable for S8000 and S8500 regulators
- W003206 and W003205 suitable for Saffire® Legend 916 regulators
- Protects gauges from accidental damage

Torches & Attachments

Cutting Assembly

Cutting Nozzles

Afrox Saffire® Torch

Afrox Saffire® 3 Seat Oxy-Acetylene A-NM6 Cutting Nozzle
W005014
W005015
W005016
W005017
W005018
W005020

Afrox Saffire® 3 Seat Oxy-LPG P-NM Cutting Nozzle
W010236
W010237
W010238
W010239
W010240
W010242

Afrox Saffire® Universal® Cutting Torch
W005803

Afrox Saffire® Flashback Arrestors

Afrox Saffire® Standard Flow Torch End Oxygen FBA
W012031

Afrox Saffire® Standard Flow Torch End Fuel FBA
W012030

Cutting Nozzles

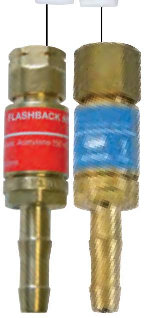
Afrox Saffire® Torch

Afrox Saffire® 3 Seat A-NM6 Acetylene Cutting Nozzle
W005014
W005015
W005016

Afrox Saffire® 3 Seat LPG P-NM Cutting Nozzle
W010236
W010237
W010238

Afrox Saffire® Type 2 Cutting Attachment
W005801

Afrox Saffire® Type 2 Shank
W005800



Afrox Saffire® Flashback Arrestors

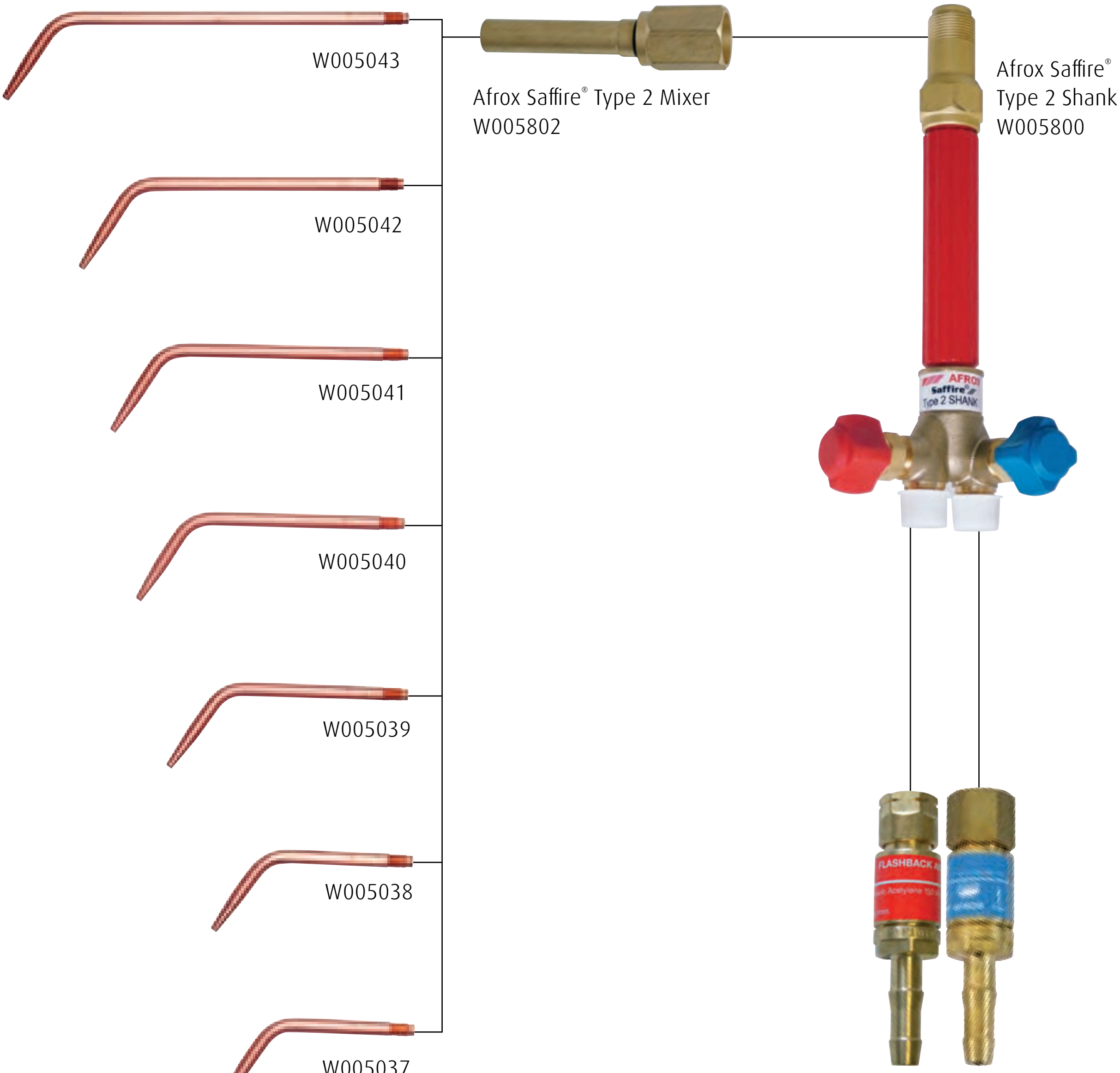
Afrox Saffire® Standard Flow Torch End Fuel FBA
W012030

Afrox Saffire® Standard Flow Torch End Oxygen FBA
W012031

Please Note: For best results, always use genuine Afrox nozzles and Afrox parts.

Afrox Type 2 Welding Assembly

Afrox Saffire® Welding Nozzles* **Afrox Saffire® Type 2 Mixer** **Afrox Saffire® Type 2 Shank**



Afrox Saffire® Flashback Arrestors

Afrox Saffire® Standard Flow Torch End Fuel FBA W012030	Afrox Saffire® Standard Flow Torch End Oxygen FBA W012031

For Your Safety...

- Afrox recommends the use of flashback arrestors on both ends (regulator and torch).

Please Note: For best results, always use genuine Afrox nozzles and Afrox parts.

Type 2 Heating & Superheating Assembly

Afrox Saffire® Type 2 Shank

Afrox Saffire® Type 2 Shank
W005800

Afrox Saffire® Type 2 Mixer
W005802

Afrox Saffire® Extension Tube
W005930

Afrox Saffire® Oxy-Acetylene Heating Tips

A-HT25
W005051

A-HT50
W005052

A-HT100
W005053

Type 2 High Capacity Mixer
W010402

Afrox Saffire® Short Extension Tube
W010403
or

Afrox Saffire® Medium Extension Tube
W010404
or

Afrox Saffire® Long Extension Tube
W010405

Afrox Saffire® Oxy-LPG Maxi Heating Tips

1H	2H	3H	4H	5H
W010406	W010407	W010408	W010409	W010410

Please Note: For best results, always use genuine Afrox nozzles and Afrox parts.

Afrox Saffire® Universal® Cutting Torch

A	Nozzle mixing helps contain backfires in the nozzle, protecting the torch from downtime and providing added operator safety
B	Large forged head provides unmatched durability and reduces warping for extended service
C	Three-tube construction keeps gases separate, allowing gas mixing only in the nozzle for added operator safety
D	Solid lever for added durability
E	Fully silver-brazed joints, thick-walled stainless steel tubes and solid brass forged head and tail result in robustness and lower maintenance costs
F	Drag adjustment for setting desired valve resistance
G	Easy-grip valves give you full control over your cutting flame
H	Heavy duty handle for positive grip, comfort and control

Heavy Duty Gas Cutting

Universal® Cutting Torch

Features

- The Afrox Universal® is a versatile, robust and well-balanced torch capable of cutting steel up to 300 mm thick.
- It is compliant with ISO 5172 and comes with a one year warranty.
- Afrox Saffire® Universal® cutting torches feature nozzle mixing technology for added safety and for protecting the torch and operator from accidental backfires.
- Can be used with either acetylene or LPG depending on type of nozzle fitted
- Preheated oxygen and fuel gas are mixed in the nozzle for greater safety and resistance to backfire
- Special nozzles for gouging are also available.

Afrox Saffire® Universal® Cutting Torch

Gas Type	Torch Length	Head	Cutting Capacity (Steel)	Inlet Connection	Item Number
Acetylene or LPG	500 mm	90º	Up to 300 mm	3/8″ BSP	W005803
Acetylene or LPG	1 000 mm	180º	Up to 300 mm	3/8″ BSP	W005837
Acetylene or LPG	1 500 mm	180º	Up to 300 mm	3/8″ BSP	W005838
Acetylene or LPG	2 000 mm	180º	Up to 300 mm	3/8″ BSP	W005839
Acetylene or LPG	1 000 mm	90º	Up to 300 mm	3/8″ BSP	W005840
Acetylene or LPG	1 500 mm	90º	Up to 300 mm	3/8″ BSP	W005841
Acetylene or LPG	2 000 mm	90º	Up to 300 mm	3/8″ BSP	W005842

Afrox Saffire® Legend 916 Heavy Duty Cutting Torch

Oxygen/Acetylene Cutting

The Saffire® Legend 916 is a heavy duty robust torch designed to perform in the harshest working conditions, but yet does so with the safety of the operator in mind. It is compliant with ISO 5172 and comes with a one year warranty.

The Saffire® Legend 916 has a brass underslung cutting oxygen lever for comfort, ease of operation and positive control, and is built for reliability and lasting control. This torch has a cutting capacity of up to 450 mm thick steel.

Features

- Tip mix principle - maximum operator safety
- Cutting capacity up to 450 mm thick steel
- Robust forged brass angle head for high strength, minimum distortion, positive tip seating and long service life
- Use with screw-in F tips
- Ease-on feature for cutting oxygen
- Needle torch control valves for fast, accurate flame adjustment
- Brass underslung cutting oxygen lever for comfort, ease of operation and positive control
- Stainless steel tubes for maximum strength and corrosion resistance
- All regulators conform to the ISO 2503 standard and are quality tested at full service pressure for superior operator safety and control.

Applications

- Cutting
- Ideally suited for mining, construction and quarry operations.

Important Note

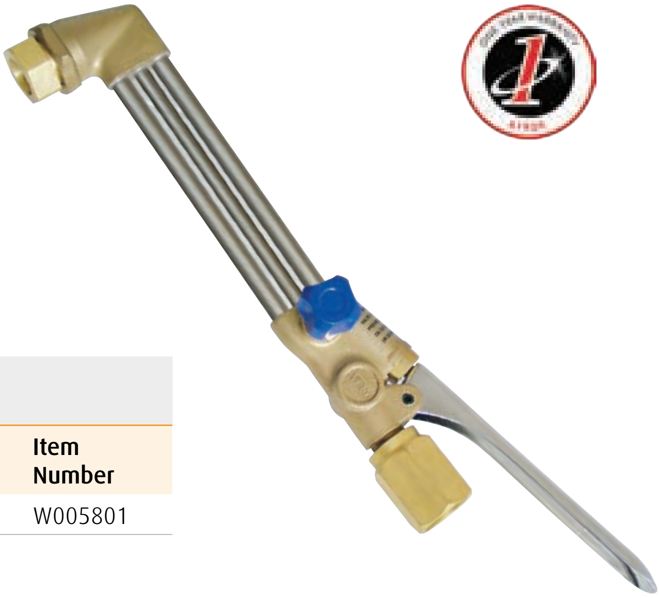
For complete safe and economical operation of equipment, remember to always use correct pressures and fit flashback arrestors to both the torch and regulator.

The material thickness determines the correct tip size and this governs the correct pressure to be used.

Saffire® Legend 916 Heavy Duty Cutting Torch

Description	Gas	Head	Length (mm)	Inlet Connection	Item Number
Saffire® Legend 916	Acetylene	90°	510	9/16" UNF RH	W231001

Medium Duty Gas Cutting, Welding & Heating



Type 2 Cutting Attachment

Features

- Forged brass head and stainless steel tubes
- Cuts steel up to 75 mm with acetylene and with LPG
- Nozzle mixing of gases ensures greater safety
- Complete range of acetylene and LPG nozzles available
- It is compliant with ISO 5172 and comes with a one year warranty.

Combination Cutting Attachments & Shanks
Afrox Saffire® Type 2 Cutting Attachment

Gas Type	Head	Cutting Capacity (Steel)	Inlet Connection	Item Number
Acetylene or LPG	90º	Up to 75 mm	3/8″ BSP	W005801

Afrox Saffire® Type 2 Shank

The Afrox Saffire® Type 2 is used in virtually every South African industry and has through the years been thoroughly tried and approved. The Afrox Saffire® Type 2 means real versatility in that its range of uses can be considerably extended by fitting various attachments for each process to the common shank.

Features

- Manufactured from extruded aluminium
- Hose connections 3/8″ BSP
- It is compliant with ISO 5172 and comes with a one year warranty.

Afrox Saffire® Type 2 Shank

Gas Type	Weight	Cutting Capacity (Steel)	Inlet Connection	Item Number
Acetylene or LPG	530 g	Up to 35 mm	3/8″ BSP	W005800

Light Duty Gas Cutting & Welding

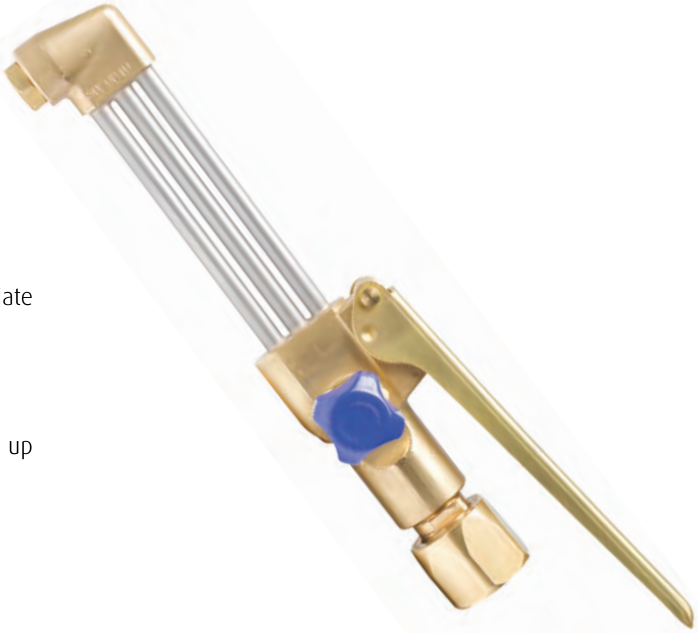
PortaPak® Combi-Lite Shank

Features

- The new Combi-Lite Shank is to be used in conjunction with either the Combi-Lite Mixer or the Combi-Lite Cutting Attachment
- When used in conjuction with the Combi-Lite Mixer and the DH nozzles, the Combi-Lite turns into a welding and brazing torch
- Capable of welding and brazing materials up to 8 mm in thickness
- Ideally suited for use in workshops, garages, laboratories and production lines
- Its handy size and weight minimises operator fatigue over many hours of use
- It is compliant with ISO 5172 and comes with a one year warranty.

PortaPak® Combi-Lite Shank

Gas Type	Cutting Capacity (Steel)	Inlet Connection	Item Number
Acetylene	Up to 35 mm	1/4”	W005716



PortaPak® Combi-Lite Cutting Attachment

Features

- The Combi-Lite Cutting Attachment is to be used in conjunction with the Combi-Lite Shank and can be used for cutting or welding by simply changing to the appropriate nozzle
- Use the LC nozzles for welding (capable of welding and brazing materials up to 4 mm)
- Use the AF-N nozzles for cutting (capable of cutting steel up to 35 mm)
- It is compliant with ISO 5172 and comes with a one year warranty.

PortaPak® Combi-Lite Cutting Attachment

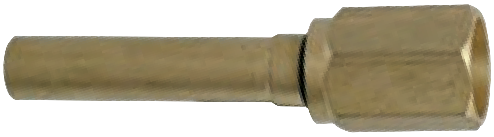
Gas Type	Item Number
Acetylene	W005719

PortaPak® Combi-Lite Mixer

- To be used with the Combi-Lite Shank and DH nozzles

Item Number	W005718

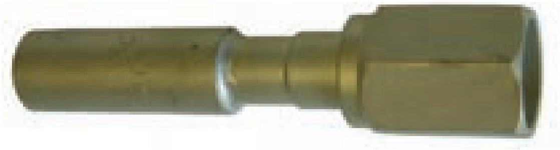
Mixers



Afrox Saffire® Type 2 Mixer

- Made of precision-machined brass and weighs only 150 g

Item Number	W005802



Type 2 High Capacity Mixer

- Used for LPG heating and superheating applications

Item Number	W010402

Extension Tubes

Afrox Saffire® Type 2 LPG Extension Tubes

Description	Item Number
LPG Short Extension Tube (300 mm)	W010403
LPG Medium Extension Tube (600 mm)	W010404
LPG Long Extension Tube (900 mm)	W010405

Afrox Saffire® Type 2 Acetylene Extension Tubes

Description	Item Number
Acetylene Extension Tube	W005930

Torch Spares & Accessories

Nozzle Nut - Combi-Lite Torch

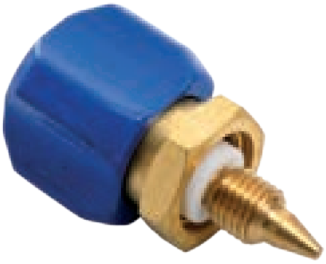
Item Number	W005715

Nozzle Nut – Type 2 and Universal® Cutting Torch

Item Number	W005850

'O' Ring Kit - Type 2 Shank

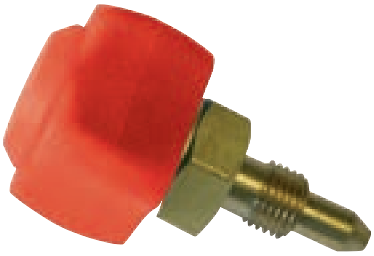
Item Number	W005820



Control Valve

- Oxygen - Type 2 cutting attachment

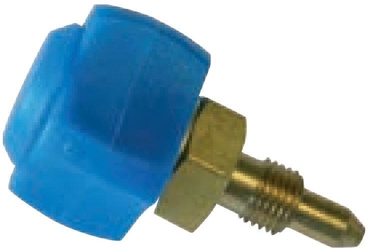
Item Number	W012075



Control Valve

- Acetylene - Universal®/Type 2 shank

Item Number	W012059



Control Valve

- Oxygen - Universal® / Type 2 shank

Item Number	W012058

Double Roller Guide

- Fits Universal® and Type 2 torches

Item Number	W005913

Circle Cutting Attachment

Item Number	W005910

Nozzles

The Afrox range of nozzles utilises the nozzle-mix principle whereby the fuel gas and preheat oxygen are kept separate right up to the nozzle and are only mixed once inside the preheat orifices.

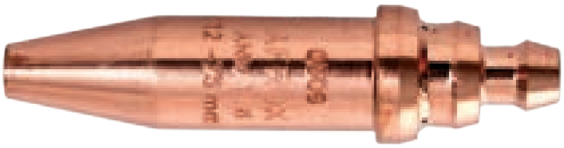
This system keeps the volume of mixed gas to an absolute minimum and therefore reduces the magnitude of a backfire. Injector-mix systems have far larger volumes of mixed gases in the torch and nozzle. Should a backfire occur, far more extensive damage to equipment, or operators, can result.

Nozzles are made of copper for good heat dissipation. Nozzle faces can be dressed back by using a fine file and orifices cleaned with appropriate cleaners. The flame shape and nozzle performance depend heavily on orifices having sharp, square edges – they should never be bell-mouthed by using pieces of wire to clean them out – use only approved nozzle cleaners.

Cutting Nozzles

Acetylene Hand Cutting – A-NM6

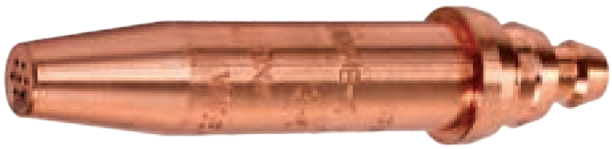
					Gas Consumptions			
Nozzle Size	**Material Thickness (mm)**	**Oxygen Pressure (kPa)**	**Acetylene Pressure (kPa)**	**Cutting Speed (mm/min)**	**Oxygen Cutting (kg/h)**	**Oxygen Heating (kg/h)**	**Acetylene Heating (kg/h)**	**Item Number**
0,8	3 - 6	150	15	500 - 850	1,13	0,41 0,69	0,31 0,52	W005014
1,2	6 - 12	200	15	440 - 700	2,45	0,49 0,82	0,37 0,62	W005015
1,6	12 - 25	250	15	300 - 610	5,37	0,56 1,06	0,44 0,76	W005016
1,6	25 - 50	300	20	230 - 400	6,23	0,60 1,06	0,49 0,76	W005016
1,6	50 - 75	350	30	180 - 300	7,03	0,76 1,06	0,49 0,76	W005016
2,0	75 - 100	300	30	180 - 250	9,55	0,76 1,17	0,56 0,87	W005017
2,4	100 - 150	300	30	150 - 180	13,92	1,17 1,62	0,87 1,20	W005018
3,2	150 - 250	450	35	100 - 125	29,84	1,65 2,06	1,23 1,54	W005020
3,2	250 - 300	550	35	90 - 125	34,48	1,88 2,42	1,39 2,00	W005020



Acetylene Machine Cutting – A-NME 6

							Gas Consumptions			
Nozzle Size	**Material Thickness (mm)**	**Cutting Speed (mm/ min)**	**Cutting Oxygen Pressure (kPa)**	**Heating Oxygen Pressure (kPa)**	**Acetylene Pressure (kPa)**	**Oxygen Cutting (kg/h)**	**Oxygen Heating (kg/h)**	**Acetylene Heating (kg/h)**	**Kerf Width (mm)**	**Item Number**
0,8	3 - 6	620	150	30	15	1,13	0,69	0,52	2,0	W005021
1,2	6 - 12	530	200	35	15	2,62	0,87	0,67	2,0	W005022
1,6	12 - 25	425	300	35	15	5,3	0,96	0,71	2,8	W005023
1,6	25 - 50	270	300	35	20	5,3	1,2	0,91	2,8	W005023
1,6	50 - 75	170	350	40	30	6,1	1,2	0,91	4,0	W005023
2,0	75 - 100	155	350	40	30	10,4	1,5	1,1	4,0	W005024
2,4	100 - 150	140	400	50	30	16,4	1,7	1,3	5,5	W005025
3,2	150 - 250	100	560	60	35	35,6	2,4	1,7	6,5	W005026
3,2	250 - 300	90	560	60	35	35,6	2,4	1,7	6,5	W005026

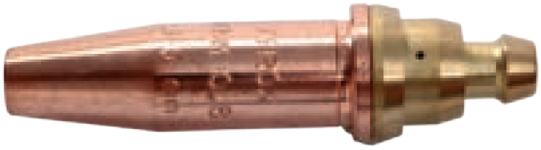
Long pattern nozzles must always be used in cutting machines.



LPG Cutting – P-NM

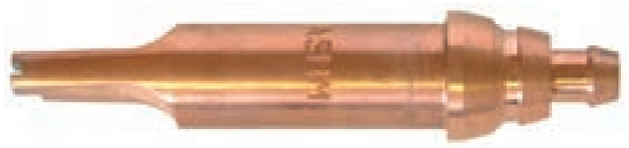
						Gas Consumptions			
Nozzle Size	**Material Thickness (mm)**	**Cutting Speed (mm/min)**	**Cutting Oxygen Pressure (kPa)**	**Heating Oxygen Pressure (kPa)**	**LPG Pressure (kPa)**	**Oxygen Cutting (kg/h)**	**Oxygen Heating (kg/h)**	**LPG Heating (kg/h)**	**Item Number**
0,8	3 - 6	460	150	30	20	1,13	1,8	0,67	W010236
1,2	6 - 12	400	200	35	20	2,62	2,0	0,91	W010237
1,6	12 - 25	300	300	35	20	5,3	2,0	0,91	W010238
1,6	25 - 50	220	300	40	30	5,3	2,3	0,91	W010238
1,6	50 - 75	160	350	50	35	6,1	2,5	1,0	W010238
2,0	75 - 100	155	350	70	40	10,4	3,1	1,3	W010239
2,4	100 - 150	140	400	70	40	16,4	3,5	1,4	W010240
3,2	150 - 250	100	560	100	50	35,6	4,5	1,8	W010242
3,2	250 - 300	90	560	100	60	35,6	4,5	1,8	W010242

Type 2 torch, maximum cutting thickness is 75 mm.



Acetylene Sheetmetal Cutting – A-SNM

				Gas Consumptions			
Material Thickness (mm)	Cutting Speed (mm/min)	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Oxygen Cutting (kg/h)	Oxygen Heating (kg/h)	Acetylene Heating (kg/h)	Item Number
Up to 3	460 - 560	150	15	1,12	0,11	0,09	W005057



Acetylene Cutting – A-FN (PortaPak®)

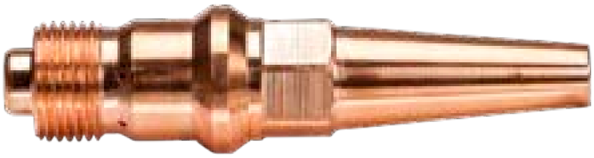
				Gas Consumptions			
Nozzle Size	Material Thickness (mm)	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Oxygen Cutting (kg/h)	Oxygen Heating (kg/h)	Acetylene Heating (kg/h)	Item Number
0,8	3 - 6	200	15	0,94	0,34	0,25	W005708
1,2	20	200	15	1,84	0,34	0,25	W005709
1,6	25	200	15	4,49	0,34	0,25	W005710
1,6	35	200	20	4,78	0,34	0,30	W005710
1,6	50	500	20	5,98	0,41	0,31	W005710

Acetylene Gouging – A-GNM

				Gas Consumptions			
Nozzle Size	Groove Width (mm)	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Oxygen Cutting (kg/h)	Oxygen Heating (kg/h)	Acetylene Heating (kg/h)	Item Number
13	8	400	50	4,9	1,3	0,9	W005061
19	11	500	50	12,4	2,4	1,8	W005062
25	13	550	55	21,6	3,0	2,2	W005063

Legend 916 2890-F Acetylene Cutting Tips

Description	Fits Torch	Plate Thickness (mm)	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Item Number
0F	Legend 916	3 - 6	70	14	W231050
1F	Legend 916	6 - 19	70 - 170	14	W231051
2F	Legend 916	19 - 40	170 - 275	14	W231052
3F	Legend 916	40 - 100	345 - 450	28	W231053
4F	Legend 916	100 -125	520 - 550	49	W231054
5F	Legend 916	125 - 150	585 - 620	70	W231055
6F	Legend 916	150 - 200	655 - 690	70	W231056
7F	Legend 916	200 - 300	760 - 895	70	W231057
8F	Legend 916	300 - 450	895 - 1 200	105	W231058



Welding Nozzles

It is important to select the correct size and type of nozzle to suit the nature of the job and the gas being used.

The use of a nozzle too large for the job may result in the welder turning down the flow of gases to try and set the small flame required. This creates a very unstable, soft flame which usually results in a backfire or flashback. Conversely, using a nozzle too small for the job results in turning up the gas flow and thus creating a very harsh flame. This is not dangerous but the flame tends to lift away from the tip of the nozzle and makes control of weld metal very difficult.

Afrox oxy-acetylene welding nozzles may also be used successfully with oxygen and Handigas for brazing and braze welding. It is usually necessary to use a larger nozzle than for oxy-acetylene due to the different ratio of oxygen to Handigas and the larger volumes involved.

Afrox oxy-acetylene welding nozzles may be used successfully with oxygen and hydrogen for special brazing and braze welding applications.

Afrox Saffire® Type 2 Welding Nozzles

					Gas Consumptions		
Nozzle Size	**Material Thickness (mm)**	**Nozzle Length (mm)**	**Oxygen Pressure (kPa)**	**Acetylene Pressure (kPa)**	**Oxygen (kg/h)**	**Acetylene (kg/h)**	**Item Number**
1	0,9	140	15	15	0,04 0,06	0,03 0,05	W005037
2	1,2	140	15	15	0,07 0,15	0,06 0,11	W005038
3	2,0	140	15	15	0,11 0,21	0,09 0,16	W005039
5	2,6	140	15	15	0,21 0,25	0,16 0,19	W005040
7	3,2	185	15	15	0,28 0,38	0,22 0,28	W005041
10	4,0	185	20	20	0,41 0,47	0,31 0,35	W005042
13	5,0	185	30	30	0,54 0,66	0,40 0,50	W005043
18	6,5	290	40	40	0,62 0,83	0,56 0,62	W005044
25	8,2	290	40	40	0,61 1,20	0,77 0,89	W005045
35	10	290	60	60	1,45 1,49	1,08 1,11	W005046
45	13	345	60	60	1,88 1,99	1,39 1,48	W005047
55	19	345	60	60	2,29 2,71	1,70 2,01	W005048
70	25	345	60	60	2,85 3,23	2,16 2,41	W005049
90	25+	345	60	60	3,72 4,20	2,78 3,15	W005050

Combi-Lite Welding Nozzles (PortaPak®)

					Gas Consumptions		
Nozzle Size	Material Thickness (mm)	Nozzle Length (mm)	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Oxygen (kg/h)	Acetylene (kg/h)	Item Number
1	0,9	140	15	15	0,04 0,06	0,03 0,05	W005090
2	1,2	140	15	15	0,07 0,15	0,06 0,11	W005091
3	2,0	140	15	15	0,11 0,21	0,09 0,16	W005092
5	2,6	140	15	15	0,21 0,25	0,16 0,19	W005093
7	3,2	140	15	15	0,28 0,38	0,22 0,28	W005094
10	4,0	140	20	20	0,41 0,47	0,31 0,35	W005095
13	5,0	140	30	30	0,54 0,66	0,40 0,50	W005096
18	6,5	210	30	30	0,62 0,83	0,56 0,62	W005097
25	8,2	210	50	50	0,61 1,20	0,77 0,89	W005098

Combi-Lite Torch Welding Nozzles (PortaPak®)

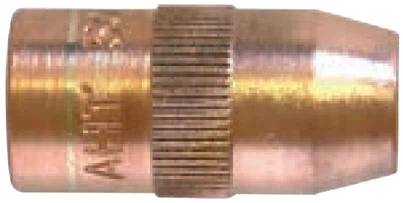
					Gas Consumptions		
Nozzle Size	Material Thickness (mm)	Nozzle Length (mm)	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Oxygen (kg/h)	Acetylene (kg/h)	Item Number
1	0,9	40	15	15	0,04 0,06	0,03 0,05	W005701
2	1,2	40	15	15	0,07 0,15	0,06 0,11	W005702
3	2,0	40	15	15	0,11 0,21	0,09 0,16	W005703
5	2,6	40	15	15	0,21 0,25	0,16 0,19	W005704
7	3,2	40	15	15	0,28 0,38	0,22 0,28	W005705
10	4,0	40	20	20	0,41 0,47	0,31 0,35	W005706

Heating Nozzles

Acetylene Spot Heating - A-HT

			Gas Consumptions				
Nozzle Type	Oxygen Pressure (kPa)	Acetylene Pressure (kPa)	Oxygen (kg/h)	Acetylene (kg/h)	Heat Output (kJ)	Use Mixer Item Number	Item Number
A-HT 25	30	30	1,46	1,20	55 000	W005802	W005051
A-HT 50	40	40	2,65	1,96	96 000	W005802	W005052
A-HT 100	70	50	3,98	3,27	146 000	W005802	W005053

Use with the Type 2 torch and bent neck tube 200 mm long
(Item Number W005930).



LPG Superheating

			Gas Consumptions						
Nozzle Type	Oxygen Pressure Lo - Hi	LPG Pressure Lo - Hi	Oxygen Lo (kg/h)	Oxygen Hi (kg/h)	LPG Lo (kg/h)	LPG Hi (kg/h)	Heat Output (kJ)	Use Mixer Item Number	Item Number
1H	70 - 200	15 - 50	4,64	9,68	1,64	3,74	76 000 172 000	W010402	W010406
2H	110 - 250	20 - 57	6,37	11,54	2,36	4,14	108 000 198 000	W010402	W010407
3H	180 - 500	30 - 110	11,01	21,88	4,14	8,08	193 000 380 000	W010402	W010408
4H	250 - 570	35 - 130	14,06	24,66	5,32	9,06	249 000 428 000	W010402	W010409
5H	350 - 870	85 - 200	16,84	37,13	6,31	13,79	265 000 652 000	W010402	W010410

Use with Type 2 torch, high capacity mixer and extension tube.

Please Note

- Heat output figures vary considerably with flame setting and regulator pressures
- Two typical readings are therefore given for each nozzle size at low and high pressures.

Flashback Arrestors & Quick Release Couplings

Flashback Arrestors

Core to the Afrox gas equipment safety offering is the Afrox flashback arrestor range. Afrox flashback arrestors are precision-manufactured, assembled and individually tested to the most stringent world-wide manufacturing standards. The superior quality of Afrox flashback arrestors makes them one of our most widely used products.

A flashback/detonation is a flame travelling at supersonic speed in the opposite direction to normal gas flow in oxy-fuel gas equipment. The backfeeding of gases that promotes flashbacks is generally caused by one of the following:

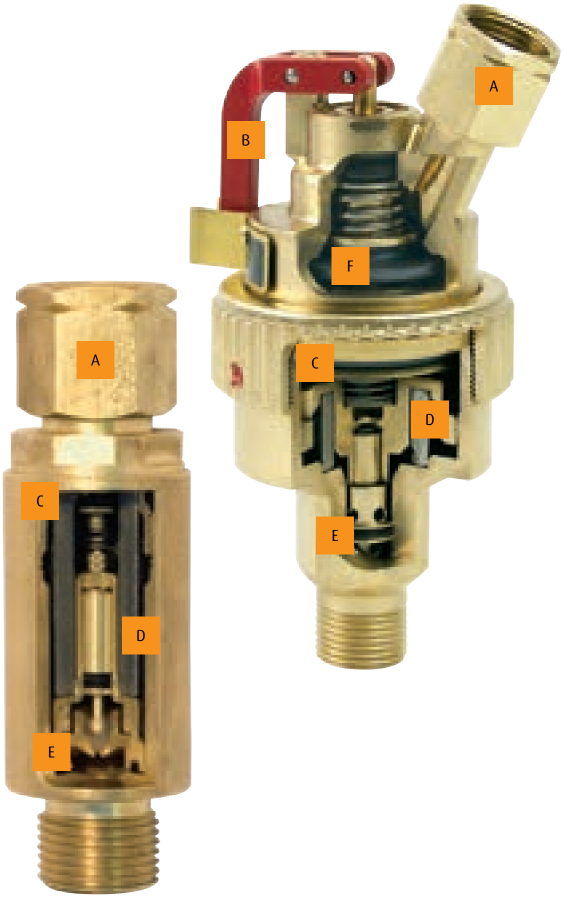
- Excessive pressure. If the flow rate exceeds the nozzle capacity, the gas at the higher pressure then flows into the lower-pressure gas line. This will occur if incorrect pressures are used or if nozzles, cutting attachments and welding torches are incompatible
- Lighting up incorrectly with both torch control valves open but one cylinder closed. In spite of better equipment, flashbacks remain a problem in oxy-fuel gas systems. There are many reasons for this, including the growing use of welding and cutting equipment by unskilled or semi-skilled persons who sometimes short-cut safety procedures in order to save time
- A drop in pressure of either gas due to leaks in the regulator, hose or connections. This could result in backfeeding into the low pressure line
- The reverse flow of gases during temporary storage or shutdown, incorrect closedown procedures or malfunctioning valves or regulators.

Features

A	Inlet filter – a large stainless steel surface made from wire mesh to prevent foreign matter entering the unit
B	Signal lever (resettable), drop-down shroud (premier)
C	Non-return valve (NV) – a spring loaded valve preventing backfeed of gas upstream of the flashback arrestor
D	Flame arrestor (FA) – a large sintered stainless steel element for repeatedly arresting flames
E	Temperature-activated cut-off valve (TV), a valve that cuts off gas supply in the event of sustained, multiple flashbacks or a flame being held in the device. Once activated, this cannot be reset and the unit must be replaced (regulator mounted flashback arrestors only)

The Afrox resettable and premier flashback arrestors also feature

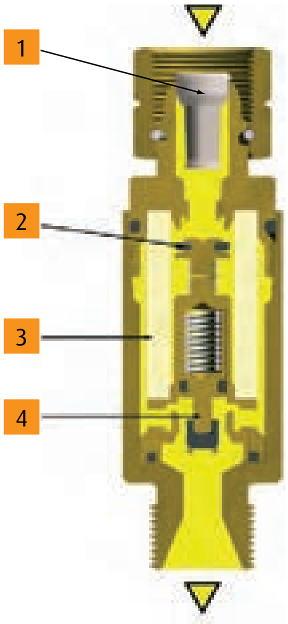
F	A pressure-sensitive cut-off device (PV) – this valve isolates the gas supply if a backfeed of gas is detected. When this valve is activated, the signal lever B is raised or the shroud drops to alert the user to a potentially dangerous situation. Once the cause of the backfeed has been corrected, the flashback arrestor can be reset, and the user can continue in safety



Maximum Working Pressures	
Acetylene	150 kPa
LPG	500 kPa
Hydrogen	500 kPa
Air/Oxygen	2 000 kPa

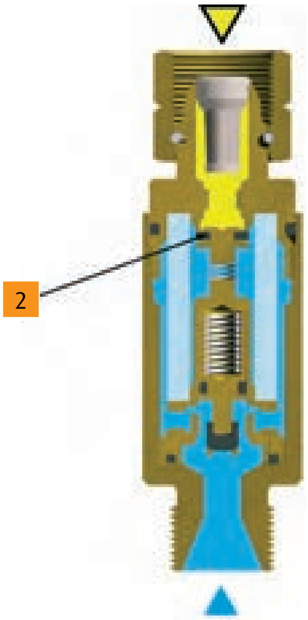
How does a FBA work?

Normal flow conditions



1	Inlet filter
2	Non-return valve
3	Flame arrestor
4	Temperature sensitive cut-off valve

Reverse flow occurring

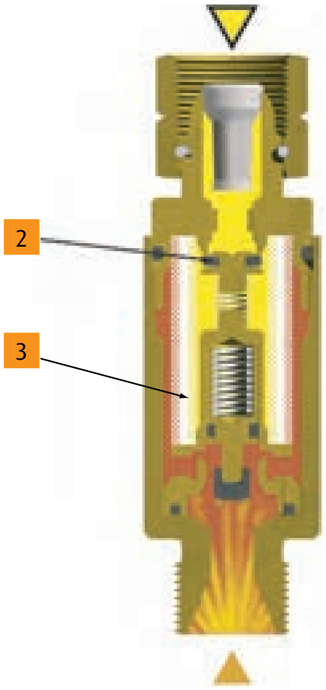


2	Non-return valve closed

Non-return valve

Prevents the mixing of gases upstream of the FBA, thereby helping to prevent conditions conducive to a flashback occurring.

Flashback occurring

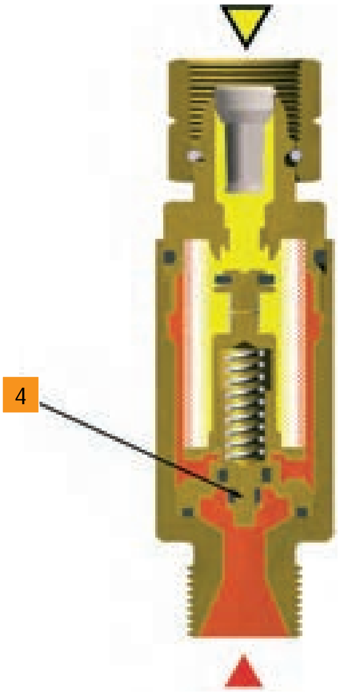


2	Non-return valve closed
3	Flame arrestor

Flame arrestor

The flame arrestor (sintered element) is one of the key components of the FBA. It has very high thermal conductivity that quickly removes the heat from the flame – extinguishing it.

Sustained backfire occurring



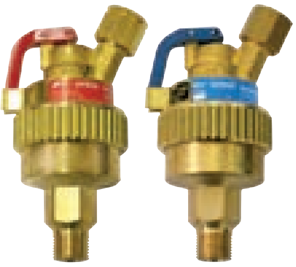
4	Temperature sensitive cut-off valve

Thermal cut-off

As a final fail-safe in the event of repetitive flashbacks or sustained backfire, the thermal cut-off is activated and permanently cuts off the flow of gas.

Cartridge & Automatic Arrestors

Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox Super 90	Fuel Gas	3/8" BSP	3/8" BSP	Afrox Regulator Mount	W012020
Afrox Super 90	Oxygen	3/8" BSP	3/8" BSP		W012021



Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox F5	Fuel Gas	3/8" BSP	3/8" BSP	Afrox Regulator Mount	W012028
Afrox F5	Oxygen	3/8" BSP	3/8" BSP		W012029

Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox PortaPak®	Fuel Gas	1/4" BSP	1/4" BSP	PortaPak® Regulator Mount	W012017
	Oxygen	1/4" BSP	1/4" BSP		W012016

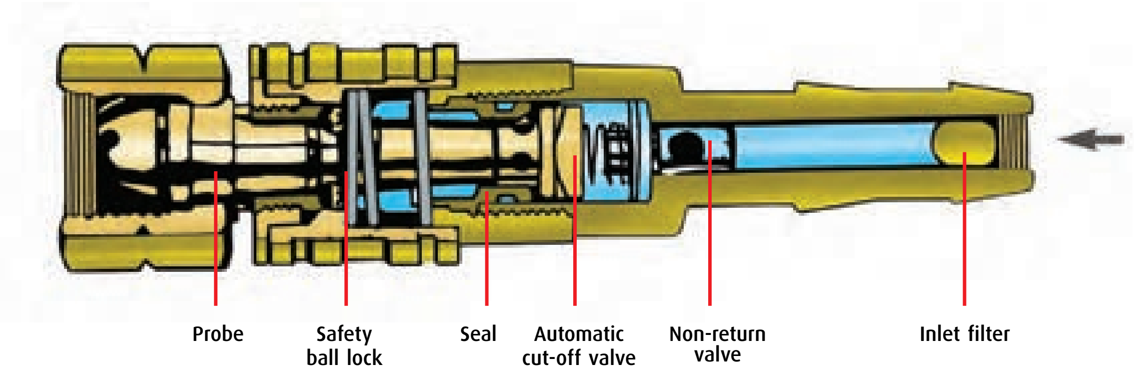
Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox 85-10	Fuel Gas	3/8" BSP	3/8" BSP	Afrox Regulator Mount (Extra high flow)	W012011
Afrox 85-10	Oxygen	3/8" BSP	3/8" BSP		W012012

Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox F7	Fuel Gas	8 mm Hose	3/8" BSP	Afrox Universal® and Type 2 Torch Mount	W012030
Afrox F7	Oxygen	8 mm Hose	3/8" BSP		W012031

Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox F8	Fuel Gas	5 mm Hose	1/4″ BSP	Afrox PortaPak®	W012032
Afrox F8	Oxygen	5 mm Hose	1/4″ BSP	Torch Mount	W012033

Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Afrox F9	Fuel Gas	3/8″ BSP	3/8″ BSP	Afrox Cutting Machine Torch Mount	W012007
Afrox F9	Oxygen	3/8″ BSP	3/8″ BSP		W012008

Quick Release Couplings



Quick release couplings make the connecting and disconnecting of hoses and regulators easy and quick. Safety is improved by incorporating non-return valves to prevent gases backfeeding and causing flashbacks.

Instant connection and disconnection of equipment provides added security and also saves time and money by avoiding lengthy changeover times.

Allows easy extension of hoses in a totally safe manner.

Non-interchangeable probes – absolutely impossible to mix hoses or gases.

Instant shut-off of gas when disconnected, even at maximum working pressures.

Non-return valves prevent any backfeeding of gases – providing greater safety.

Includes flashback arrestors for torch or regulator mount if required.

Conforms to DIN 8544 and ISO 7289 and carries approvals.

Maximum Working Pressures	
Acetylene	150 kPa
LPG	500 kPa
Hydrogen	500 kPa
Air/Oxygen	2 000 kPa

Complete Kits for 8 mm Hose

Model	Description	Gas	Inlet Connection	Outlet Connection	Item Number
RF 53 NSK	From regulator to 8 mm hose with flashback arrestor. These probes are approved to the new ISO 7289 standard and are not interchangeable with current items	Oxygen	3/8″ RH	8 mm Hose Nipple	W012120
		Acetylene/LPG	3/8″ LH	8 mm Hose Nipple	W012121
CPN 460	8 mm hose to torch with 3/8″ connections with flashback arrestor	Oxygen	3/8″ RH	8 mm Hose Nipple	W012088
		Acetylene/LPG	3/8″ LH	8 mm Hose Nipple	W012089

Test Equipment

WITT Test Panel

For bi-annual testing of flashback arrestors.

Item Number W012212

The following tests can be carried out:

1. Leak tightness to atmosphere.
2. Test of non-return valve against low and high back pressure.
3. Operating pressure of pressure-sensitive gas cut-off valve.
4. Leak tightness of pressure-sensitive gas cut-off valve.
5. Measurement of flow capacity.

Please Note: Not available for resale. Can only be purchased by end users who are required to undergo extensive training and assessment by qualified Afrox gas equipment specialists. Inexperienced operators, if untrained, are vulnerable to safety risks. Also available for Afrox Legend 916 compatible Flashback Arrestors.

Gas Hoses & Fittings

When did you last check your hose assembly?

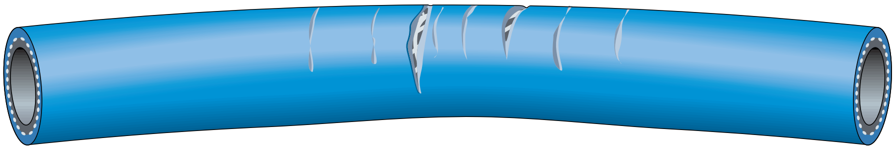
Afrox Gas Hose Care and Maintenance

Hose has a limited life and the user must be alert to signs of impending failure, particularly when the conditions of service include high working pressures and/or the conveyance of hazardous materials.

Examples of dangerous and high risk hoses

Perished cover

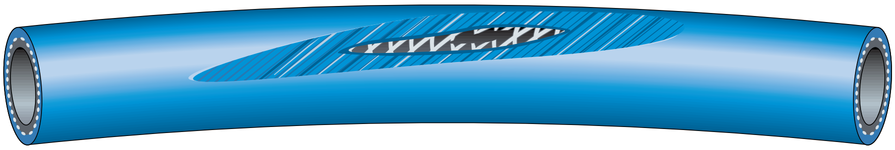
The hose has perished due to prolonged exposure to UV, which accelerates the ageing process. This will result in the cover becoming brittle and cracking – therefore no longer protecting the reinforcement.



Perished cover

Cover wear

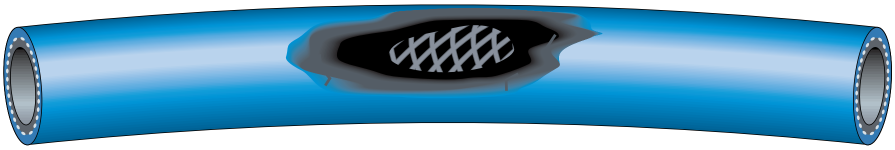
The cover is worn, exposing the reinforcement.



Cover wear

Scorched cover

Excessive heat will prematurely age the cover. This will result in the cover becoming brittle and cracking – therefore no longer protecting the reinforcement.



Scorched cover

Hoses & Fittings

The Afrox gas hose is high quality with a flame retardant outer and carries ISO approval for use with oxygen, acetylene and LPG.

The hose is colour-coded red for acetylene, blue for oxygen and orange for LPG.

Afrox LPG neoprene hose exceeds the requirements of SANS 1156-2 and carries ISO 3821 certification.

All Afrox gas hoses carry ISO 3821 certification.

Picture shown with optional hose connections

Pre-Packed Hose (SANS Approved) - 5 mm

Description	Item Number
3 m Acetylene	W002600
3 m Oxygen	W002601
6 m Acetylene	W002602
6 m Oxygen	W002603
6 m Inert	W237100
100 m Inert	W237101

Pre-Packed Hose (SANS Approved) - 8 mm

Description	Item Number
6 m Acetylene	W002560
6 m Oxygen	W002561
12 m Acetylene	W002562
12 m Oxygen	W002563
18 m Acetylene	W002564
18 m Oxygen	W002565
30 m Acetylene	W002568
30 m Oxygen	W002569
50 m Acetylene	W002572
50 m Oxygen	W002573
100 m Acetylene	W002576
100 m Oxygen	W002577

Cut to Length Hose (SANS Approved)

Description	Item Number
5 mm Handigas (LPG Neoprene)	W002439
8 mm Handigas (LPG Neoprene)	W002440
Flexible Hose Outlet LH	W237158
Flexible Hose Outlet RH	W237159

Hose Connection Kits

Description	Item Number
5 mm Hose Kit, 1/4″ BSP R/H	W002270
5 mm Hose Kit, 1/4″ BSP L/H	W002271
8 mm Hose Kit, 3/8″ BSP R/H	W002274
8 mm Hose Kit, 3/8″ BSP L/H	W002275
Comprise two nipples, two nuts and three 'O' clips	

Parallel Hose Clips

Description	Item Number
5 mm Parallel Clip (Pack of 10)	W002530
8 mm Parallel Clip (Pack of 10)	W002531

'O' Clips

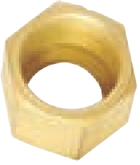
Description	Item Number
5 mm 'O' Clip (Pack of 10)	W002543
8 mm 'O' Clip (Pack of 10)	W002544

Hose Connection Nipples

Description	Item Number
5 mm Hose Nipple, Fits 1/4″ Nut	W002518
5 mm Hose Nipple, Fits 3/8″ Nut	W002175
8 mm Hose Nipple, Fits 3/8″ Nut	W002170

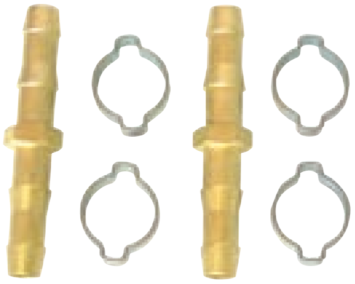
Hose Connection Nuts

Description	Item Number
1/4″ BSP Nut L/H	W002516
1/4″ BSP Nut R/H	W002517
3/8″ BSP Nut L/H	W002166
3/8″ BSP Nut R/H	W002167



Fittings for Hose Joining

Description	Item Number
5 mm Equal Hose Joiner (2 of incl. 4 'O' clips)	W002171
8 mm Equal Hose Joiner (2 of incl. 4 'O' clips)	W002172



Equal Hose Coupler

Description	Item Number
3/8″ BSP Equal Hose Coupler L/H (2 of)	W002176
3/8″ BSP Equal Hose Coupler R/H (2 of)	W002177

Gas Equipment Accessories

Afrox Saffire® Safetest Leak Detection Solution	
Description	**Item Number**
For Leak Testing of Gas Equipment & Gas Pipelines	W012045

Afrox Saffire® Standard Nozzle Cleaners	
Description	**Item Number**
For One Piece Nozzles	W012172

Industrial Cylinder Trolley

Item Number	W012035

‘O’ Clip Crimping Tool

Item Number	W012580

Afrox Saffire® Boilermaker’s Chalk

Item Number	W012176

Multi-Purpose Spanner

Multi-Purpose Spanner

Description	Item Number
Saffire® range	W012590
Legend range	W237304

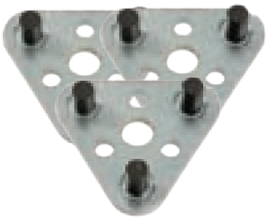
Triple Flint Spark Lighter

- Includes spare replacement flint

Item Number	W012621

Regulator Spanner - 27 mm

Item Number	W012585



Triple Flint Replacement Flint - 3 Sets

Item Number	W012622

PortaPak®

The Afrox PortaPak® is the ideal welding and cutting set for those difficult-to-get-to jobs. Light and robust, with man-sized capabilities, it is easily moved by one person, and can be lifted through hatches or into service vehicles. Because of its small size and portability, the set is ideal for emergency vehicles or on maintenance duty in industry where portability is a must.

Welding and Cutting Capabilities

The PortaPak® can be used for fusion weld, braze weld, silver solder, heating and cutting. Nozzles provided will fusion weld steel up to 4 mm and cut steel up to 50 mm thick. The cutting capability can be extended to 20 mm by using the AFN 1,2 mm or to ± 35 mm using the AFN 1,6 mm nozzle available as an optional extra.

Continuous Operating Times

Brazing and welding with No. 5 nozzle – six hours. Cutting with 0,8 mm nozzle – 45 minutes. These times are for non-stop operation. The average job requires a fair amount of preparation and welding and cutting is normally intermittent, which in practice extends these times considerably.

Features

Regulators

Single-stage regulators that give exceptional performance and reliability. Both are equipped with gauges indicating cylinder and outlet pressures. Gauges are colour-coded for easy and safe setting of welding and cutting pressures. When replacing regulator stem sealing washers, use only the correct Afrox replacement parts (see ordering information).

Accessory Box

Convenient robust metal box with provision to hold the full range of nozzles, flint lighter, goggles, and spanner.

Cylinders

Capacities: oxygen 1,43 kg, acetylene 0,9 kg.

There are no rentals or deposits on the cylinders but a charge will be made for subsequent refills.

Cylinders may only be filled by Afrox.

Filler Rod Holder

Easily removable holder allows access to short lengths of filler rods.

Trolley

Designed as a robust lightweight unit, it gives maximum mobility and incorporates a positive cylinder-securing device ensuring safe handling of the set. A lifting eye is provided at the centre of gravity to enable safe hoisting of the unit.

Torch

The Afrox Combi-Lite Torch converts from welding to cutting by simply changing the nozzle.

Flashback Arrestors

For ultimate safety, regulator and torch mounted flashback arrestors are incorporated as standard equipment, thereby eliminating any possibility of ignition of mixed gases in the hoses.

Hose

Completely assembled industrial grade 5 mm SANS approved hoses, supplied in 3 m lengths and fitted with safety flashback arrestors that protect against mishaps. The hose is flame retardant, durable and resistant to abrasion.

Ordering Information

The Outfit Comprises

Description	Item Number
Oxygen Cylinder	W005740
Acetylene Cylinder	W005782
Complete Accessory Kit	W005772

The Accessory Kit Comprises

Description	Item Number
Oxygen Regulator	W003031
Acetylene Regulator	W003034
PortaPak® Combi-Lite Shank	W005716
PortaPak® Combi-Lite Cutting Attachment	W005719
3 m Lengths of Fitted Hose Acetylene (DA) *	W002600
3 m Lengths of Fitted Hose Oxygen (O_2) *	W002601
Parallel Hose Clips	W002530
Goggles	W012257
Multi-purpose Spanner	W012590
Triple Flint Lighter	W012621
Data Card	N/R
Replacement Inlet Stem Seals (Two x 0_2, one x DA)	W003077
Nozzle Cleaners	W012172
Reg. Mount Flashback Arrestor Acetylene	W012017
Reg. Mount Flashback Arrestor Oxygen	W012016
Torch Mount Flashback Arrestor Acetylene	W012032
Torch Mount Flashback Arrestor Oxygen	W012033
No. 1 LC Nozzle	W005701
No. 3 LC Nozzle	W005703
No. 7 LC Nozzle	W005705
AFN 1,2 Cutting Nozzle	W005709
AFN 1,6 Cutting Nozzle	W005710
No. 3 Welding Nozzle	W005092
No. 5 Welding Nozzle	W005093
No. 7 Welding Nozzle	W005094

* Fittings sold separately

View the **PortaPak®** video on YouTube™

Gas Welding & Cutting Outfits

Afrox Saffire® Type 2 Economy Outfit

The Afrox Saffire® Type 2 Economy Outfit is designed to get you started on general oxy-acetylene welding and cutting, with the flexibility to add accessories specific to your personal and job requirements – creating your own specially customised kit. The economy outfit is presented in a useful toolbox.

The Series 6000 regulators in the outfit feature unique Afrox encapsulated valves, which provide extremely stable control of gases. The versatile and robust Afrox Saffire® Type 2 shank and cutting attachment are constructed from solid brass forgings and have silver-brazed joints for extra strength.

Description	Item Number
A flexible outfit that is ideal for oxy-acetylene welding and cutting, but can be customised to suit your needs	W005860

A	Toolbox
B	Medium-duty welding nozzle - No. 7
C	Cutting nozzle ANM - 0,8 mm
D	Acetylene regulator Series 6000 - 150 kPa
E	Oxygen regulator Series 6000 - 400 kPa
F	F5 regulator mounted flashback arrestors
G	F7 torch mounted flashback arrestors
H	Type 2 cutting attachment
I	Type 2 shank
J	Multi-purpose spanner
K	Nozzle cleaners
L	Triple flint lighter
M	Type 2 mixer
N	Fitted hose (oxygen)
O	Fitted hose (acetylene)
P	Goggles

Also included but not shown:

- Operation and instruction manual

Please Note: For ultimate safety, always use genuine Afrox Saffire® flashback arrestors and parts. Replacement parts are available for all outfits.

Afrox Saffire® Type 2 Professional Outfit

The Afrox Saffire® Type 2 Professional Outfit is a top-of-the-range premium outfit – the supreme kit for professionals and all welding, brazing, heating and cutting operations, presented in a reusable toolbox. The outfit is capable of cutting up to 75 mm and welds up to 5 mm.

The Series 8500 regulators in the outfit feature unique Afrox encapsulated valves, which provide extremely stable control of gases. The versatile and robust Afrox Saffire® Type 2 shank and cutting attachment are constructed from solid brass forgings and have silver-brazed joints for extra strength.

Description	Item Number
A premium outfit for welding, brazing, heating and cutting application	W005861

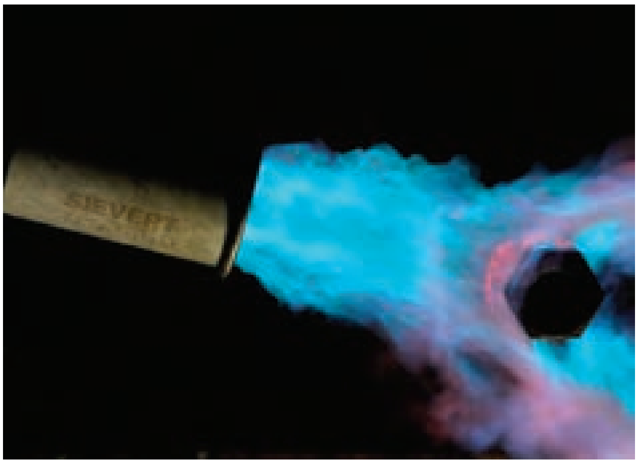
A	Toolbox
B	Heating neck tube
C	Acetylene heating nozzle
D	Medium-duty welding nozzles - No. 2, 3, 5, 7, 13
E	Cutting nozzles ANM - 0,8, 1,2, 1,6
F	S8500 AGM 150 kPa multi-stage regulator
G	S8500 OGM 400 kPa multi-stage regulator
H	F5 regulator mounted flashback arrestors
I	F7 torch mounted flashback arrestors
J	Type 2 cutting attachment
K	Type 2 shank
L	Multi-purpose spanner
M	Nozzle cleaners
N	Triple flint lighter
O	Type 2 mixer
P	Fitted hose (oxygen)
Q	Fitted hose (acetylene)
R	Goggles
S	Circle cutting guide

Also included but not shown:

- Operation and instruction manual

Please Note: For ultimate safety, always use genuine Afrox Saffire® flashback arrestors and parts. Replacement parts are available for all outfits.

Sievert® Equipment



Established in 1882, Sievert® AB is a Swedish world-leading manufacturer of LPG and electric-powered heating tools for professionals.

Product development takes place in close collaboration with customers and cooperative partners. Sievert® heating tools and equipment are used by professionals in mining, construction, oil and gas, automotive, plumbing, energy and telecom industries.

Whether you should preheat large structural steel parts, apply heat shrinking sleeves on telecom connections, heat up mechanical rusted parts to unlock them, or braze HVAC copper pipes, Sievert® offers a complete range of heating tools for maintenance and repairing operations.

Sievert® Promatic range

Promatic is the most advanced and safest system in the Sievert® range. The patented piezoelectric ignition, universal handle, advanced design and ergonomic appearance make Promatic a superior system for all possible heating tasks where efficiency and professional workmanship are the most important requirements.

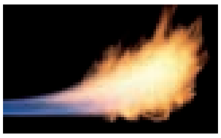
Promatic operates with propane and butane gases.

Promatic Handle

- Plastic composite handle reinforced with 30% glass fibres for maximum durability
- Double moulded soft grip for highest comfort and usability
- Piezo igniton with instant trigger on/off function
- Bayonet fitting for burners: no gas emission until burner is fitted for maximum safety
- Swivelling hose connection to avoid hose drag
- Combined suspension hook and footstand
- Valve for precise flame setting.

Sievert® Model No.	Working Pressure	Length	Height	Weight	Item Number
336611	1,5-4 bar	180 mm	80 mm	290 g	W010020

Hose connections BSP 3/8”LH

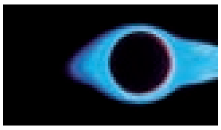


Promatic Soft Flame Burner

Ideal for cable work and other heat shrinking applications.

Sievert® Model No.	Burner Diameter	Gas Consumption	Heat Effect	Item Number
334191	38 mm	900 g/h at 2 bar	11,5 kw	W010028

For thick walled sleeves max, 150 mm. Also for thin walled sleeves.



Promatic Cyclone Burner

Ideal for brazing and soft soldering thanks to the rotating flame that provide an all-around heat transfer to the pipe.

Sievert® Model No.	Burner Diameter	Gas Consumption	Soft Soldering	Heat Effect	Item Number
333501	19 mm	250 g/h at 2 bar	± 400°C	3,2 kw	W010022

Soft soldering about 400°C max. pipe diameter – 32 mm.
Brazing up to 720°C max. pipe diameter – 18 mm.

Sievert® PRO 86-88 Range

Sievert® PRO range is based on two universal handles that can be equipped with different necktubes and burners all compatible, to create the perfect torch system according to specific customer needs.

Sievert® Pro 86 Handle

- Single-valved handle mainly for smaller burners
- The spindle and valve are designed to give a very exact and quick flame setting
- The spring loaded metal knob gives a precise and stable setting for the finest of flames
- All metal parts made of high quality brass
- Ergonomically designed plastic composite handle
- Double moulded soft grip for highest comfort and usability.

Sievert® Model No.	Working Pressure	Length	Height	Weight	Item Number
348641	1,5-8 bar	180 mm	70 mm	245 g	W010108

Sievert® Pro 88 Handle

- Double-valved handle mainly for larger burners
- Incorporates one main valve and one economiser valve enabling a gas saving pilot flame
- Trigger for instant shifting between pilot and main flame and for pulsing the main flame
- All metal parts made of high quality brass
- Ergonomically designed plastic composite handle
- Double-moulded soft grip for highest comfort and usability.

Sievert® Model No.	Working Pressure	Length	Height	Weight	Item Number
348841	1,5-8 bar	205 mm	90 mm	385 g	W010109

Sievert® PRO Neck Tubes

Shorter neck tubes are recommended for smaller heating applications like gold and silver forging. Longer neck tubes are recommended for larger jobs like metal preheating, roofing and road work. Titanium neck tube weighs up to 60% less than brass and provides a better heat transfer, ideal for preheating applications.

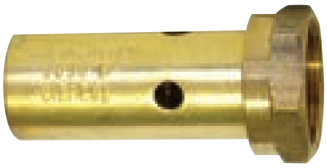
Sievert® Model No.	Length	Material	Item Number
350902	180 mm (with hook)	Brass	W010105
351001	350 mm	Brass	NEW (Available on Request)
350701	500 mm	Brass	NEW (Available on Request)
350601	750 mm	Brass	W010106
355601	750 mm	Titanium	NEW (Available on Request)

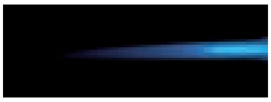
Sievert® PRO Burners

Sievert® burners are designed for high-pressure operation (200 kPa) and all of them can be connected to the universal handles by means of the neck tubes. The special design ensures that cool primary air forms a cooling air gap between flame and burner tube, thus ensuring a very long burner lifetime. Each burner is individually flame-tested before delivery.

Sievert® PRO Pin-point Burners

Finest flame for precision works such as gold and silver forging. Working pressure 2 bar.

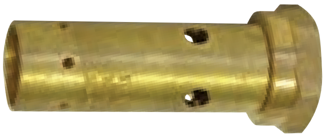




Sievert® Model No.	Burner Diameter	Material	Gas Consumption at 2 Bar	Heat Effect	Max Pipe Diameter Soft Soldering	Item Number
393802	17 mm	Brass	20 g/h	0,25 kw	10 mm	W010146

Sievert® PRO Standard Burners

Brush-type flame for all kinds of soft soldering – small heating applications. Working pressure 2 bar.

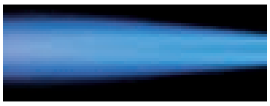


Sievert® Model No.	Burner Diameter	Material	Gas Consumption at 2 Bar	Heat Effect	Max Pipe Diameter Soft Soldering	Item Number
394002	17 mm	Brass	90 g/h	1,2 kw	12 mm	W010119

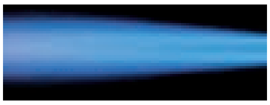
Sievert® Model No.	Burner Diameter	Material	Gas Consumption at 2 Bar	Heat Effect	Max Pipe Diameter Soft Soldering	Item Number
294102	28 mm	Brass	600 g/h	7,7 kw	60 mm	W010120

Sievert® PRO Power Burners

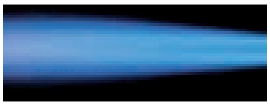
Heavy duty power burners with extremely strong and windproof flame. Ideal for preheating before welding, bitumen laying, drying, field torching and other heat demanding applications. Working pressure 4 bar. Titanium burner weighs up to 60% less than brass and provides a better heat transfer, ideal for preheating applications.



Sievert® Model No.	Burner Diameter	Material	Gas Consumption at 4 Bar	Heat Effect	Item Number
294302	35 mm	Brass	3,350 g/h	43,5 kw	W010122



Sievert® Model No.	Burner Diameter	Material	Gas Consumption at 4 Bar	Heat Effect	Item Number
294402	50 mm	Brass	6,700 g/h	86,0 kw	W010123



Sievert® Model No.	Burner Diameter	Material	Gas Consumption at 4 Bar	Heat Effect	Item Number
295401	70 mm	Titanium	12,500 g/h	155,0 kw	NEW (Available on Request)

Hose and Hose Nipples

Use only Type B nitrile compound hose on LPG. The normal rubber lined acetylene hoses are not suitable as LPG perishes the lining, causing it to break up. Small particles will then block the extremely small holes in the burner jets.

Description	Item Number
Hose - 5 mm	W002439
Hose - 8 mm	W002440

Suitable for 5 and 8 mm Type B nitrile compound hose. The design is such that, whilst providing a gas tight joint, the hose nipple is free to rotate, thereby avoiding hose kinks as the operator moves about the job.

Description	Item Number
Rotating Nipple & Nut	W010174

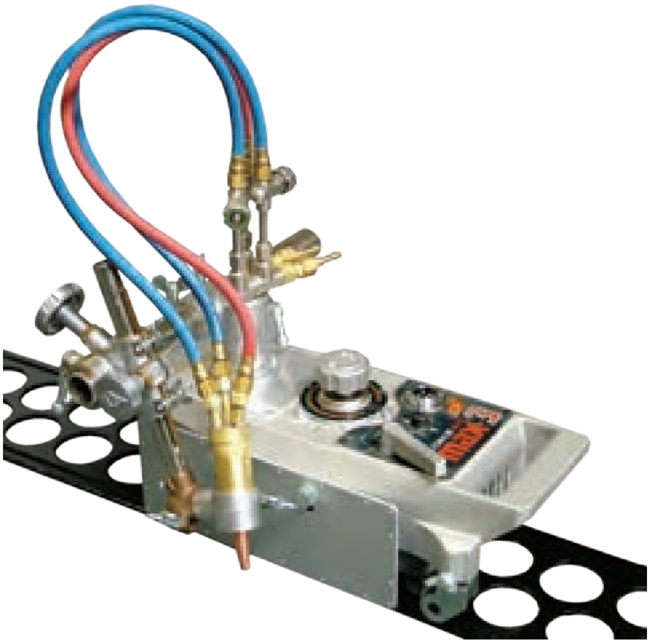
Always use Sievert® equipment with Afrox Saffire® S6000 LPG 400 Regulator (Item Number W010611).

Gas Cutting Machines

Portable Automatic Gas Cutting Machine

The IK-12MAX3 is a high quality motor driven portable flame cutting machine designed to cut straight lines, circles and bevels with clean, sharp, smooth edges.

- All functions controlled by forward/off/reverse switch, clutch lever and speed adjustment knob
- Versatility and convertibility inherent in the design ensure all types of straight line, circle and bevel cutting are simply performed
- Use of Afrox A-NME oxy-fuel cutting nozzles in conjunction with the uniquely accurate guidance driving system provides unequalled performance in the cutting of clean, sharp and smooth edges
- Plate track for straight line cutting is available in interlocking sections of 1 800 mm each which may be extended indefinitely
- An adjustable radius bar for circle cutting and a circle cutting track are optionally available
- High speed mode in the range of 240 - 2 400 mm/min at 50 cycle and 300 - 3 000 mm/min at 60 cycle is available
- The exclusive Double Cone Reduction Gear system provides very smooth travelling and therefore set speed is kept in any of long time operation.



Description	Item Number
1K-12MAX3 Portable	W014112

Specifications	IK-12MAX3
Cutting Speed (Standard type)	80 - 800 mm/min
Travelling Speed (High speed type)	240 - 2 400 mm/min
Speed Control	Double cone stepless speed control system
Speed Meter	Dial induction (w/conversion scale)
Power	42/110/220 V AC
Machine Dimensions	Length 430 mm Width 170 mm Height 215 mm
Max. Loading Weight	50 kg
Weight	10 kg

Optional Extras / Spares	Afrox Item Number
IK-12MAX3 Track 1,8 m	W014111
IK-12MAX3 Heatshield	W014113
Torch Block Model SP400	W014131

Afrox BlueBox Heavy Duty Oxy-Acetylene Kit

Description	Item Number
Afrox BlueBox Heavy Duty Oxy-Acetylene Kit	W230614

Ideal for rugged working environments, such as mines, construction sites, shipyards, quarries, scrap cutting yards and heavy fabrication sites.

The Afrox BlueBox offer is a not just a product, it is a unique service offer as well. This service offer entails the following:

- Serialised numbering of boxes and equipment for tracing and accountability
- Servicing of the equipment by specialist Afrox personnel on a pre-determined schedule as agreed with the customer
- Better cost control
- Improved safety and risk control
- Longer lasting products
- Only ISO/SANS approved equipment is used.

Features

- Saffire® Legend 916 acetylene cutting torch capable of cutting up to 450 mm plate
- Leak/pressure tested at Afrox Gas Equipment Factory
- Tip mix minimising risk of flashbacks
- Regulator to tip pre-assembled
- 9/16” connectors and fittings
- Cutting of up to 450 mm thick steel with the right sized cutting tip.

Applications

- Steel cutting up to 450 mm with an 8F cutting tip.

Kit Consists of

A	Saffire® Legend 916 cutting torch
B	Saffire® Legend 916-1F tip
C	Saffire® Legend 916-105K acetylene multi-stage gaugeless regulator
D	Saffire® Legend 916 oxygen multi-stage gaugeless regulator
E	DGN regulator mounted flashback arrestors
F	GT torch mounted flashback arrestors
G	18 m oxygen and acetylene flexible gas hoses (SANS approved)
H	Multi-purpose spanner
I	Tip cleaner
J	Triple flint lighter and one spare flint
K	Safetest leak detection solution
L	Blue and yellow welding gauntlet
M	Gas welding goggles
N	Plastic blue box

Afrox RedBox Heavy Duty Oxy-Acetylene Kit

Description	Item Number
Afrox RedBox Heavy Duty Oxy-Acetylene Kit	W230600

Ideal for rugged working environments, such as mines, construction sites, shipyards, quarries, scrap cutting yards and heavy fabrication sites.

The Afrox RedBox offer is a not just a product, it is a unique service offer as well. This service offer entails the following:

- Serialised numbering of boxes and equipment for tracing and accountability
- Servicing of the equipment by specialist Afrox personnel on a pre-determined schedule as agreed with the customer
- Better cost control
- Improved safety and risk control
- Longer lasting products
- Only ISO/SANS approved equipment is used.

Features

- The Saffire® Universal® torch can cut up to 300 mm thick steel with the correct size ANM6 cutting nozzle
- Afrox Saffire® multi-stage regulators are ISO 2503 approved
- ‘Set and forget’ technology – constant pressure delivery
- Flashback arrestors are SANS 50730-1 approved
- Gas hoses are SANS 3821 approved
- 3/8” outlet connectors and fittings.

Applications

- Steel cutting of up to 300 mm with a 3,2 ANM6 nozzle.

Kit Consists of

A	Saffire® cutting torch	I	Nozzle cleaner
B	Saffire® S8500 acetylene multi-stage regulator	J	Triple flint lighter
C	Saffire® S8500 oxygen multi-stage regulator	K	Safetest leak detection solution
D	Saffire® ANM6 1,6 cutting tip	L	Gas welding goggles
E	Saffire® F5 regulator-mounted flashback arrestors	M	Afrox red chrome leather gauntlet gloves – 20 cm
F	Saffire® F7 torch-mounted flashback arrestors	N	Plastic red box
G	18 m oxygen and acetylene gas hoses (SANS approved)	O	Boiler Makers Chalk
H	Multi-purpose spanner		

IBEDA

Flashback Arrestors & Quick Release Couplings

Regulator Mounted Flashback Arrestors

IBEDA Standard Flashback Arrestor with Thermal Cut-Off Valve

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 60 mm
- Heating up to 50 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks
- Thermal cut-off valve prevents excessive temperatures.

IBEDA Standard Flashback Arrestor with Thermal Cut-Off Valve

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Thread	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
DGN	Fuel	32 600	-	150	500	350	9/16" UNF LH	9/16" UNF LH	W236001
DGN	O_2	32 600	2 000	-	-	-	9/16" UNF RH	9/16" UNF RH	W236002

IBEDA High Flow Flashback Arrestor with Thermal Cut-Off Valve

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 500 mm
- Heating >100 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks
- Thermal cut-off valve prevents excessive temperatures.

IBEDA High Flow Flashback Arrestor with Thermal Cut-Off Valve

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Thread	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
DG 91 N	Fuel	54 700	-	150	500	400	9/16" UNF LH	9/16" UNF LH	W236009
DG 91 N	O_2	54 700	2 000	-	-	-	9/16" UNF RH	9/16" UNF RH	W236010

IBEDA High Flow Flashback Arrestor with Thermal Cut-Off Valve and Resettable Pressure Gas Cut-Off Valve

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 500 mm
- Heating >100 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks
- Thermal cut-off valve prevents excessive temperatures
- Resettable pressure sensitive gas cut-off valve stops gas flow (Model DS2000).

IBEDA High Flow Flashback Arrestor with Thermal Cut-Off Valve and Resettable Pressure Gas Cut-Off Valve

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Thread	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
DS 2000	Fuel	54 700	-	150	500	400	9/16" UNF LH	9/16" UNF LH	W236037
DS 2000	O_2	54 700	2 000	-	-	-	9/16" UNF RH	9/16" UNF RH	W236038

Torch Mounted Flashback Arrestors

IBEDA Standard Flashback Arrestor

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 200 mm
- Heating up to 50 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks.

IBEDA Standard Flashback Arrestor

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Connection	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
GT	Fuel	26 300	-	150	500	350	Ø Hose 8 mm	9/16" UNF LH	W236021
GT	O_2	26 300	2 000	-	-	-	Ø Hose 8 mm	9/16" UNF RH	W236022

IBEDA Standard Flashback Arrestor for Profile Machine Torches

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 300 mm
- Heating up to 50 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks.

IBEDA Standard Flashback Arrestor for Profile Machine Torches

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Thread	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
GG	Fuel	26 300	-	150	500	350	9/16” UNF LH	9/16” UNF LH	W236017
GG	O_2	26 300	2 000	-	-	-	9/16” UNF RH	9/16” UNF RH	W236018

IBEDA High Flow Flashback Arrestor

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 500 mm
- Heating up to 100 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks.

IBEDA High Flow Flashback Arrestor

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Thread	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
DG 91 UA	Fuel	54 700	-	150	500	400	9/16” UNF LH	9/16" UNF LH	W236013
DG 91 UA	O_2	54 700	2 000	-	-	-	9/16” UNF RH	9/16" UNF RH	W236014

Regulator Mounted Flashback Arrestors & Quick Release Couplings

IBEDA Standard Flashback Arrestor with Quick Release Couplings

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 200 mm
- Heating up to 50 mm.

IBEDA Standard Flashback Arrestor with Quick Release Couplings

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Thread	Outlet Connection	Item Number
			O_2	Da	LPG	H_2			
DGN-K + N2	Fuel	32 600	-	150	500	350	9/16" UNF LH	Ø Hose 8 mm	W236088
DGN-K + N2	O_2	32 600	2 000	-	-	-	9/16" UNF RH	Ø Hose 8 mm	W236089

Torch Mounted Flashback Arrestors & Quick Release Couplings

IBEDA Standard Flashback Arrestor with Quick Release Coupling

This safety device can be used for

- Welding up to 30 mm
- Flame cutting up to 200 mm
- Heating up to 50 mm.

Safety Features

- Dust inlet filter promoting longer life
- Non-return valve preventing dangerous gas mixtures
- Flame arrestor preventing flashbacks
- Thermal cut-off valve prevents excessive temperatures
- Automatic gas cut-off when disconnecting
- Double 'O'-ring seal
- Coloured marking of coupling and pin
- No mixing of gas connections through different coding of pins.

IBEDA Standard Flashback Arrestor

Description	Gas	Maximum Air Flow (L/H)	Maximum Pressure (kPa)				Inlet Connection	Outlet Thread	Item Number
			O_2	Da	LPG	H_2			
NKST + N1	Fuel	22 100	-	150	500	350	Ø Hose 8 mm	9/16" UNF LH	W236086
NKST + N1	O_2	22 100	2 000	-	-	-	Ø Hose 8 mm	9/16" UNF RH	W236087

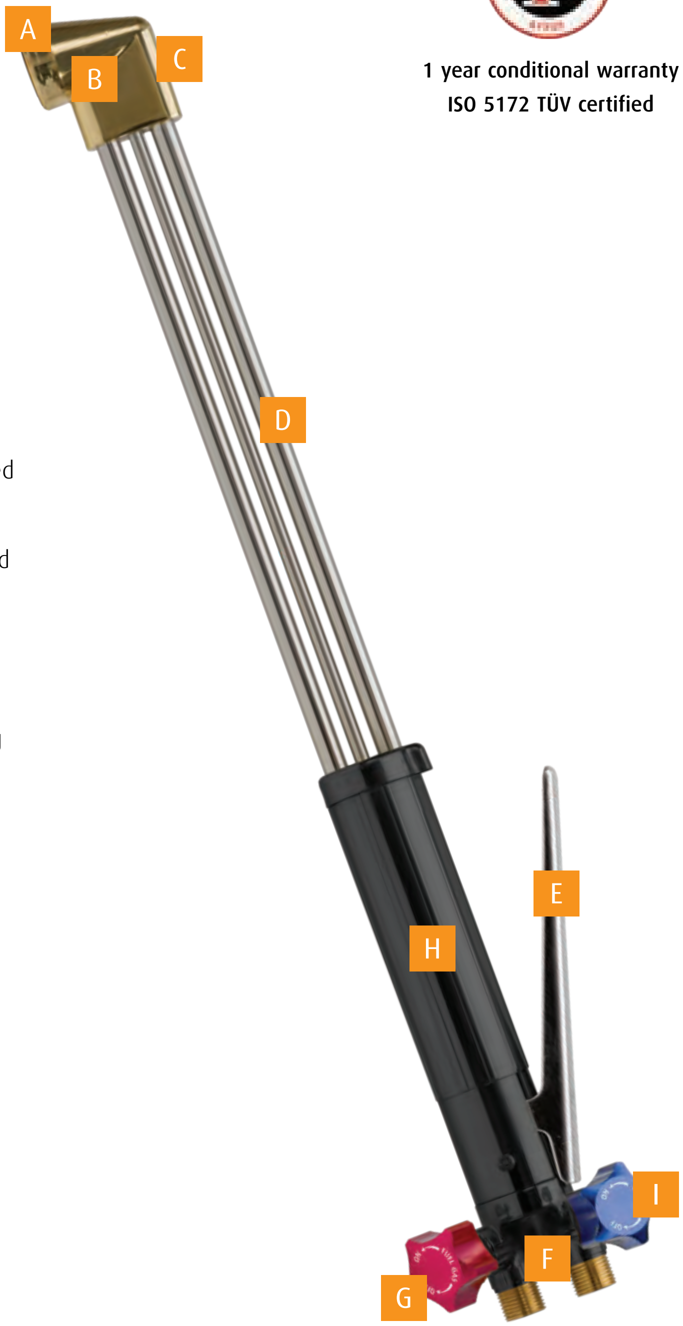
TRANSARC® GAS EQUIPMENT

1 year conditional warranty
ISO 5172 TÜV certified

The Transarc® NM250 cutting torch is a versatile, well-balanced torch capable of cutting steel up to 270 mm thick. The torch provides excellent flame control and exceptional handling for all industrial cutting applications.

Transarc® NM250 cutting torches feature nozzle mixing technology for added safety and for protecting the torch and operator from accidental backfires.

They can be used with acetylene or LPG, depending on the type of nozzle fitted.



A Nozzle mixing helps contain backfires in the nozzle, protecting the torch from downtime and providing added operator safety

B Custom angle head design allows for proficient and rapid nozzle change

C Large forged head provides unmatched durability and reduces warping for extended service

D Three-tube construction keeps gases separate, allowing gas mixing only in the nozzle for added operator safety

E Solid lever for added durability

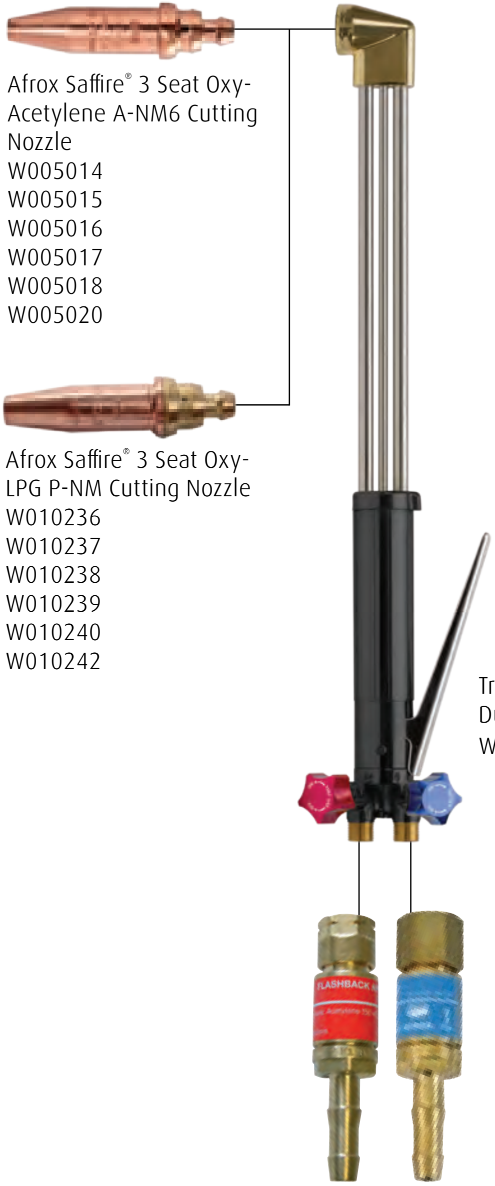
F Fully silver-brazed joints, thick-walled stainless steel tubes and solid brass forged head and tail result in robustness and lower maintenance costs

G Easy-grip valves give you full control over your cutting flame

H Heavy duty cast handle for positive grip, comfort and control

I Colour coded control knobs to improve operator productivity and safety

Transarc® Heavy Duty Torch



Afrox Saffire® 3 Seat Oxy-Acetylene A-NM6 Cutting Nozzle
W005014
W005015
W005016
W005017
W005018
W005020

Afrox Saffire® 3 Seat Oxy-LPG P-NM Cutting Nozzle
W010236
W010237
W010238
W010239
W010240
W010242

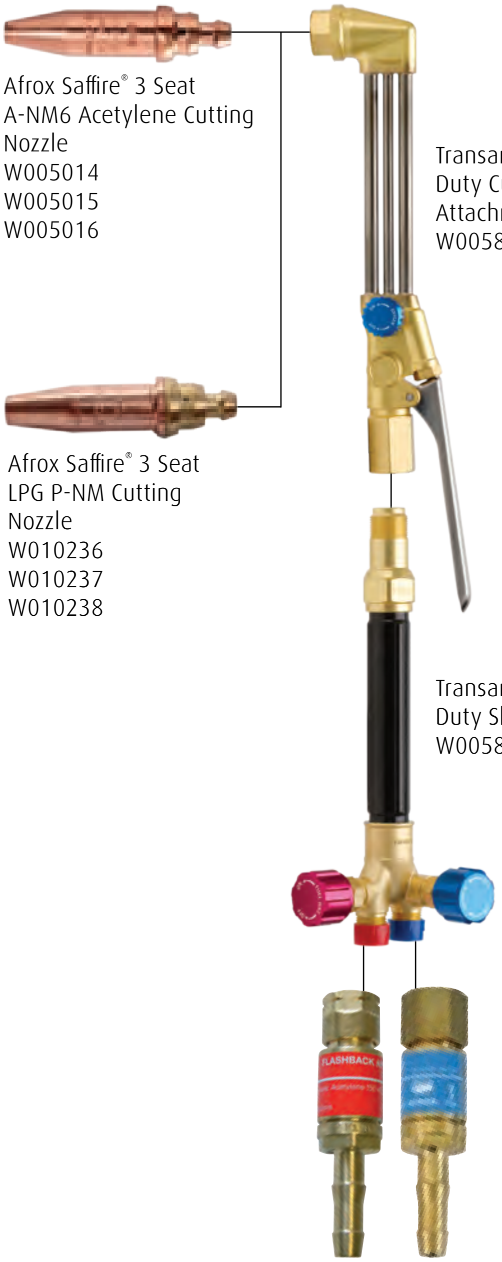
Transarc® Heavy Duty Cutting Torch
W005843

Transarc® Standard Flow Torch End Oxygen FBA
TM35
W012042

Transarc® Standard Flow Torch End Fuel FBA
TM35
W012041

Cutting Nozzles

Transarc® Torch



Afrox Saffire® 3 Seat A-NM6 Acetylene Cutting Nozzle
W005014
W005015
W005016

Afrox Saffire® 3 Seat LPG P-NM Cutting Nozzle
W010236
W010237
W010238

Transarc® Medium Duty Cutting Attachment
W005846

Transarc® Medium Duty Shank
W005844

Transarc® Flashback Arrestors

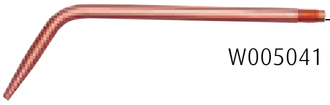
Transarc® Standard Flow Torch End Fuel FBA
TM35
W012042

Transarc® Standard Flow Torch End Oxygen FBA
TM35
W012041

Afrox Saffire® Welding Nozzles*


W005043


W005042


W005041


W005040


W005039


W005038


W005037

Afrox Saffire® Type 2 Mixer


Transarc® Medium Duty Mixer
W005845

Transarc® Medium Duty Shank


Transarc®
Medium Duty
Shank
W005844

Transarc® Flashback Arrestors

Transarc® Standard Flow Torch End Fuel FBA TM35 W012042	Transarc® Standard Flow Torch End Oxygen FBA TM35 W012041

For Your Safety:
Use flashback arrestors on both ends (regulator and torch).

Transarc® Regulator Series

The Transarc® series comprises a range of versatile pressure regulators designed to offer a safe and reliable product. The range is ISO 2503 certified and each regulator has been designed to provide optimum flow control utilising Afrox's patented Quadflow encapsulated valve technology. The product has been designed to the latest and most stringent regulatory standards to offer an extended product life.

Features

- 3rd generation Quadflow technology encapsulated valve
- 62 mm gauges colour-coded for ease of use and setting
- Full technical and back up service from Afrox
- 1 year conditional warranty.

Afrox Transarc® Single-Stage Regulator

Model	Description	Gas Type	Delivery Pressure	Inlet Connection	Outlet Connection	Max Inlet Pressure	Item Number
S6000 AGS 150	Single-stage general-purpose regulator for welding, cutting and heating	Acetylene	0 - 150 kPa	5/8″ LH	3/8″ LH	2 750 kPa	W003858
S6000 OGS 600	Single-stage medium outlet pressure regulator for medium duty welding and cutting	Oxygen	0 - 600 kPa	5/8″ RH	3/8″ RH	30 000 kPa	W003859
S6000 LGS 400	Single-stage 400 kPa Handigas (LPG) regulator suitable for the full range of Afrox LPG nozzles	Handigas (LPG)	0 - 400 kPa	5/8″ LH	3/8″ LH	2 000 kPa	W003612

Transarc® Flashback Arrestors

Afrox Transarc® Flashback Arrestors

Model	Gas	Inlet Connection	Outlet Connection	Description	Item Number
Transarc® TM35	Fuel Gas	8 mm Hose	3/8″ BSP	Torch Mount	W012042
Transarc® TM35	Oxygen	8 mm Hose	3/8″ BSP	Torch Mount	W012041
Transarc® RM35	Fuel Gas	8 mm Hose	3/8″ BSP	Regulator Mount	W012037
Transarc® RM35	Oxygen	8 mm Hose	3/8″ BSP	Regulator Mount	W012036


AFROX


kPa
LPG
750 kPa
AFROX

SAFETY EQUIPMENT

11

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Head & Face Protection 380

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Respiratory Protection 385

Afrox Self-Rescue Division (SRD) 386

Customer Support 392

EYE PROTECTION

Afrox Wraparound Specs

Ultra-lightweight design for comfort and balance. Large moulded-in side shield for extra protection. Polycarbonate lens for high impact resistance and UV absorption. Available in clear shade lens and amber shade lens. Meets ANSI Z87.1 and CE EN166

Description	Item Number
Clear	W053730

Afrox Wraparound Vented Specs

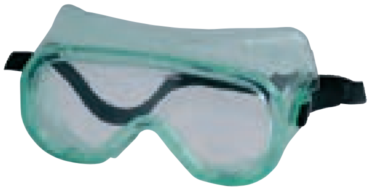
Lightweight wraparound design. One-piece distortion-free polycarbonate lens which eliminates lens dislodging on impact. Improved comfort and peripheral vision. Temple venting system which allows air flow to reduce heat build-up. Interlocking temple hinge which reduces temple dislodging. Available in clear shade lens and green shade 2,5 lens. Meets ANSI Z87.1 and CE EN166

Description	Item Number
Clear	W053135

Afrox Medium Range Specs

Ultra-light and ultra-durable for a consistently secure and comfortable fit. 9,5 base lens provides more than 180 degrees of coverage. High impact 100% polycarbonate lens is scratch resistant, reduces static and eliminates more than 99,9% of harmful UV-A and UV-B rays. Available in clear shade lens and smoke shade lens. Meets ANSI Z87.1 and CE EN166

Description	Item Number
Smoke	W053731



Grinding Goggles Heavy Duty

Lightweight soft PVC frame fits comfortably to contours of face. Spectacles can be worn underneath. Impact resistant and optically correct lens. Diamond anti-fog coating and anti-scratch. Meets ANSI Z87.1 and CE EN166

Item Number	W012799

Welding Goggles

50 mm lift-front goggle. Soft PVC (free from cadmium). Coated frame. Lift-front locks in open or closed position. Adjustable elastic headband. Four capped vents ensure good indirect ventilation. Suitable for use over prescription eyewear. Meets ANSI Z87.1 and CE EN 175

Item Number	W012257

PROTECTIVE CLOTHING

Chrome Leather Apron

- Chrome leather welding apron with bib and reinforced straps
- 90 x 60 cm

Item Number	W053076

Leather Apron

- Furniture leather apron with bib, reinforced strap attachments, suitable for welding
- 60 x 90 cm

Item Number	W050228

Standard Leather Spats

- Full boot/shoe coverage and protection

Item Number	W053071

HEAD & FACE PROTECTION

Transarc® OHE410 Auto-Darkening Helmet

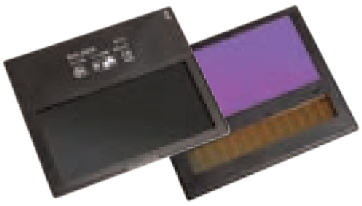
- High quality electronic welding helmet built to exacting professional standards
- Provides complete, reliable lightweight protection and is also extremely comfortable to wear
- Equipped with a high quality shade 4/9-13 electronic auto-darkening filter lens
- Switching time from clear to dark is approx. 0,005 s (0,5 ms), providing quick and effective protection
- Powered by solar cells with an enclosed back-up lithium battery
- Ability to work hands-free
- Optimal protection from eye damage caused by the welding arc

Description	Item Number
Transarc® OHE410 Auto-Darkening Helmet	W500063
Transarc® OHE410 Replacement Auto Lens	W500064
Transarc® OHE410 Inner Protect Lens PO10	W500065
Transarc® OHE410 Headgear Incl Nut Bolts	W500066
Transarc® OHE410 Comfort Band PO2	W500067
Transarc® OHE410 Outer Protect Lens PO10	W500068
Transarc® OHE410 ADF Frame Retainer	W500069

Afrox Industrial Self-Darkening Helmet

- Full protection of the ears, neck and throat
- Made from PA material with rubber fibres (almost unbreakable, high temperature resistance)
- Lightweight, well balanced helmet
- Enlarged space in front of the mouth and nose for more comfortable breathing (reduction of CO_2 concentration)
- Smooth round edges all around the perimeter for better comfort
- Aerodynamic design for fume deflection
- Front loaded ADF, easy to change the front cover plates
- Adjustable shade 9 - 13
- Adjustable sensitivity
- TIG detection down to 5 amp
- Optical quality 1/1/1/1
- 3 year warranty

Description	Item Number
Afrox Industrial Self-Darkening Helmet	W053221
Afrox Industrial and Afrox Elite External Lens Covers 10 pck	W053153
Afrox Industrial Internal Lens Covers 10 pck	W053154



Electronic Lens for Afrox Industrial

- Adjustable shade 9 - 13

Item Number	W053211

Afrox Scull Cap with Back Flap

- Worn under helmet for head and neck protection
- Applications: MIG and electrical arc welding

Item Number	W053033

Helmet Flip Front 108 x 51 mm

- Polypropylene welding helmet for MIG, TIG and arc welding
- Lightweight and perfectly balanced for comfort
- Offers full protection and complies with EN175
- Extremely flexible, strong, moisture resistant and naturally heat resistant
- Flip front lens holder
- Fully adjustable ratchet type headgear by push button

Item Number	W053151

Filter Lenses

Our shaded and clear lenses are a standard size of 108 x 51 mm replacements for flip front helmets. They offer high quality eye protection for all types of arc welding, including the necessary protection against ultra-violet rays. Clear cover plates, inserted in front of the shaded lenses protect them from molten metal spatter and typical wear.

Uom	Description	Weld Current Range	Process	Process Area	Item Number
Proclear					
Each	Clear glass	All	All	Indoor/outdoor	W053046
Protec					
Each	1 000 hr clear lens	All	All	Indoor/outdoor	W053157
Polytec					
Each	Inner clear lens (impact)	All	All	Indoor/outdoor	W053158
Protane 8					
Each	Protane 8	Up to 100 A	MMA	Indoor/outdoor	W053165
Protane 10					
Each	Protane 10	100 to 200 A	MMA	Indoor	W053161
Protane 12					
Each	Protane 12	Over 300 A	MMA	Indoor	W053160

HAND PROTECTION

Working Leather Gloves

Replacement Item Image	Material Name	Detailed Description	Size and Length of Glove	Material Makeup	Certification	Material Number
	Candy striped cow split leather working glove	Inside elastic back, three-piece patched palm. Leather winged thumb and index finger. Protective leather strap on knuckles. Lined palm and wrist protector	26,67 cm length, 13 cm width of palm. Economic laminated 6,5 cm cuff	Cow split leather and cotton, light cotton or polyester palm lining	CE EN3880-2123	W051001
	Short leather working glove	Chrome cow split leather. Unlined. Polypropelene stitching. Lock and back stitched seams	27 cm length, 12,5 cm width of palm. 7 cm chrome leather cuff	Cow split leather glove and cuff with polypropelene thread	N/A	W051005

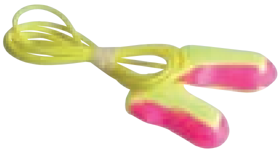
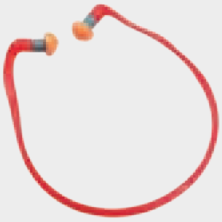
Synthetic Gloves

Replacement Item Image	Material Name	Detailed Description	Size and Length of Glove	Material Makeup	Certification	Material Number
	Latex coated assembling glove	Latex coated glove. Textured natural latex palm on a 10 gauge polycotton knit liner. Comfortable fit. Knit wrist. Excellent grip and flexibility	26 cm length, 11,5 cm width of palm	10 gauge polycotton knit liner. Latex coated palm and fingertips	CE420&388-4142	W051033

Welders' Gloves

Replacement Item Image	Material Name	Detailed Description	Size and Length of Glove	Material Makeup	Certification	Material Number
	Classic red welders' gauntlet	Red split leather welding gauntlet, fully lined for comfort and feel. Stitched with fire retardant thread to provide extra strength and durability. All cow split leather. Polycotton lining. Lock and back stitched	40 cm length, 13,5 cm width of palm	Cow split leather. 1,3 mm up thickness. Polycotton lining	N/A	W051021
	Classic blue and yellow welders' gauntlet	High quality blue butt hide gauntlet with reinforced palm and knuckle bar. Fire retardant stitching provides additional strength and durability	40 cm length, 13,5 cm width of palm	Cow split leather. Thickness 1,3 mm up. Polycotton sock lining. Sock lined split leather guantlet with reinforced palm and knuckle bar	N/A	W051023
	TIG welders' glove	High quality TIG glove made from soft pig grain leather on palm, and split leather cuff. Unlined. Lock and back stitched	28 cm length, 11 cm width of palm	Pig grain and split leather. Thickness up to 1,1 mm	N/A	W051024
	General purpose handling glove	All chrome double leather palm. Unlined. Lock and back stitched	30 cm length, 12,5 cm width of palm. 10 cm chrome leather cuff	Chrome leather. 1,2-1,4 mm thickness. Chrome leather gauntlet and cuff with polypropylene thread. Unlined	N/A	W051027

HEARING PROTECTION

Replacement Item Image	Item Description	Features	Noise Reduction	Certification	Item Number
	Afrox Hush disposable corded earplug	Non-allergenic. Designed for high noise exposure	37 dB	N/A	W050781
	Afrox exclusive earmuff	Enhanced noise reduction and comfort. Flexible padded headband. Dielectric design	30 dB	CE EN 352	W053038
	Afrox Hush disposable uncorded earplug	Non-allergenic. Non-irritating. Designed for high noise exposure	37 dB	N/A	W050780
	Laser Lite disposable corded earplug - pack of 100	Non-irritating, non-allergenic. Ideal for small ear canals. Tapered and pre-shaped. Follows the contour of the ear canal. Easy insertion and a comfortable natural seal. Winged end promotes optimum insertion depth and easy grasp for removal	35 dB	N/A	W053702
	Howard Leight QB3 banded hearing protector	Semi-aural protection. Super soft pads rest outside the ear for outstanding comfort. Patented band design prevents ear pads from touching dirty or contaminated surfaces. Lightweight and portable – designed especially for environments with intermittent noise hazards	23 dB	N/A	W053040
	Laser Lite disposable uncorded earplug - pack of 200	Non-irritating, non-allergenic. Ideal for small ear canals. Tapered and pre-shaped. Follows the contour of the ear canal. Easy insertion and a comfortable natural seal. Winged end promotes optimum insertion depth and easy grasp for removal	35 dB	N/A	W053718

RESPIRATORY PROTECTION

Replacement Item Image	Item Description	Homologation	Features	Item Number
	Afrox Dust Mask FF2 - Pack of 20 Without valve	AZ 2006/26	▪ Afrox disposable respirators (maintenance-free) provide lightweight, comfortable protection against a variety of hazards at an economical price ▪ Twin elastic headband, adjustable nose bridge and a foam rubber nose seal ▪ High level of protection to include mechanically and thermally generated particulates up to 10 times the standard ▪ Ideal for use when exposed to dust, silica, coal and lead dust, glass fibre and zinc oxide	W053715
	Dust Mask FF2 - Pack of 10 With valve	AZ 2006/27	▪ Afrox disposable respirators (maintenance-free) provide lightweight, comfortable protection against a variety of hazards at an economic price ▪ Twin elastic headband, adjustable nose bridge and a foam rubber nose seal ▪ High level of protection to include mechanically and thermally generated particulates up to 10 times the standard ▪ Ideal for use when exposed to dust, silica, coal and lead dust, glass fibre and zinc oxide	W053716

AFROX SELF-RESCUE DIVISION (SRD)

AfroxPac self-contained self-rescuers (SCSRs) are closed-circuit, chemical oxygen generating, body-worn emergency breathing devices. They comply with the stringent SABS 1737 standard for SCSRs which is a legislated requirement for any short duration body-worn SCSR deployed in South African mines.

AfroxPac SCSRs generate oxygen by reacting the moisture in the breath of the user with potassium superoxide contained within the device. This produces a rapid and effective supply of oxygen. At the same time carbon dioxide is absorbed by the chemical, making the device completely self-contained with no exposure to atmospheric toxins.

AfroxPacs are produced at Afrox's Germiston factory according to strict quality and environmental standards (ISO 9001 and ISO14001). Afrox has designed, manufactured and marketed AfroxPac SCSRs since 1996.

By 2022, more than 550 000 Afroxpac self-contained self-rescuers had been supplied to the mining industry.

AfroxPac 35i

The AfroxPac 35i enhances the proven technology of the AfroxPac by improving the bag material and ensuring containment of the oxygen-generating chemical. This provides added protection against inadvertent exposure to high temperatures. The AfroxPac 35i has been proven in independent monitoring of thousands of units selected from the toughest of underground conditions to continue to deliver life-saving oxygen - on average at better than the rated duration of a new unit - even after years of exposure to harsh conditions.

- Self-contained, escape-type breathing apparatus, which mine workers can carry on their persons, for use in an emergency
- SANS 1737:2008 compliant
- Rated duration: 30 minutes at a ventilation rate of 35 $\ell.\text{min}^{-1}$
- Ergonomically designed to be continuously worn on the body
- Oxygen source: potassium superoxide (KO_2)
- Silicone-based heat resistant breathing bag
- Internal seal ensures chemical containment and prevents migration of chemical to breathing bag

Item Number	W022060

AfroxPac 35i Self-Contained Self-Rescuer

AfroxPac 35i is a self-contained, closed-circuit, chemical oxygen-generating, body worn escape type emergency breathing apparatus.

Rated Duration
30 minutes at a ventilation rate of 35 ℓ.min^{-1}

Resting Duration
>120 minutes at a ventilation rate of 10 ℓ.min^{-1}

Oxygen Generation		
At Start-Up (1-2 minutes)	Spec: 19%	Typical: >20%
In Use (10 minutes to termination)	Spec: 21%	Typical: >90%

Carbon Dioxide[1]		
Maximum	Spec: 3%	Typical: < 2%
Average	Spec: 1,5%	Typical: 1% at 30 min

Breathing Resistance		
Inhalation/Exhalation	Spec: 1 kPa	Typical: < 0,7 kPa
Sum of Resistance	Spec: 1,6 kPa	Typical: < 1,3 kPa

Functional Performance
Post-durability testing breathing duration >30 minutes

Mass	
Full Set (Including case)	2,4 kg
Breathing Apparatus	1,2 kg

Dimensions	
Height	195 mm
Width	172 mm
Hip-Out	101 mm

Oxygen Source

Potassium superoxide (KO_2)

Activation

Oxygen generation is initiated by moisture in the exhaled breath of the user. No 'self-starter' is required

Breathing Bag

- 9 ℓ volume
- Silicone coated, heat resistant
- Chemical containment: internal seal on chemical canister prevents chemical migration to the breathing bag
- Comfort mouthpiece design reduces irritation and salivation

Shelf-Life

Exceeds 10 years on the storage rack. Specific conditions of use may reduce functional performance

Identification

Individual serialisation and month of manufacture

Batch Testing

Samples for independent functional performance batch testing by CSIR Consulting and Analytical Services are independently selected and tested at a rate of 0,5 – 1% of new production

[1] Input CO_2 at 4,5% in exhaled gas

Kidney Support A

- Can be fitted to standard mining belts

Item Number	W012923

Shoulder Braces B

- Can be fitted to standard mining belts for support

Item Number	W012922

Anti-Vibration Box

- Durable stainless steel casing for storage of SCSRs on vehicles, etc.
- Protects SCSRs against undue vibration and shock
- SCSR readily accessible during an emergency

Item Number	W012838

Mining Belt

Standard mining belt - accommodates both the cap lamp battery and self-rescuer

Item Number	W012992

Chest Harness

Makes it possible to wear the self-rescuer on the chest in cases where SCSRs cannot be worn on the belt

Item Number	W012925

Heat Simulator

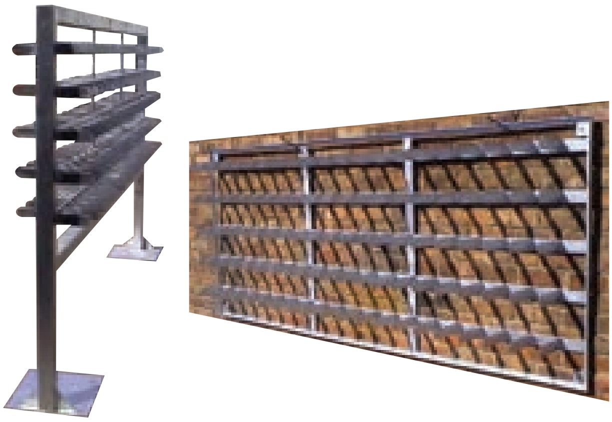
- The heat simulator complements the training of mine personnel in the use of self-contained self-rescuers (SCSRs)
- By breathing air from the heat simulator, mine personnel will experience the increase in air temperature that occurs during the actual usage of a chemical SCSR in an emergency situation

Item Number	W012916

Disposable Mouthpieces for the Heat Simulator

- For hygienic purposes, disposable mouthpieces are issued to trainees for training on the heat simulator
- One-directional flow that prevents inhalation of air exhaled by other trainees

Item Number	W022010



Storage Racks

- Special racks to accommodate the SCSRs. Two types of racks are available:
  - Wall-mounted racks - accommodate 100 SCSRs
  - Free-standing racks - accommodate 200 SCSRs, 100 on either side

Description	Item Number
Wall-mounted	W012991
Free-standing	W012940

AfroxPac Training Materials

- Easy to use and understand training materials will show workers the right procedures during emergencies and how the relevant equipment works. Available training materials* include:
- Training and Instruction Manual
- Trainer's AfroxPac
- Trainee's AfroxPac
- Training posters
- Training & maintenance DVD in three languages
- Training mouthpieces and nose clips
- Hard hat stickers

*SRD should be contacted for more details on training material item numbers

Item Number	Various

Disposable Training Mouthpieces

- Made from medical-grade polymer
- Simulate the AfroxPac mouthpiece
- Single-use for hygiene purposes
- Blanked-off to prevent exhaled breath entering the training AfroxPac
- Easy fit and removal from the training unit breathing hose
- Individually sterilised and packaged

Item Number	W012920

Customer Support

SRD offers support in the field to assist customers in maintaining their AfroxPacs in life-saving condition, to provide training to trainers and lamproom personnel and to furnish repairs quickly and efficiently. The SRD database maintains records of each unit sold, serviced and repaired as well as details of all training and certificates issued.

Quarterly Leak test and Condition Monitoring Service

The service entails the following:

The Afrox service technician and assistant shall, in the presence of the mine official, examine all available AfroxPacs at least once every three months to ascertain that:

- The tampering seals on the closing mechanism are intact
- The moisture indicator has not changed colour from blue to pink/white
- The clamping or closing mechanism is not damaged
- The belt loops are not damaged
- The exterior of the container does not show undue damage other than fair wear and tear
- In addition to the above, a negative pressure test is conducted on all units deployed on the mine.

A report will be compiled and forwarded to the mine. Cost of service is dependent on the number of units deployed and the distance to be travelled. Emergency and ad-hoc call-outs will be charged separately.

Monthly Maintenance Service

The service entails the following:

- Monthly visual inspections for two months per quarter and a quarterly leak test and visual inspection in the 3rd month of each quarter
- Preventative maintenance by replacement of any wear-and-tear damaged components. The cost of this is included in the monthly maintenance fee
- Isolation and quarantining of any mine-damaged units (these will be separately quoted for repair).

Repairs

- Units are collected from mines
- Quotations provided within one week
- Units repaired on receipt of written order and delivered back to the mine.

Customer Training

- A trainer is available for training at customer's site
- Certificates of training are issued
- Train the Trainer, Lamproom Maintenance and Leak Tester training is available.

WELDING CONSUMABLES

12

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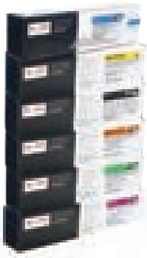

CARBON STEELS

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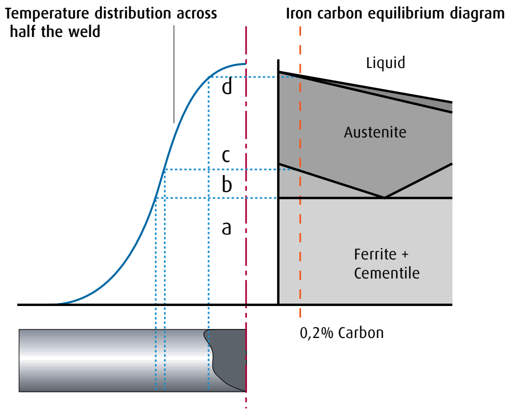
Welding of Carbon Steels

Weldability of Steel

Weldability is a term used to describe the relative ease or difficulty with which a metal or alloy can be welded. The better the weldability, the easier it is to weld. However, weldability is a complicated property, as it encompasses the metallurgical compatibility of the metal or alloy with a specific welding process, its ability to be welded with mechanical soundness, and the capacity of the resulting weld to perform satisfactorily under the intended service conditions.

Before attempting to weld any material, it is essential to know how easy it is to weld and to be aware of any problems that might arise. One of the main problems likely to be encountered when welding carbon and alloy steels is hydrogen cracking. For hydrogen cracking to occur, it is necessary to have a supply of hydrogen to the weld and a heat affected zone (HAZ), a susceptible hardened microstructure, and tensile stress. If any one of these three components is eliminated, then hydrogen cracking will not happen. Solidification cracking and lamellar tearing are other potential problems associated with welding steel.

The main problem when welding steel is hardenability. As long as the steel contains sufficient carbon when it is cooled rapidly from high temperature, a phase transformation takes place. The phase transformation from austenite to martensite causes the material to harden and become brittle. It is then liable to crack on cooling, due to restraint, or later under the action of hydrogen.


Temperature distribution across half the weld

Iron carbon equilibrium diagram

Variation in temperature from the centre of the weld to the base material

The weldability of steel depends primarily on its hardenability and this, in turn, depends largely on its composition (most importantly its carbon content). Steels with carbon content under 0,3% are reasonably easy to weld, while steels with over 0,5% are difficult. Other alloying elements that have an effect on the hardenability of steel, but to a much lesser extent than carbon, are manganese, molybdenum, chromium, vanadium, nickel and silicon. These, together with carbon, are all generally expressed as a single value (the carbon equivalent). The higher the carbon equivalent, the higher the hardenability, the more difficult the steel is to weld, and the more susceptible the microstructure is likely to be to hydrogen cracking.

This effect can be overcome by preheat combined with the use of a low hydrogen process or low hydrogen welding consumables. Calculation of preheat is usually based on carbon equivalent (derived from steel composition), combined thickness of the components, and heat input from the welding process. It also takes account of the amount of hydrogen likely to be introduced into the weld metal by the welding process. If welding under high restraint, extra preheat may need to be applied. Some high carbon steels and low alloy steels may also need a post weld stress relief or tempering.

Hardenability and Hardness

To become harder, steel must undergo a phase change. The starting point is austenite, so the steel must first be heated into the austenitic temperature range (see diagram on left).

- Austenite, quenched rapidly, will be transformed into martensite, a hard but brittle phase
- A slower cooling rate will promote formation of bainite and/or other softer phases
- Cooled even more slowly, a soft structure of ferrite plus cementite, called perlite, results.


Martensite, tempered martensite and heavily tempered martensite

Hardenability

Hardenability is the potential for any particular steel to harden on cooling and, as the carbon content of the steel increases towards 0,7%, so the potential of the steel to harden increases. Increasing the alloy content of the steel also increases the hardenability.

While hardness and strength may be desirable in a welded steel structure, martensite can be brittle and susceptible to cracking, and it should be noted that the potential brittleness of the material also increases as hardenability increases.

Hardenability describes the potential of steel to form hard microstructures. What hardness is actually achieved in steel with known hardenability depends on the maximum temperature to which it is heated and the cooling rate from that temperature. During welding, the parent material close to the weld will be heated to temperatures near melting point, while further away it will remain at ambient temperature. The cooling rate depends on the mass of material, its temperature, and the welding heat input. Therefore, when welding any given hardenable steel, the hardness in the HAZ depends on the cooling rate – the faster the cooling rate, the harder the microstructure produced and the more susceptible it is to cracking.

After welding, the hardness in the HAZ may range from less than 300 HV to more than 550 HV, depending on the parent steel composition and the other factors described above. As the hardness of the HAZ increases, so does its susceptibility to hydrogen cracking. However, as a rule of thumb, if the maximum hardness in the HAZ is maintained below 350 HV, then hydrogen cracking will be avoided.

Carbon Equivalent

Carbon has the greatest effect on the hardenability of steel, but other alloying elements may be added to increase its hardenability. The addition effectively reduces the critical cooling rate and the temperature at which the austenite to martensite transformation takes place, making it easier for martensite to form at slower cooling rates.

Alloying elements that have the greatest influence on the hardenability of steel are manganese, molybdenum, chromium, vanadium, nickel, copper and silicon, but they have a much smaller effect than carbon.

The effect of these elements on the tendency to form HAZ martensite, and hence the likelihood of hydrogen cracking, is expressed conveniently as a carbon equivalent (CE). This basically describes the influence of each element on hardenability in terms of the effect that carbon has. There have been many different formulae derived to express carbon equivalent, but the one quoted here is the International Institute of Welding (IIW) equation that is applicable to carbon steel and is widely used:

Carbon equivalent (CE) =

$$\%C + \frac{\%Mn}{6} + \frac{(\%Ni + \%Cu)}{15} + \frac{(\%Cr + \%Mo + \%V)}{5}$$

The equation is only valid for certain maximum percentages of each element and these percentages can be found in the technical literature.

The carbon equivalent is used mainly for estimating preheat. Preheat is necessary to slow down the cooling rate sufficiently to reduce hardening in the HAZ of welds in susceptible carbon and low alloy steels. This, in turn, helps to prevent subsequent HAZ hydrogen cracking. The overall effect is to improve the weldability of the steel being welded, or at least to overcome the weldability problems presented by it.

CE is calculated from the composition of the steel in question and is used – together with welding heat input, potential hydrogen from the consumable, and combined thickness, or by reference to published data – to determine the preheat. It is recommended that the actual composition of the steel is used to ensure accuracy of calculation of CE, but nominal or maximum specified compositional data may be used when this is unavailable. The use of nominal composition obviously carries some risk that CE will be underestimated and too low preheat will be used, with potential cracking problems.

Weldability

Weldability describes the relative ease or difficulty with which a metal or alloy can be welded.

The relative weldability of carbon and low alloy steels are summarised here.

As has already been stated, weldability varies with the chemistry of the steel, particularly with reference to its carbon content.

The majority of carbon steels are weldable, but some grades have better weldability and, therefore, are more easily welded than others. As the carbon content increases, weldability tends to decrease as the hardenability increases and the steel becomes more prone to cracking.

Low carbon steels containing <0,15% carbon and <0,6% manganese generally have good weldability, as the composition is too lean to give any significant hardening effect during welding. However, steels with <0,12% carbon and low levels of manganese can be prone to porosity, although they are not susceptible to hydrogen cracking.

Steels with carbon contents between 0,15 and 0,3% carbon and up to 0,9% manganese, have good weldability, particularly those with carbon content below 0,22%. These are mild steels and rarely present problems, as long as impurity levels are kept low. They are all weldable without preheat, using any of the common welding processes. Those at the top end of the composition range, above about 0,25% carbon, may be prone to cracking under certain circumstances. They may be welded using any of the common welding processes, but are best welded with a low hydrogen process such as MIG or low hydrogen consumables. Thick sections may require preheating to reduce the cooling rate.

Medium carbon steels containing between 0,25 and 0,5% carbon, with generally <1% manganese, are hardenable by heat treatment and so are prone to cracking when welded. They can be welded, but require suitable welding procedures, specifying preheat and interpass temperature control to account for the carbon content or carbon equivalent and the combined thickness of the joint being produced. These steels should always be welded using a low hydrogen welding process or controlled hydrogen consumables.

Steels with even higher carbon levels, between 0,5 and 1,0%, with <1% manganese, are used where their higher hardness and strength can be exploited. However, their high hardenability means that they have poor weldability and are difficult to weld without cracking. They are generally welded in the hardened condition and so require preheating, interpass temperature control and post weld stress relief to give any chance or avoiding cracking. Low hydrogen processes, such as MIG and TIG welding or low hydrogen consumables, such as low hydrogen MMA electrodes will always be required when welding these steels.

Carbon-manganese steels have carbon typically between 0,15 and 0,5%, and manganese levels between 1,0 and 1,7%. For structural purposes, carbon is normally held below 0,3%, manganese not above 1,2% and sulphur and phosphorous are required to be below 0,05%. Generally, they are weldable, although some will require controls on preheat and heat input. Those at the higher end of the carbon range also benefit from the use of low hydrogen welding processes or controlled hydrogen consumables.

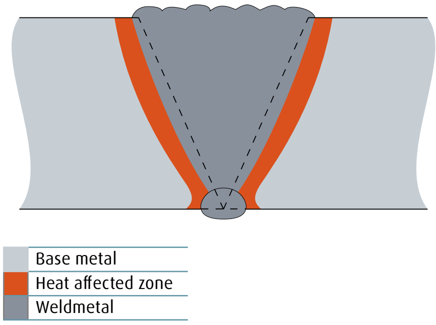
Structural steels often have limits imposed on maximum carbon equivalent to ensure good weldability and ease of welding for the fabricator.

Weldable high strength low alloy (HSLA) steels have weldability similar to the low carbon steels, and so do not usually present problems.

Most quenched and tempered steels can be welded, but they rely on relatively high cooling rates for the strong martensitic structures to form. Careful control of preheat, heat input and interpass temperature is required to achieve the correct structure without cracking. Welding must be carried out using a low hydrogen process, or hydrogen-controlled consumables, and welding procedures need to be tested and approved.

Weld and HAZ Cracking

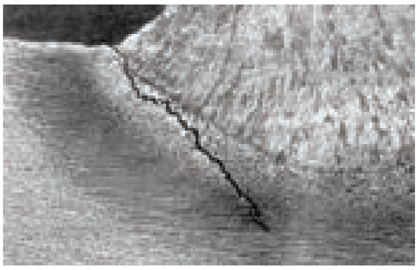
With steel, poor weldability often manifests in a reduction of the resistance of the steel to cracking after welding.



The main causes of cracking in steel are:

- High levels of carbon and other alloy elements, resulting in brittle zones around the weld
- High cooling rates after welding increasing the hardness, which increases the susceptibility to cold cracking
- Joint restraint preventing contraction after welding, leading to cracking
- Hydrogen in the weld bead or HAZ, leading to hydrogen-induced cold cracking
- Contaminants like sulphur and phosphorous, resulting in solidification cracking
- Lamellar tearing due to inclusions layering during rolling, resulting in deterioration of the through-thickness properties.

The most common cause of cracking in steel is the presence of hydrogen. Hydrogen (or cold) cracking is usually considered the most serious potential problem with modern steels. Hydrogen cracking is most frequently a HAZ phenomenon, but it can also occur in weld metal, particularly in high alloy steels. Hydrogen, like carbon, is more soluble in austenite than ferrite and can easily be picked up by the weld metal. When ferrite is formed as the material cools, hydrogen solubility decreases and hydrogen diffuses to the HAZ, where it becomes trapped and can cause crack propagation.



Heat affected zone (cold cracking)

There are published guidelines and standards that contain welding procedures to avoid hydrogen cracking. For hydrogen cracking to occur, it is necessary to have a supply of hydrogen to the weld and HAZ, a susceptible hardened microstructure, and tensile stress. If any one of these three components is eliminated, then hydrogen cracking will not happen.

To avoid cold cracking, the following points should be noted:

- The lower the carbon equivalent, the lower the potential for cracking
- Limit the hydrogen content of weld metal and HAZ by using a low hydrogen process or low hydrogen consumables
- Keep joint restraint to a minimum by careful joint design
- Reduce the cooling rate of the weld area by preheat and suitable welding heat input
- Eliminating hydrogen after the weld is completed by keeping the weld hot (hydrogen release treatment)
- Ensure impurities are kept at a low level.

The above guide is of a very general nature. If in doubt, seek expert technical advice.

Factors Influencing Weldability

In terms of avoiding weldability problems, particularly hydrogen cracking, when welding carbon or low alloy steels, there are several factors that demand consideration. These include the amount of hydrogen generated by the welding process or consumable, the heat input into the weld, the combined thickness (heat sink) of the joint, and the level of preheat applied to the components prior to welding. Joint configuration and restraint are also important factors when considering weldability.

Process Hydrogen

One of the three key components necessary for hydrogen cracking is a source of hydrogen. During welding, the most likely sources of hydrogen are the welding consumables or contaminants on the parent material. Here we consider hydrogen from the welding process and consumables only.

The amount of hydrogen put into the weld will vary from one welding process to another and may also vary within a process from one consumable type to another. The risk of hydrogen cracking increases as the amount of hydrogen from the process or consumable gets larger.

Solid wire processes, such as MIG and TIG, are capable of giving hydrogen levels below 5 ml/100 g of weld metal. These are generally thought to be low hydrogen processes, provided the MIG wire is clean.

The manual metal arc process can give a wide range of hydrogen levels, from well over 15 ml/100 g of weld metal (with cellulosic and rutile coated electrodes) to less than 5 ml/100 g of weld metal (with basic coated electrodes) given the appropriate baking or re-drying treatment.

The potential hydrogen levels can vary with product type for cored wire welding processes too. Basic type flux cored wires may be capable of getting below 5 ml/100 g of weld metal, but rutile cored and metal cored wire types may give 10 or 15 ml/100 g of weld metal. Some recent developments have enabled metal cored and rutile cored wire to achieve hydrogen levels below 10 ml/100 g, with some even below 5 ml/100 g.

Submerged arc wires, like MIG wires, should be able to give low levels of hydrogen but, when used in combination with different fluxes, the hydrogen level may vary between <5 to 15 ml/100 g of weld metal.

Welding Heat Input

The heat input from the welding process plays a major role in the heating and cooling cycles experienced by the weld and parent plate during welding. For a given plate thickness, a high heat input is likely to result in a slower cooling rate than a low heat input, and will therefore produce a softer microstructure in the HAZ that is less prone to hydrogen cracking. However, that does not mean that welding should always be carried out with a high heat input, because this brings with it other problems, such as loss of mechanical properties and an increased risk of solidification cracking. So it is necessary to select a heat input to give a sound weld with the desired mechanical properties and to use preheat to exert control of the cooling rate.

Heat input 'Q' may be calculated as:

$$Q = \frac{k \times V \times I \times 60}{S \times 1\,000} \quad \text{kJ/mm}$$

where 'V' is arc voltage (V), 'I' is welding current, and 'S' is welding speed in mm/min.

The value derived from this formula may be multiplied by a factor 'k', the thermal efficiency factor for the welding process, to give an energy input that takes the efficiency of the welding process into account. Typical thermal efficiency factors are:

- 'k' = 1,0 for submerged arc welding
- 'k' = 0,8 for MIG / MAG, MMA, flux cored and metal cored arc welding
- 'k' = 0,6 for TIG and plasma welding

For example, when MIG welding, the welding heat input formula becomes:

$$Q = \frac{0{,}8 \times V \times I \times 60}{S \times 1\,000} \quad \text{kJ/mm}$$

Welding heat input will vary with process and consumable type and size. With small diameter electrodes, low current and fast welding speeds, heat inputs below 1,0 kJ/mm are readily attained. With large diameter electrodes, high currents and slower welding speeds, heat inputs in excess of 6,0 kJ/mm can be reached.

Note that a weld made using a stringer bead technique will have a lower heat input than a weld made with the same size electrode at the same current but using a weave bead technique.

Combined Thickness

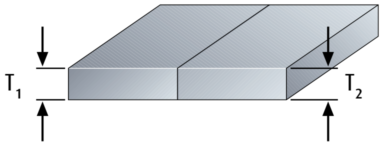
The cooling rate of plate in the region of a weld depends on the thickness of the plates in the joint, the number of plates meeting at the joint, the amount of heat put into the weld area, and the initial temperature of these plates. Cooling occurs by conduction and so the greater the heat sink, the faster the cooling rate. Therefore, other factors being constant, the thicker the plate, the greater the potential for rapid cooling, and so the greater the likelihood of hardening in the HAZ of susceptible steels.

Estimates of preheat will normally take into account the thickness of each of the components in the joint to allow for the cooling effect. The thickness of each component is added together to give what is normally referred to as 'combined thickness' (CT).

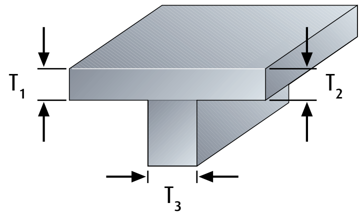
How the combined thickness is derived depends on the joint configuration and is illustrated below:

$$CT = T_1 + T_2 + T_3 \ldots$$

Example of combined thickness calculation for butt joint



Example of combined thickness calculation for fillet joint



For butt welds, the CT equals the sum of the thicknesses of the two plates being welded; for fillet welds, the CT equals twice the thickness of the base plate plus the thickness of the up-stand. Therefore, for a given plate thickness, a fillet joint has a faster cooling rate than a butt joint.

Recommendations for the Storage, Handling and Treatment of Afrox Hydrogen Controlled Basic Carbon Steel Electrodes

Handling

Afrox electrodes are packed in cardboard cartons with a moisture resistant polythene wrapping. Further protection is provided by shrinking these rigid cartons into packs of three.

The packs are stacked to a maximum of eight high on wooden pallets.

This is the recommended maximum height to avoid crushing and hence possible damage during storage.

Storage

Basic low hydrogen electrodes should be stored in dry conditions, off the floor on pallets or racks in their unopened containers. The rate of moisture re-absorption which takes place is determined by the resistance of the electrode to the atmospheric conditions of relative humidity and temperature prevailing during storage.

Storage is not really the most important issue in determining subsequent weld metal hydrogen content of low hydrogen electrodes, but rather, the rate at which moisture is lost during re-baking of electrodes prior to use.

Storage under the correct conditions will provide indefinite product shelf-life.

Re-baking

It is essential that hydrogen-controlled electrodes be re-baked prior to use. The re-baking temperature recommendations depend on the maximum permissible hydrogen content tolerable in the deposited weld metal and the hardenability of the parent material.

Standard Re-baking Temperatures

Product	5-10 ml H_2/ 100 g	<5 ml H_2/100 g
7018-1	350 - 370°C	–
78MR	250 - 270°C	370 - 400°C
Ferron 1	350 - 370°C	–
Baking time one-two hours		
Diffusible hydrogen content determined using Yanaco gas chromatograph		

Optimum conditions for re-baking are achieved when electrodes are placed on the oven shelves not more than five deep. This is normally only required when diffusible hydrogen contents of less than 5 ml H_2/100 g of weld metal are specified and hardenable materials in thick sections have to be welded.

For general shop conditions, the electrode pile in the oven can be increased provided consumables in the centre of the pile achieve the minimum re-baking temperature for a minimum period of one hour.

Note: When electrodes are placed in a baking oven, the temperature in the electrode pile rises far more slowly than it takes for the oven's own temperature to rise to the set temperature. It is therefore incorrect to take the oven temperature as an accurate indication of the actual baking temperature reached by the electrodes and hence a guide to the time at temperature.

Unless the temperature during baking is timed on the basis of the electrode temperature, the electrodes cannot be considered properly re-baked prior to use.

If possible, it is recommended that fabricators carry out checks on their re-drying ovens to establish the correct conditions for actual electrode re-baking temperatures and times as compared to oven temperatures and times.

It is important to note that if the electrodes are maintained at the re-bake temperature for long periods of time, the coating may become brittle. Coating brittleness may also result if the electrode is re-baked above the maximum recommended temperature.

Number of Re-bakes

Repeated re-baking has an adverse effect on electrode coating strength and adhesion to the core wire. From tests carried out by Afrox, it is recommended that:

Re-baking at 370-400°C be limited to two times and re-baking at 250-270°C be limited to three times. (This does not include the factory bake).

Holding Conditions

Immediately after baking, the electrodes should be transferred to a holding oven alongside the baking oven. The recommended holding temperature is 150°C ± 20°C. The holding time is virtually indefinite with a working limit suggested as 120 hours. Any electrodes that are inadvertently exposed to excessive moisture, rain, etc. or are damaged, should be removed from the work site and destroyed.

Quivers

Electrodes drawn from holding ovens should be held in heated quivers at a minimum temperature of 75°C. The suggested period for the electrodes to remain in the quivers is eight hours. After this time, any remaining electrodes should be returned for re-baking.

General

In some instances, it may be possible to modify the above requirements, depending on the type of work which is being undertaken and technical requirements being imposed. Please refer any technical queries to the Marketing Department, Afrox Welding Consumables on (011) 490 0400.

Preheating of Materials

What is Preheat?

A heating procedure applied to parent metal components immediately before welding commences, and considered as an essential part of the welding operation, is called ‘preheat’.

Preheating can be applied locally to the areas to be welded, or to the whole component. It is usually done to raise the temperature of the weld area so that the weld does not cool too quickly after welding. This protects the material being welded from the various adverse effects that can be caused by the normally rapid cooling cycle created by the welding process.

Note that, while preheat is applied before welding begins, it is essential that the minimum preheat temperature is maintained throughout the welding operation.

What Does Preheat Do?

Basically, preheat puts the parent metal components in a suitable condition for the subsequent welding operation. Preheating may be carried out for any of the following reasons:

- Slow down the cooling rate
- Reduce shrinkage stress and weld distortion
- Promote fusion
- Remove moisture.

Slow down the cooling rate

Some alloys (notably high carbon and low alloy steels), if welded and allowed to cool quickly, can develop hard or brittle phases in the heat affected zone (HAZ). These phases can render such alloys susceptible to cracking under the action of tensile shrinkage stresses as the weld area cools down, or they can result in low toughness of the HAZ.

Many steels are susceptible to hydrogen cracking, and fast cooling rates not only promote the formation of hard, susceptible microstructures but also lock the hydrogen into the solidifying weld metal. Because of this trapped hydrogen gas, pressure builds up in the weld and the heat affected zone, which can result in cracking of the already brittle microstructure. Such cracks are normally detected by post weld inspection techniques, but should they escape detection, they may lead to premature failure in service, with potentially disastrous consequences.

Preheating of components prior to welding in these situations is designed primarily to slow down the rate of cooling of the weldment. In reducing the cooling rate, preheat is protecting the parent metal by helping to prevent hardening of the weld by the formation of brittle phases. A softer, more ductile structure is more resistant to cracking. The slower cooling rate also gives more time for any hydrogen introduced into the weld to diffuse away from the welded joint.

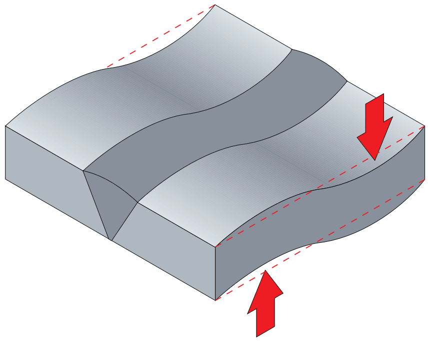
Reduce shrinkage stress and weld distortion

If welds are made in highly restrained joints, or in materials with very low ductility (e.g. cast irons), the welding cycle of heating, followed by rapid cooling, can result in cracking in the weld or the surrounding area. This is due to the weld metal or adjacent parent metal not being able to withstand the effects of shrinkage stresses created by contraction.

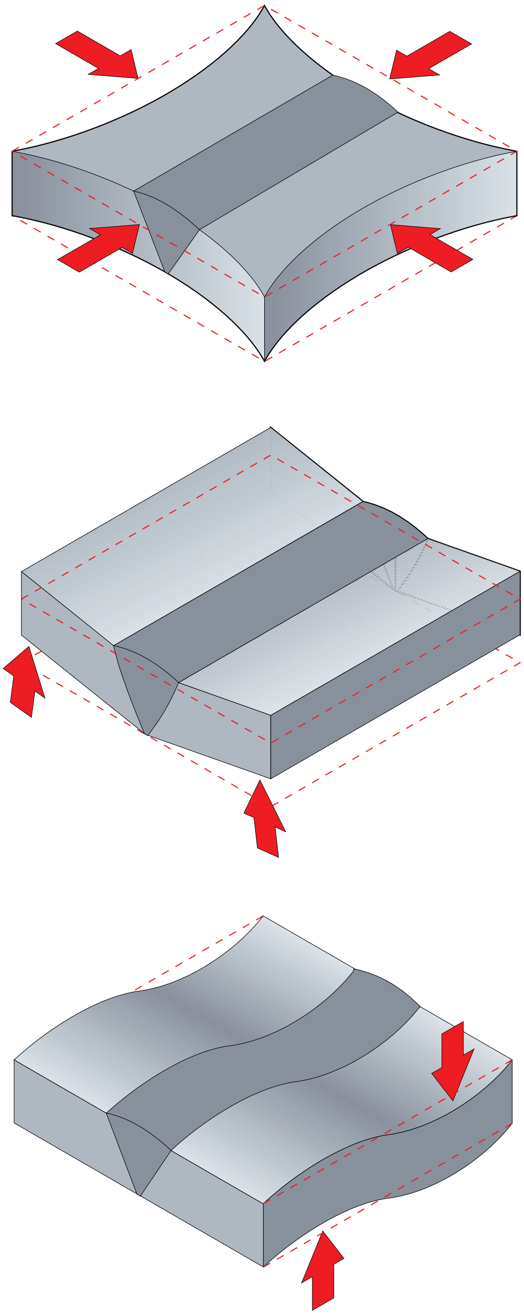
Metals and alloys that should not be preheated

Preheat and high interpass temperatures can have a negative effect on the mechanical properties or corrosion resistance of some alloys. For example:

- Austenitic manganese (13% Mn) steel
- Austenitic stainless steels
- Duplex stainless steels
- Titanium alloys.



Residual stresses present in a welded joint



Distortion due to the presence of residual stress

Here preheating is used to balance the thermal cycle and so reduce the shrinkage stresses in the weld and in the adjacent parent material.

When welding wrought materials in highly restrained joints, preheat is normally applied locally in the weld area.

When welding castings, the preheat applied may be 'local' (heating in the area of the weld only), 'total' (the whole casting is heated), or 'indirect' (heating a part of the casting away from the weld area to balance the effects of expansion and contraction).

Promote fusion

Some alloy systems (e.g. copper and aluminium) have very high thermal conductivity, and if a weld is attempted on thick, cold plate, the parent material could chill the deposited weld metal so quickly that it does not fuse with the parent metal. This may be referred to as a 'cold start'. The heat conduction away from the joint area can be such that a weld may be impossible using a conventional arc welding process.

Preheat is used in this case to raise the initial temperature of the material sufficiently to ensure full weld fusion from the start. This is particularly important when using a welding process / plate thickness combination that is likely to produce a cold start.

Remove moisture

Any metallic components left overnight in a cold workshop or brought in from outside are likely to be damp or even wet. If they are welded in that condition, problems can arise in the resultant welds. For example, if the components are made of steel, then the moisture will act as a source of hydrogen and the result could be hydrogen cracking. Aluminium has a porous oxide layer, which will absorb moisture from the atmosphere, and, if not removed before welding, this can result in weld metal porosity and subsequent rejection of the weld.

While not normally the main objective of preheating, its use for removal of surface moisture prior to welding is not only advisable, but very often essential.

Carbon Steel and Alloy Steel

These two groups of materials have, quite rightly, been given more attention in estimation of preheat temperature than any other alloy system, as the penalty for getting it wrong can be severe.

The following list is intended only to give some indication of the level of preheat required for certain types of steel. In these examples, it is assumed that the weld is a butt weld, and the thicknesses given are the normally used 'combined thickness', where this is the total thickness of all the parts to be joined.

When calculating the 'combined thickness' of parts with varying thicknesses (such as forgings), the thickness of each part is usually averaged over a distance of 75 mm from the weld line. However, for some processes and materials, account must be taken of any difference of thickness beyond the 75 mm point, and it is important to refer to the specific welding procedures or relevant standards in each case.

Steel Type	Combined Thickness (mm)	Typical Preheat (°C)
Low C and mild steels	<50	50
	>50	100 – 150
Medium C, CMn steels	<40	100 – 200
	>40	150 – 250
High C, CMn steels	All	200 – 300
QT steels, HSLA steels	All	None to 150 (max.)
0,5% Mo, 1% Cr-0,5% Mo steels*	All	100 – 250
2% Cr-1% Mo, 5% Cr-0,5% Mo steels*	All	200 – 300
Direct hardening steels	All	150 – 300
Case hardening steels	All	150
13% manganese steel	All	None
*Preheat is usually specified by procedure and tightly monitored and controlled with these materials		

It is recommended that more comprehensive documentation be consulted when selecting a temperature for a specific application.

Information to assist with calculation of preheat for CMn steels can be found in international standards (e.g. BS 5135 and AWS D1.1). These standards set out minimum preheat temperatures based on factors such as the type of steel specification or carbon equivalent, thickness, the welding process or heat input, and the hydrogen class of the welding consumable. The guidelines do not take restraint into consideration, so highly restrained joints may need higher levels of preheat than indicated.

The information in these standards is often used as a rough guide to determine preheat for low alloy steels. This should be done with extreme caution, as low alloy steels will frequently need much higher preheat than estimated by this means because of their alloy content.

When joining or surfacing hardenable steels (steels with high CE), it is sometimes possible to weld with an austenitic type consumable and to use a lower preheat than would be needed if ferritic consumables were to be used.

The decision-making process, when deciding whether to use preheat with carbon steel and alloy steel, can become quite complicated. Carbon and carbon-manganese steels and low alloy steels may require preheating, but this depends on their carbon equivalent, combined thickness and proposed welding heat input.

Preheat with these ferritic materials is primarily aimed at reducing the severity of the ‘quench’ after welding, and helping to prevent the formation of hard brittle microstructures in the weld and HAZ. It also allows hydrogen to diffuse away from the weld area, thus reducing the risk of hydrogen cracking. The objective is to keep the maximum HAZ hardness to below about 350 HV although this will not always be possible, particularly with some low alloy steels with high hardenability. These low alloy types may, additionally, need a post weld heat treatment to restore properties.

How Much Preheat to Apply

The actual preheat temperature required for a specific welding operation depends not only on the material or materials being welded, but also the combined thickness of the joint, the heat input from the welding process being used, and the amount of restraint imposed upon the components. There are no hard and fast rules regarding how much preheat to apply, but there are many publications available that give helpful guidance.

Fundamentals of Manual Metal Arc (MMA) Welding

Welding Technique

Successful MMA welding depends on the following factors:

- Selection of the correct electrode
- Selection of the correct size of the electrode for the job
- Correct welding current
- Correct arc length
- Correct angle of electrode to work
- Correct travel speed
- Correct preparation of work to be welded.

Electrode Selection

As a general rule, the selection of an electrode is straightforward, in that it is only a matter of selecting an electrode of similar composition to the parent metal. However, for some metals there is a choice of several electrodes, each of which has particular properties to suit specific classes of work. Often, one electrode in the group will be more suitable for general applications due to its all round qualities.

The table below shows just a few of the range of electrodes available from Afrox, with their typical areas of application.

For example, the average welder will carry out most fabrication using mild steel and for this material has a choice of various standard Afrox electrodes, each of which will have qualities suited to particular tasks. For general mild steel work, however, Afrox Vitemax® electrodes will handle virtually all applications. Afrox Vitemax® is suitable for welding mild steel in all positions using AC or DC power sources. Its easy striking characteristics and the tolerance it has for work where fit-up and plate surfaces are not considered good, make it the most attractive electrode of its class.

Electrodes and Typical Applications

Name	AWS Classification	Application
Afrox Vitemax®	E6013	A premium quality electrode for general structural and sheet metal work in all positions, including vertical-down using low carbon steels
Afrox Afrolux	E7024	An iron powder electrode for high speed welding of H-V fillets and flat butt joints. Medium to heavy structural applications in low carbon steels
Afrox 7018-1	E7018-1	A premium quality, all positional hydrogen-controlled electrode for carbon steels in pressure vessel applications and where high integrity welding is required; and for free-machining steels containing sulphur

Electrode Size

The size of the electrode generally depends on the thickness of the section being welded, and the thicker the section the larger the electrode required. In the case of light sheet, the electrode size used is generally slightly larger than the work being welded. This means that, if 2,0 mm sheet is being welded, 2,5 mm diameter electrode is the recommended size.

The following table gives the maximum size of electrodes that may be used for various thicknesses of section.

Recommended Electrode Sizes

Average Thickness of Plate or Section (mm)	Maximum Recommended Electrode Diameter (mm)
1,5 – 2,0	2,5
2,0 – 5,0	3,2
5,0 – 8,0	4,0
8,0	5,0

Welding Current

Correct current selection for a particular job is an important factor in arc welding. With the current set too low, difficulty is experienced in striking and maintaining a stable arc. The electrode tends to stick to the work, penetration is poor and beads with a distinct rounded profile will be deposited.

Excessive current is accompanied by overheating of the electrode. It will cause undercut and burning through of the material, and will give excessive spatter. Normal current for a particular job may be considered as the maximum, which can be used without burning through the work, overheating the electrode or producing a rough spattered surface (i.e. the current in the middle of the range specified on the electrode package is considered to be the optimum).

In the case of welding machines with separate terminals for different size electrodes, ensure that the welding lead is connected to the correct terminal for the size electrode being used. When using machines with adjustable current, set on the current range specified. The limits of this range should not normally be exceeded. The following table shows the current ranges generally recommended for Vitemax®.

Generally Recommended Current Range for Afrox Vitemax®

Electrode Size (mm)	Current Range (A)
2,5	60 – 95
3,2	110 – 130
4,0	140 – 165
5,0	170 – 260

Arc Length

To strike the arc, the electrode should be gently scraped on the work until the arc is established. There is a simple rule for the proper arc length; it should be the shortest arc that gives a good surface to the weld. An arc too long reduces penetration, produces spatter and gives a rough surface finish to the weld. An excessively short arc will cause sticking of the electrode and rough deposits that are associated with slag inclusions.

For downhand welding, an arc length not greater than the diameter of the core wire will be most satisfactory. Overhead welding requires a very short arc, so that a minimum of metal will be lost. Certain Afrox electrodes have been specially designed for 'touch' welding. These electrodes may be dragged along the work and a perfectly sound weld is produced.

Electrode Angle

The angle that the electrode makes with the work is important to ensure a smooth, even transfer of metal.

The recommended angles for use in the various welding positions are covered later.

Correct Travel Speed

The electrode should be moved along in the direction of the joint being welded at a speed that will give the size of run required. At the same time, the electrode is fed downwards to keep the correct arc length at all times. As a guide for general applications, the table below gives recommended run lengths for the downhand position.

Correct travel speed for normal welding applications varies between approximately 100 and 300 mm per minute, depending on electrode size, size of run required and the amperage used.

Excessive travel speeds lead to poor fusion, lack of penetration, etc. while too slow a rate of travel will frequently lead to arc instability, slag inclusions and poor mechanical properties.

Run Length per Electrode – Afrox

Electrode Size (mm)	Electrode Length (mm)	Run Length (mm)	
		Min	Max
4,0	350	175	300
3,2	350	125	225
2,5	350	100	225

Correct Work Preparation

The method of preparation of components to be welded will depend on equipment available and relative costs. Methods may include sawing, punching, shearing, machining, flame cutting and others.

In all cases, edges should be prepared for the joints that suit the application. The following section describes the various joint types and areas of application.

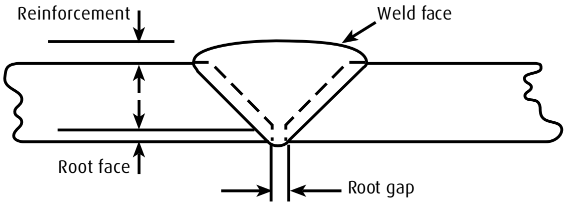
Types of Joints

Butt welds

A butt weld is a weld made between two plates so as to give continuity of section.

Close attention must be paid to detail in a butt weld to ensure that the maximum strength of the weld is developed. Failure to properly prepare the edges may lead to the production of faulty welds, as correct manipulation of the electrode is impeded.

Butt Welding

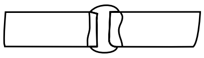


Two terms relating to the preparation of butt welds require explanation at this stage. They are:

- Root face: the proportion of the prepared edge that has not been bevelled (land)
- Root gap: the separation between root faces of the parts to be joined.

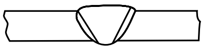
Various types of butt welds are in common use and their suitability for different thickness of steel are described as follows:

Square Butt Weld



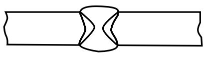
The edges are not prepared, but are separated slightly to allow fusion through the full thickness of the steel. Suitable for plate up to 6 mm in thickness

Single 'V' Butt Weld



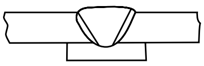
This is commonly used for plate up to 16 mm in thickness and on metal of greater thickness where access is available from only one side

Double 'V' Butt Weld



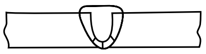
Used on plate of 12 mm and over in thickness when welding can be applied from both sides. It allows faster welding and greater economy of electrodes than a single 'V' preparation on the same thickness of steel and also has less tendency to distortion as weld contraction can be equalised

Butt Weld with Backing Material



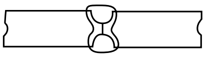
When square butt welds or single 'V' welds cannot be welded from both sides, it is desirable to use a backing bar to ensure complete fusion

Single 'U' Butt Weld



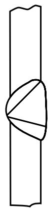
Used on thick plates as an alternative to a single 'V' preparation. It has advantages in speed of welding. It takes less weld metal than a single 'V', there is less contraction and there is, therefore, a lessened tendency to distortion. Preparation is more expensive than in the case of a 'V', as machining is required. This type of joint is most suitable for material over 40 mm in thickness

Double 'U' Butt Weld



For use on thick plate that is accessible for welding from both sides. For a given thickness it is faster, needs less weld metal and causes less distortion than a single 'U' preparation

Horizontal Butt Weld



The lower member in this case is bevelled to approximately 15° and the upper member 45°, making an included angle of 60°. This preparation provides a ledge on the lower member, which tends to retain the molten metal

General notes on butt welds

The first run in a prepared butt weld should be deposited with an electrode not larger than 4,0 mm. The angle of the electrode for the various runs in a butt weld is shown opposite.

It is necessary to maintain the root gap by tacking at intervals or by other means, as it will tend to close during welding.

All single 'V', single 'U' and square butt welds should have a backing run deposited on the underside of the joint, otherwise 50% may be deducted from the permissible working stress of the joint.

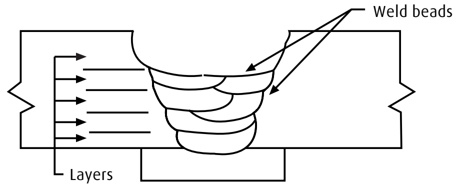
Before proceeding with a run on the underside of a weld, it is necessary to back-gouge or grind that side of the joint.

Butt welds should be overfilled to a certain extent by building up the weld until it is above the surface of the plate. Excessive reinforcement, however, should be avoided.

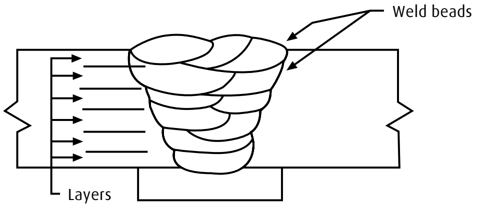
In multi-run butt welds, it is necessary to remove all slag and surplus weld metal before a start is made on additional runs. This is particularly important with the first run, which tends to form sharp corners that cannot be penetrated with subsequent runs. Electrodes larger than 4,0 mm are not generally used for vertical or overhead butt welds.

The diagrams opposite indicate the correct procedure for welding thick plate when using multiple runs.

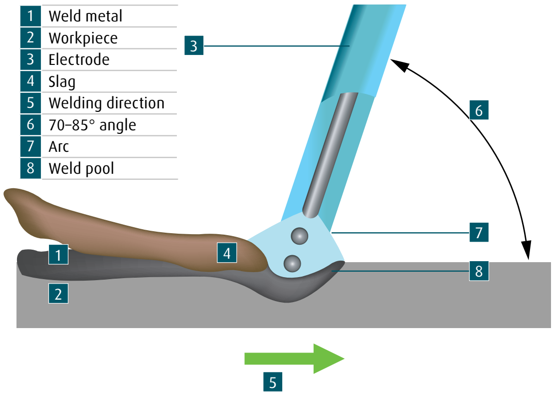
Bead Sequence for 1st and 2nd Layers



Bead Sequence for Subsequent Layers



Welding Progression Angle

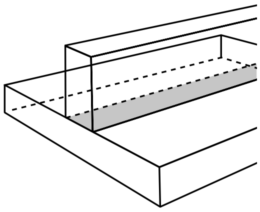


Fillet welds

A fillet weld is approximately triangular in section, joining two surfaces not in the same plane and forming a lap joint, 'T' joint or corner joint. Joints made with fillet welds do not require extensive edge preparation, as is the case with butt welded joints, since the weld does not necessarily penetrate the full thickness of either member. It is, however, important that the parts to be joined be clean, close fitting, and that all the edges on which welding is to be carried out are square. On sheared plate, it is advisable to entirely remove any 'false cut' on the edges prior to welding.

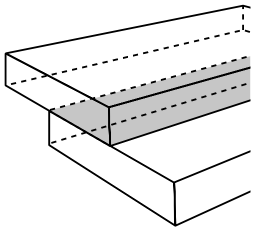
Fillet welds are used in the following types of joints:

‘T’ Joints



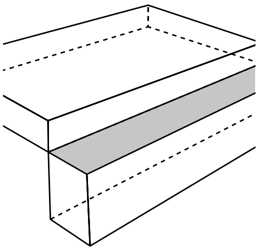
A fillet weld may be placed either on one or both sides, depending on the requirements of the work. The weld metal should fuse into or penetrate the corner formed between the two members. Where possible, the joint should be placed in such a position as to form a ‘natural V’ fillet since this is the easiest and fastest method of fillet welding

Lap Joints



In this case, a fillet weld may be placed either on one or both sides of the joint, depending on accessibility and the requirements of the joint. However, lap joints, where only one weld is accessible, should be avoided where possible and must never constitute the joints of tanks or other fabrications where corrosion is likely to occur behind the lapped plates. In applying fillet welds to lapped joints, it is important that the amount of overlap of the plates be not less than five times the thickness of the thinner part. Where it is required to preserve the outside face or contour of a structure, one plate may be joggled

Corner Joints



The members are fitted as shown, leaving a ‘V’-shaped groove in which a fillet weld is deposited. Fusion should be complete for the full thickness of the metal. In practice, it is generally necessary to have a gap or a slight overlap on the corner. The use of a 1,0–2,5 mm gap has the advantage of assisting penetration at the root, although setting up is a problem. The provision of an overlap largely overcomes the problem of setting up, but prevents complete penetration at the root and should therefore be kept to a minimum (i.e. 1,0–2,5 mm)

The following terms and definitions are important in specifying and describing fillet welds.

Leg length

A fusion face of a fillet weld, as shown on the right.

Throat thickness

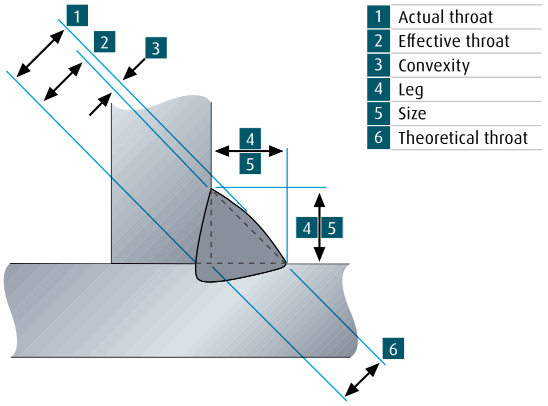
A measurement taken through the centre of a weld from the root to the face, along the line that bisects the angle formed by the members to be joined. Many countries use throat thickness rather than leg length.

Effective throat thickness is a measurement on which the strength of a weld is calculated. The effective throat thickness is based on a mitre fillet (concave fillet weld), which has a throat thickness equal to 70% of the leg length. For example, in the case of a 20 mm fillet, the effective throat thickness will be 14 mm.

Convex fillet weld

A fillet weld in which the contour of the weld metal lies outside a straight line joining the toes of the weld. A convex fillet weld of specified leg length has a throat thickness in excess of the effective measurement.

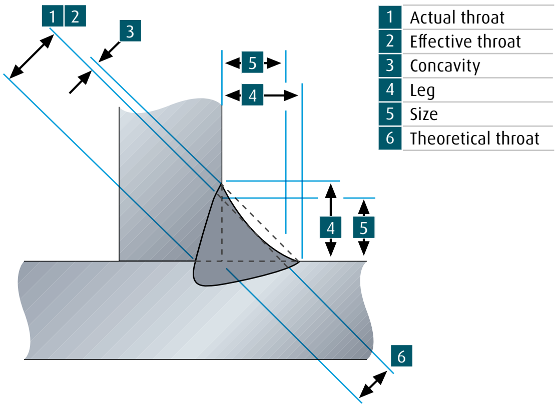
Convex Fillet Weld



Concave fillet weld

A fillet in which the contour of the weld is below a straight line joining the toes of the weld. It should be noted that a concave fillet weld of a specified leg length has a throat thickness less than the effective throat thickness for that size fillet. This means that, when a concave fillet weld is used, the throat thickness must not be less than the effective measurement. This entails an increase in leg length beyond the specified measurement

Concave Fillet Weld



The size of a fillet weld is affected by the electrode size, welding speed or run length, welding current and electrode angle. Welding speed and run length have an important effect on the size and shape of the fillet, and on the tendency to undercut.

Insufficient speed causes the molten metal to pile up behind the arc and eventually to collapse. Conversely, excessive speed will produce a narrow irregular run having poor penetration, and where larger electrodes and high currents are used, undercut is likely to occur.

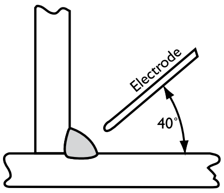
Fillet weld data

Nominal Fillet Size (mm)	Min. Throat Thickness (mm)	Plate Thickness (mm)	Electrode Size (mm)
5,0	3,5	5,0 – 6,3	3,2
6,3	4,5	6,3 – 12,0	4,0
8,0	5,5	8,0 – 12,0 and over	5,0
10,0	7,0	10,0 and over	4,0

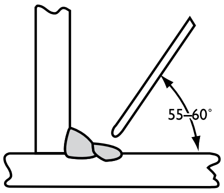
Selection of welding current is important. If it is too high, the weld surface will be flattened and undercut accompanied by excessive spatter is likely to occur. Alternatively, a current which is too low will produce a rounded narrow bead with poor penetration at the root. The first run in the corner of a joint requires a suitably high current to achieve maximum penetration at the root. A short arc length is recommended for fillet welding. The maximum size fillet which should be attempted with one pass of a large electrode is 8,0 mm. Efforts to obtain larger leg lengths usually result in collapse of the metal at the vertical plate and serious undercutting. For large leg lengths, multiple run fillets are necessary. These are built up as shown below. The angle of the electrode for various runs in a downhand fillet weld is also shown.

Recommended electrode angles for fillet welds

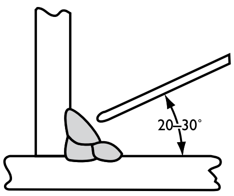
1st Run



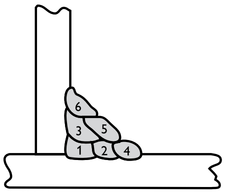
2nd Run



3rd Run



Multi-run Fillet



Multi-run (multi-pass) horizontal fillets have each run made using the same run lengths (Run Length per Electrode table). Each run is made in the same direction, and care should be taken with the shape of each, so that it has equal leg lengths and the contour of the completed fillet weld is slightly convex with no hollows in the face.

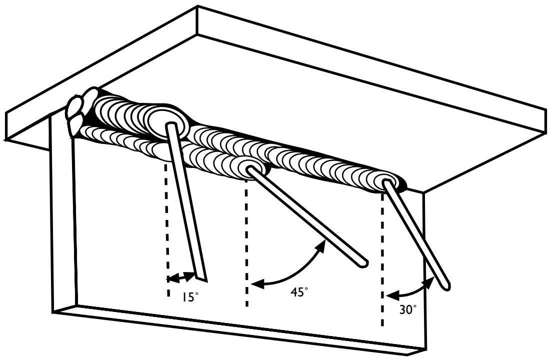
Vertical fillet welds can be carried out using the upwards or downwards technique. The characteristics of each are: Upwards – current used is low, penetration is good, surface is slightly convex and irregular. For multiple run fillets, large single-pass weaving runs can be used. Downwards – current used is medium, penetration is poor, each run is small, concave and smooth.

The downwards method should be used for making welds on thin material only. Electrodes larger than 4,0 mm are not recommended for vertical-down welding. All strength joints in vertical plates 10,0 mm thick or more should be welded using the upward technique. This method is used because of its good penetration and weld metal quality. The first run of a vertical-up fillet weld should be a straight sealing run made with 3,2 mm or 4,0 mm diameter electrode. Subsequent runs for large fillets may be either numerous straight runs or several wide weaving runs.

Correct selection of electrodes is important for vertical welding.

In overhead fillet welds, careful attention to technique is necessary to obtain a sound weld of good profile. Medium current is required for best results. High current will cause undercutting and bad shape of the weld, while low current will cause slag inclusions. To produce a weld having good penetration and of good profile, a short arc length is necessary. Angles of electrode for overhead fillets is illustrated below.

Recommended Electrode Angles for Overhead Fillet Welds



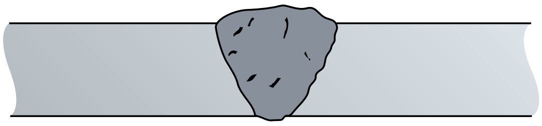
Welding Defects and Problems

Manual metal arc welding, like other welding processes, has welding procedure problems that may develop and which can cause defects in the weld. Some defects are caused by problems with the materials. Other welding problems may not be foreseeable and may require immediate corrective action. A poor welding technique and improper choice of welding parameters can cause weld defects.

Defects that can occur when using the shielded metal arc welding process are slag inclusions, wagon tracks, porosity, wormhole porosity, undercutting, lack of fusion, overlapping, burn through, arc strikes, craters and excessive weld spatter. Many of these welding technique problems weaken the weld and can cause cracking. Other problems that can occur and which can reduce the quality of the weld are arc blow, finger nailing and improper electrode coating moisture contents.

Defects Caused by Welding Technique

Slag inclusions



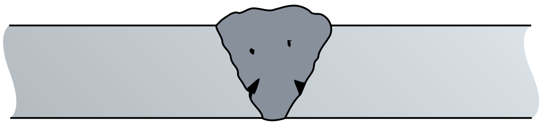
Slag inclusions occur when slag particles are trapped inside the weld metal, which produces a weaker weld. These can be caused by:

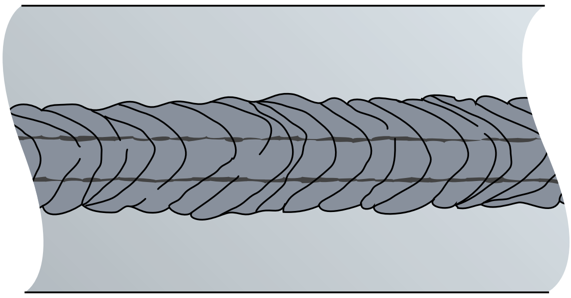
- Erratic travel speed
- Too wide a weaving motion
- Slag left on the previous weld pass
- Too large an electrode being used
- Letting slag run ahead of the arc.

This defect can be prevented by:

- A uniform travel speed
- A tighter weaving motion
- Complete slag removal before welding
- Using a smaller electrode
- Keeping the slag behind the arc, which is done by shortening the arc, increasing the travel speed or changing the electrode angle.

Wagon tracks

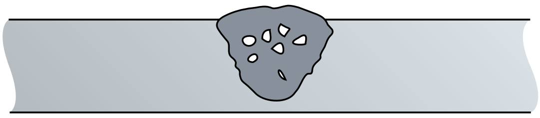




Top view through transparent bead

Wagon tracks are linear slag inclusions that run the longitudinal axis of the weld. They result from allowing the slag to run ahead of the weld puddle and by slag left on the previous weld pass. These occur at the toe lines of the previous weld bead.

Porosity



Porosity is gas pockets in the weld metal that may be scattered in small clusters or along the entire length of the weld. Porosity weakens the weld in approximately the same way that slag inclusions do.

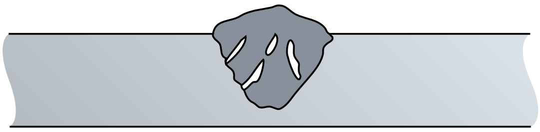
Porosity may be caused by:

- Excessive welding current
- Rust, grease, oil or dirt on the surface of the base metal
- Excessive moisture in the electrode coatings
- Impurities in the base metal
- Too short an arc length, except when using low hydrogen or stainless steel electrodes
- Travel speed too high, which causes freezing of the weld puddle before gases can escape.

This problem can be prevented by:

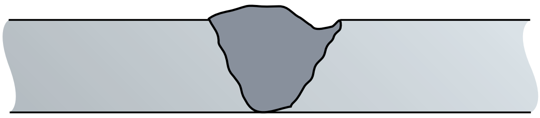
- Lowering the welding current
- Cleaning the surface of the base metal
- Re-drying electrodes
- Changing to a different base metal with a different composition
- Using a slightly longer arc length
- Lowering the travel speed to let the gases escape
- Preheating the base metal, using a different type of electrode, or both.

Wormhole porosity (Piping porosity)



Wormhole porosity is the name given to elongated gas pockets. The best method of preventing this is to lower the travel speed to permit gases to escape before the weld metal freezes.

Undercutting



Undercutting is a groove melted in the base metal next to the toe or root of a weld that is not filled by the weld metal. Undercutting causes a weaker joint and it can cause cracking. This defect is caused by:

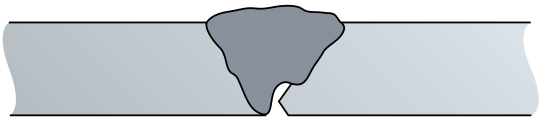
- Excessive welding current
- Too long an arc length

- Excessive weaving speed
- Excessive travel speed.

On vertical and horizontal welds, it can also be caused by too large an electrode size and incorrect electrode angles. This defect can be prevented by:

- Choosing the proper welding current for the type and size of electrode and the welding position
- Holding the arc as short as possible
- Pausing at each side of the weld bead when a weaving technique is used
- Using a travel speed slow enough so that the weld metal can completely fill all of the melted out areas of the base metal.

Lack of fusion



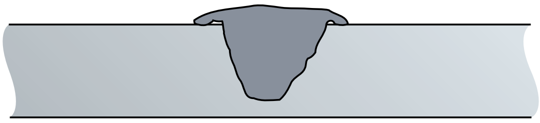
Lack of fusion is when the weld metal is not fused to the base metal. This can occur between the weld metal and the base metal or between passes in a multiple-pass weld. Causes of this defect can be:

- Excessive travel speed
- Electrode size too large
- Welding current too low
- Poor joint preparation
- Letting the weld metal get ahead of the arc.

Lack of fusion can usually be prevented by:

- Reducing the travel speed
- Using a smaller diameter electrode
- Increasing the welding current
- Better joint preparation
- Using a proper electrode angle.

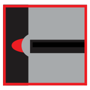
Overlapping



Overlapping is the protrusion of the weld metal over the edge or toe of the weld bead. This defect can cause an area of lack of fusion and create a notch, which can lead to crack initiation. Overlapping is often produced by:

- Too slow a travel speed, which permits the weld puddle to get ahead of the electrode
- An incorrect electrode angle.

Legend to Welding Position Abbreviations

Symbol	Abbreviation	Description
	F	Flat
	H-V FILLET	Horizontal-Vertical Fillet
	H	Horizontal
	V	Vertical
	V-DOWN	Vertical-Down
	OH	Overhead

Coating Types

It is the composition of the coating that differentiates one type of electrode from another and, to a degree, what type of application it can be used for. MMA electrodes, with a solid wire core, are generally categorised by the type of flux coating they employ. There are three main groups of electrode coating: rutile, basic and cellulosic, plus a less widely used acid type. The name of each group is a description of the main constituent of the coating. Although not strictly a coating type, iron powder electrodes are often considered as a separate group.

Electrodes for cutting, grooving and gouging, plus those for hard surfacing, including tubular MMA electrodes, are not classified by coating type.

Rutile Electrodes

Rutile electrodes have a coating that contains about 50% rutile sand (a pure form of titanium dioxide), plus additions of ferro-manganese, mineral carbonates and silicates, held together with approximately 15% sodium silicate, also known as waterglass. The rutile's characteristics include easy striking, stable arc, low spatter, good bead profile and, generally, easy slag removal from the electrode.

The electrode can operate on both AC and DC currents and can operate in all positions if the formulation of the coating is so designed.

One negative aspect of these electrodes is that they produce a high level of hydrogen, typically greater than 15 ml/100 g of deposited weld metal. This cannot be avoided, because they rely on a certain amount of moisture being present in the coating to operate properly. If the electrodes are dried too much, they will fail to function properly.

Rutile coated electrodes are manufactured for welding mild and low carbon steels. In this context, they are often referred to as general purpose or GP electrodes. Some low alloy grades also use rutile coatings. Rutile type coatings, which are modifications of those used for ferritic steels, are also used on many austenitic stainless steel electrodes.

Basic Electrodes

Basic, or low hydrogen electrodes contain calcium carbonate and calcium fluoride in place of the rutile sand and mineral silicates. This makes them less easy to strike and more difficult to re-strike, due to the very deep cup formed at the tip during operation. They also have a poorer, more convex bead profile than rutile electrodes. The slag is more difficult to remove than the rutile types, but they do give better weld metal properties than rutile types, with a higher metallurgical quality.

Basic electrodes are capable of being used on AC or DC currents and can be used in multi-pass welds on materials of all thicknesses.

Basic electrodes do not rely on moisture to function properly, and for the more critical applications should be used completely dry. It is important to note that basic electrodes are only low hydrogen electrodes if they have been correctly dried before use. This conventionally involves re-drying in ovens on site in accordance with manufacturers' recommendations. Drying can reduce weld metal hydrogen to less than 5 ml/100 g, as can vacuum-packing the electrodes.

Cellulosic Electrodes

Cellulosic electrodes contain a high proportion of organic material, replacing all or some of the rutile sand. This produces a fierce, deep penetrating arc and a faster burn-off rate. Cellulosic electrodes are more prone to spatter than rutile types. Only carbon and some low alloy steels are made with a cellulosic coating and most run only on DC+ polarity, but some are made that will also operate on AC and DC-. They are truly all-positional electrodes in all sizes and even larger diameters up to 6 mm will operate vertical-down. Cellulosic electrodes are used for root passes and pipeline welding.

It should be noted that cellulosic electrodes generate high amounts of hydrogen. This presents a risk of hydrogen-induced cracking if correct welding procedures are not followed.

Acid Electrodes

Acid electrodes for mild steels have been largely replaced by rutile types, but some are still produced by a few manufacturers. These electrodes contain high amounts of iron oxide, are relatively easy to use and give a voluminous glassy slag that detaches easily. They are lower-strength products, so they are confined to use on non-structural components.

Acid-rutile electrodes for stainless steel are now replacing conventional rutile types. They are higher in silicon, which gives improved operating and wetting characteristics, and they are much more welder-friendly. They strike and re-strike readily and will operate on AC and DC current. They produce low spatter levels and an easily removed slag. However, they are prone to 'start porosity' and need re-drying before use to avoid this.

Iron Powder Electrodes

Iron powder electrodes are often considered an independent group of consumables. As their name suggests, these electrodes contain high levels of iron powder held within the coating – as the coating melts, the iron powder creates more weld metal. This effectively improves the productivity from the electrode, allowing either larger or longer welds to be created from a single rod. The amount of iron powder added depends on the consumable being produced, but it is not uncommon for 75% of the core weight to be added.

The addition of the iron powder to the coating has the effect of increasing the overall diameter of the electrode and reducing the amount of fluxing agent present in the coating. With less fluxing agent available, the slag coating tends to be thinner, so many of the MMA electrode's positional welding characteristics are lost. This means that many of the electrodes can only be used in the flat or horizontal-vertical (H-V) positions.

Coatings for iron powder electrodes may be based on either the rutile or basic systems.

Fundamentals of Metal Inert Gas (MIG) Welding

Welding Technique

Successful welding depends on the following factors:

- Selection of correct consumables
- Selection of the correct power source
- Selection of the correct shielding gas
- Selection of the correct application techniques:
    - Correct angle of electrode to work
    - Correct electrical stick out
    - Correct travel speed
- Selection of the welding preparation.

Selection of Correct Consumables

Chemical composition

As a general rule, the selection of a wire is straightforward, in that it is only a matter of selecting an electrode of similar composition to the parent material. However, there are certain applications for which electrodes will be selected on the basis of mechanical properties or the level of residual hydrogen in the weld metal. Solid MIG wires are all considered to be of the 'low hydrogen type' consumables.

Physical condition

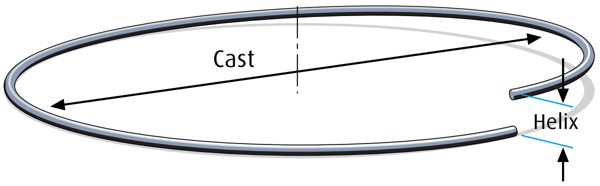
Surface condition

The welding wire must be free from any surface contamination, including mechanical damage such as scratch marks.

A simple test for checking the surface condition is to run the wire through a cloth that has been dampened with acetone for 20 seconds. If a black residue is found on the cloth, the surface of the wire is not properly cleaned.

Cast and helix

The cast and helix of the wire has a major influence on the feedability of MIG wire.



Cast – Diameter of the circle

Helix – Vertical height

If the cast is too small, the wire will dip down from the tip. The result of this is excessive tip wear and increased wear in the liners.

If the helix is too large, the wire will leave the tip with a corkscrew effect and cause feeding problems.

Selection of the Correct Power Source

Power sources for MIG/MAG welding are selected on a number of different criteria, including:

- Maximum output of the machine
- Duty cycle
- Output control (voltage selection, wire feed speed control)
- Portability.

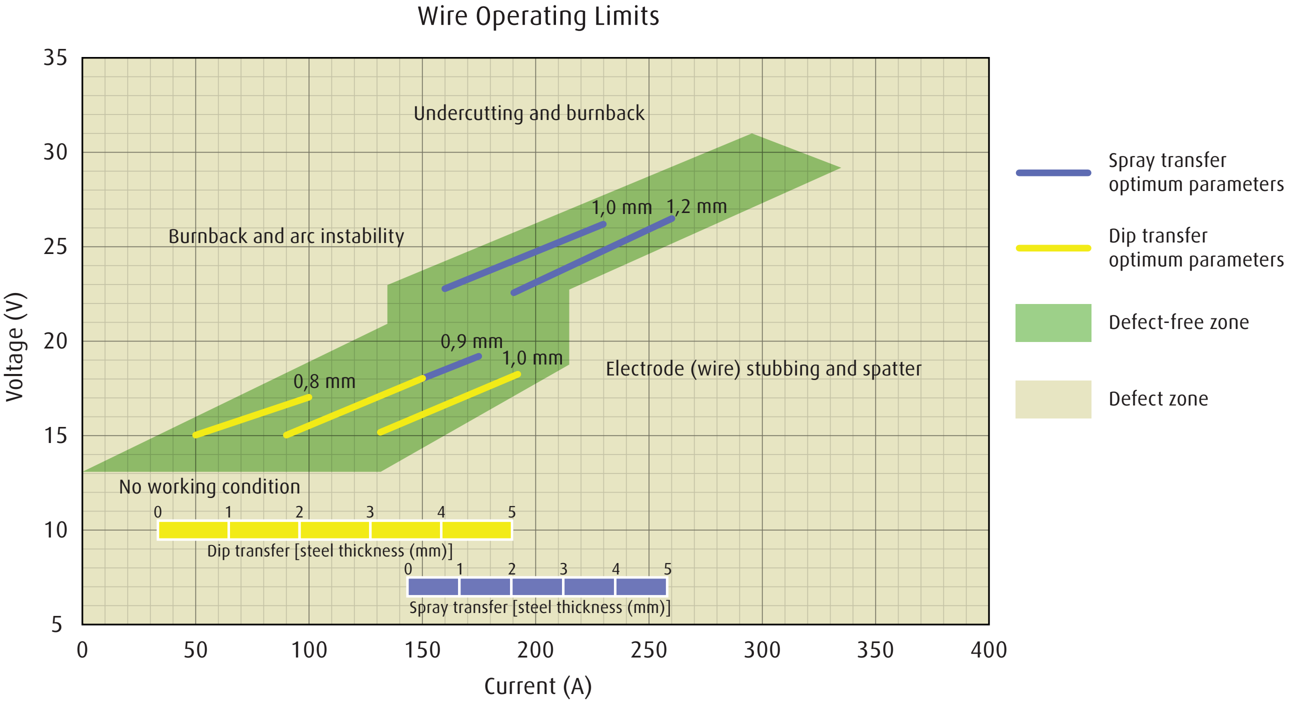
The following table and diagram gives an indication of the operating amperage for different size wires.

Wire Size (mm)	Amperage Range (A)
0,8	60 – 180
0,9	70 – 250
1,0	90 – 280
1,2	120 – 340

Selection of the Correct Shielding Gas

The selection of the shielding gas has a direct influence on the appearance and quality of the weldbead.

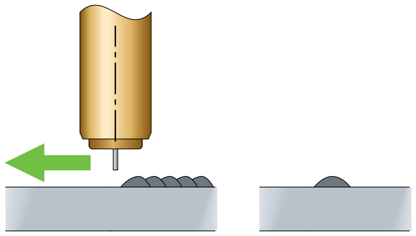
The type and thickness of the material to be welded will determine the type of shielding gas that is selected. As a general rule, the thicker the material (CMn and alloy steels), the higher the percentage of CO_2 in the shielding gas mixture.



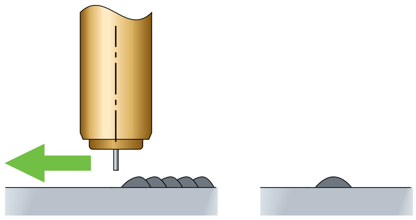
Correct Application Techniques

Direction of welding

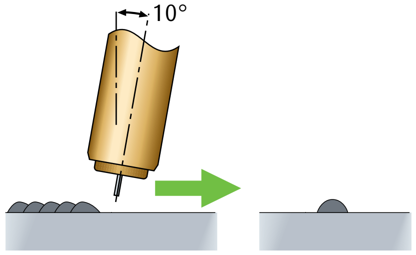
MIG welding with solid wires takes place normally with a push technique. The welding gun is tilted at an angle of 10° towards the direction of welding (push technique).



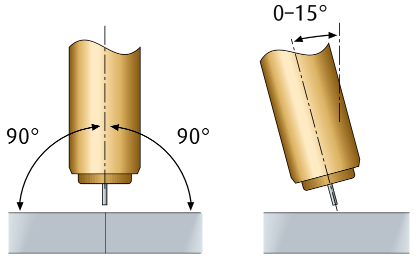
The influence of changing the torch angle and the welding direction on the weld bead profile can be seen below.



Torch perpendicular to workpiece. Narrow bead width with increased reinforcement.

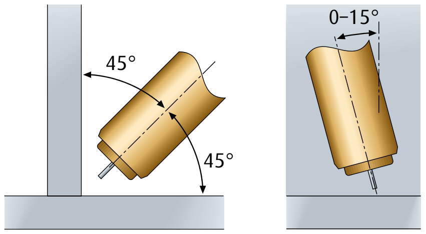


Torch positioned at a drag angle of 10°. Narrow bead width with excessive reinforcement.



Torch position for butt welds

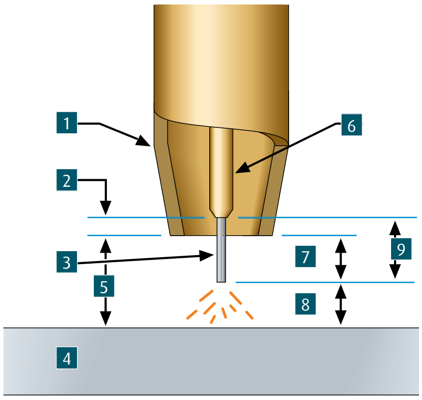
When welding butt welds, the torch should be positioned within the centre of the groove and tilted at an angle of ±15° from the vertical plane. Welding is still performed in the push technique.



Torch position for fillet welds

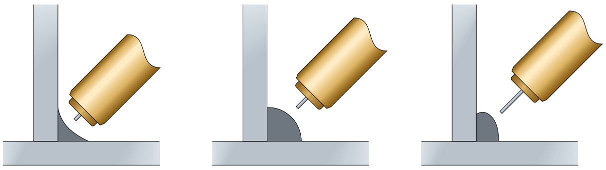
When welding fillet welds, the torch should be positioned at an angle of 45° from the bottom plate, with the wire pointing into the fillet corner. Welding is still performed in the push technique.

Electrical stick out



1	Gas nozzle
2	Contact tube setback
3	Consumable electrode
4	Workpiece
5	Standoff distance
6	Contact tube
7	Visible stick out
8	Arc length
9	Electrical stick out

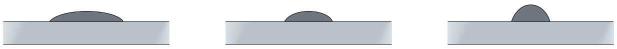
The electrical stick out is the distance between the end of the contact tip and the end of the wire. An increase in the electrical stick out results in an increase in the electrical resistance. The resultant increase in temperature has a positive influence in the melt-off rate of the wire that will have an influence on the weldbead profile.



Short Normal Long

Influence of the change in electrical stick out length on the weldbead profile.

Travel speed



Slow Normal Fast

The travel speed will influence the weldbead profile and the reinforcement height.

If the travel speed is too slow, a wide weldbead with excessive rollover will result. Conversely, if the travel speed is too high, a narrow weldbead with excessive reinforcement will result.

Fundamentals of Flux and Metal Cored Arc Welding

Welding Technique

Successful flux and metal cored arc welding depends on the following factors:

- Selection of correct consumables
- Selection of the correct power source
- Selection of the correct shielding gas
- Selection of the correct application techniques:
    - Correct angle of electrode to work
    - Correct electrical stick out
    - Correct travel speed
- Selection of the welding preparation.

Selection of Correct Consumables

Chemical composition

As a general rule, the selection of a wire is straightforward, in that it is only a matter of selecting an electrode of similar composition to the parent material. However, there are certain applications for which electrodes will be selected on the basis of mechanical properties or the level of residual hydrogen in the weld metal. The classification system for flux cored wires will provide an indication of the residual hydrogen level that can be expected in the weldmetal.

Physical condition

The wire must be free from any surface contamination, including surface rust. Most flux and metal cored wires have a thin film of graphite on the surface of the wire to assist with feedability.

The AWS standard for flux cored wires does not specify a cast or helix, other than to stipulate that it should be of such a nature that the wire can be fed uninterrupted.

Selection of the Correct Power Source

Power sources for flux and metal cored welding are selected on a number of different criteria, including:

- Maximum output of the machine
- Duty cycle
- Output control (voltage selection, wire feed speed control)
- Portability.

The following table gives an indication of the operating amperage for different size wires.

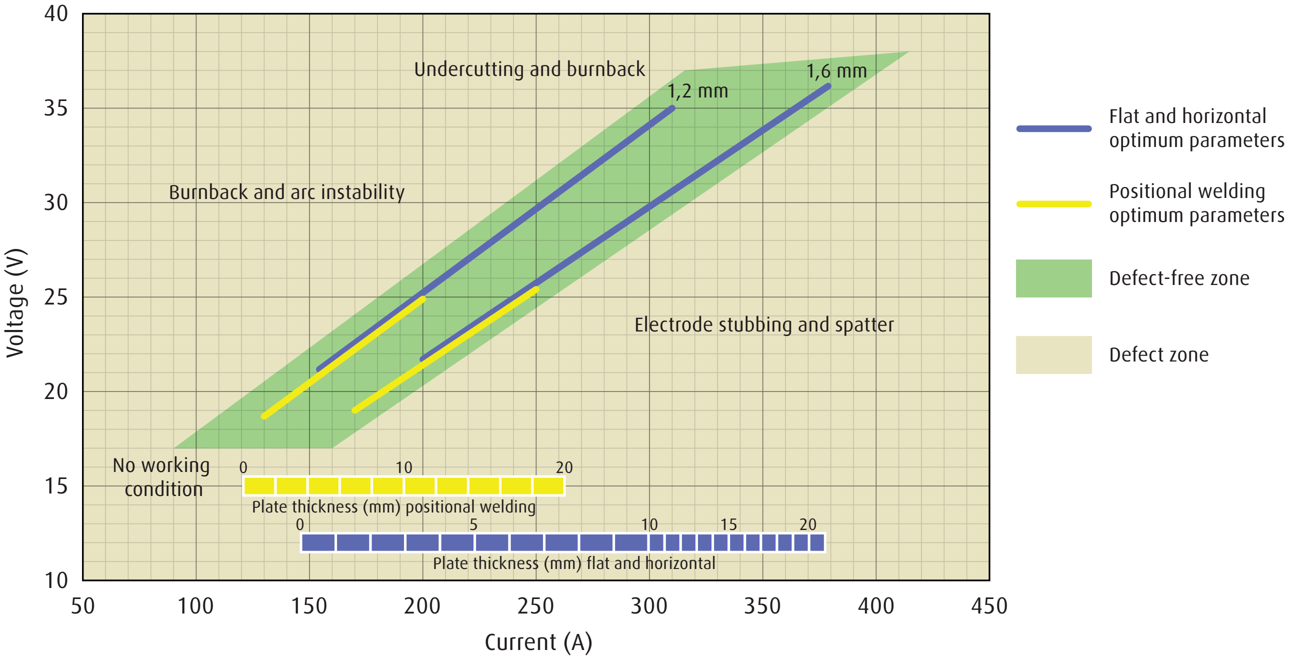
Wire Size (mm)	Direction	Amperage Range (A)
FCAW		
1,2	Horizontal	200 – 300
1,2	Vertical-up	150 – 250
1,6	Horizontal	300 – 400
1,6	Vertical-up	180 – 250
MCAW		
1,2	Horizontal	150 – 350
1,6	Horizontal	300 – 500

Selection of the Correct Shielding Gas

The selection of the shielding gas has a direct influence on the appearance and quality of the weldbead.

Flux cored wires are manufactured to be welded with either 100% CO_2 or an argon-CO_2 gas mixture.

Current/Voltage Envelope for Argoshield® 52



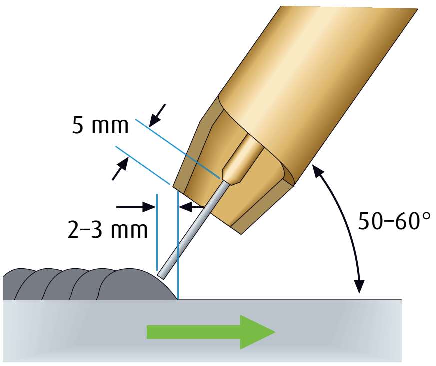
Correct Application Techniques

Direction of travel

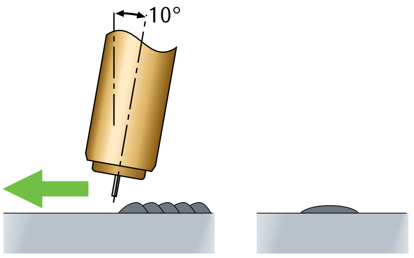
Flux cored welding is normally performed using a 'drag' technique. The welding gun is tilted to a 50–60° backhand angle. If, however, a flatter bead profile is required, the backhand angle can be reduced.

Metal cored wire, because of its similarity to solid wires (no slag formers added to the core mainly metallic powders), are normally welded with the 'push' technique.

Travel direction (Flux cored)

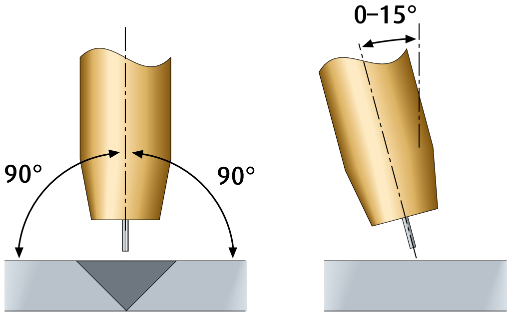


Travel direction (Metal cored)

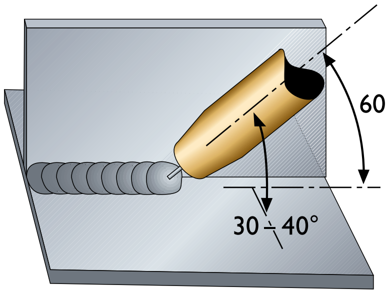


When welding butt welds with flux or metal cored wires, the torch should be positioned within the centre of the groove and tilted at an angle of ±20°. Flux cored welding is still performed with the 'drag' technique and metal cored welding with the 'push' technique.

Torch position for butt welds



Torch angle for fillet welds

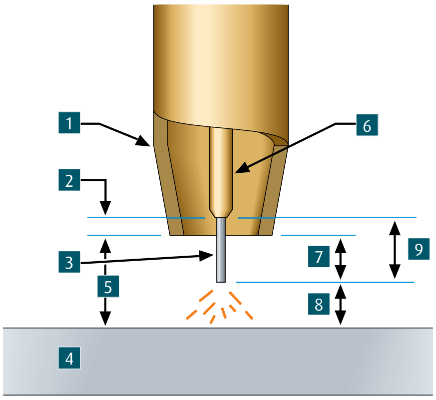


When welding horizontal-vertical fillet welds, the wire tip must be aimed exactly in the corner of the joint. For the first bead, the welding gun is tilted at an angle of 30–40° from the horizontal plane. Flux cored welding is still performed with the 'drag' technique and metal cored welding with the 'push' technique.

Vertical-up

Vertical-up welding can be undertaken in a similar way, as MMA with a slight weave motion. Vertical-up welding with metal cored wire can successfully be undertaken with pulsed MIG welding equipment.

Electrical stick out



1	Gas nozzle
2	Contact tube setback
3	Consumable electrode
4	Workpiece
5	Standoff distance
6	Contact tube
7	Visible stick out
8	Arc length
9	Electrical stick out

The electrical stick out is the distance between the end of the contact tip and the end of the wire. An increase in the electrical stick out results in an increase in the electrical resistance. The resultant increase in temperature has a positive influence in the melt-off rate of the wire that will have an influence on the weldbead profile.

Travel speed

The construction of flux and metal cored wires ensures the highest current density for a given current setting compared to all other welding processes.

High current densities produce high deposition rates.

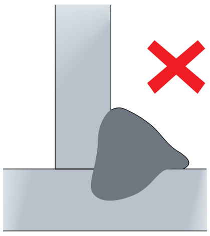
$$\textbf{Current Density} = \frac{\text{Amperage}}{\text{Cross-sectional area of wire}}$$

$$\textbf{or J} = \frac{I}{A}$$

Electrode / Wire	Diameter (mm)	Cross Section Area (mm²)	Current (A)	Current Density (A/mm²)	Deposition Rate (kg/h)
MMA electrode (E7024)	4,0	12,57	235	18,7	3,0
FCAW wire (E71T-1)	1,2	0,625	235	376,0	3,8
MIG wire (ER70S-6)	1,2	1,130	235	287,5	3,3
MCAW wire (E70C-6M)	1,2	0,625	300	480,0	5,2

Consequently, travel speed must be increased proportionately to maintain control of the weld pool and bead shape, and to balance the deposited weld metal versus fusion obtained.

Travel speed too slow

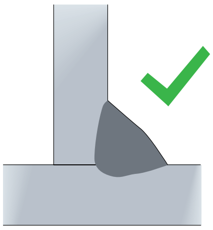


Excessive penetration

Excessive weld metal deposited

Roll over of weld metal on horizontal plate

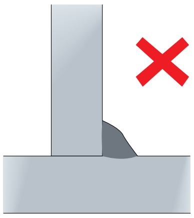
Correct travel speed



Recommended penetration depth

Proper sidewall fusion without roll over or undercut

Travel speed too fast



Weld bead too small

Inadequate sidewall fusion

Lack of root penetration

MMA Electrodes

Vitemax®

Vitemax® is a premium quality rutile electrode for use in all positions including vertical downwards. The electrode has a smooth, quiet arc action, low spatter loss with good striking and restrike characteristics and excellent slag detachability. In most cases the slag is self-lifting. The electrode welds relatively cold which makes it ideally suited for bridging large gaps, i.e. where poor fit-up occurs and for tacking. This versatile electrode, which has a rapid burn-off rate, produces smooth welds in all positions. The weld metal deposited complies with radiographic quality to AWS A5.1 grade 1.

Applications

Vitemax® is recommended for welding a wide variety of carbon-manganese steels having a carbon equivalent below 0,28%. It can also be used successfully in applications with higher carbon equivalents, provided the correct degree of preheat is used.

Technique

Either the touch or free arc technique can be used. For vertical-down welding, the touch weld technique must be used with a high rate of travel.

Re-drying Procedure

Rutile coated electrodes do not normally require re-drying prior to use, however if suspected of being damp, as shown by an erratic arc behaviour, the electrodes should be re-dried at 100-120°C for 1–2 hours.

Classifications		
AWS	A5.1	E6013
EN	2560	E 38 0 RC 11

Approvals
Lloyds Register of Shipping Grade DXVuO,BF,2m,NR
American Bureau of Shipping Grade 2
Germanischer Lloyd Grade 2
Det Norske Veritas (DNV)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 - 0,1	% Sulphur	0,025 max
% Manganese	0,35 - 0,6	% Phosphorous	0,025 max
% Silicon	0,2 - 0,5		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	400 MPa min
Tensile Strength	460 - 530 MPa
% Elongation on 50 mm	24 min
Charpy V-Notch at +20°C	70 J min
Charpy V-Notch at 0°C	50 J min

Typical Current Values (AC 50 OCV min or DC+/-)	
Diameter (mm)	**Current (A)**
2,0	40 - 80
2,5	60 - 95
3,15	110 - 130
4,0	140 - 165
5,0	170 - 260

Deposition Data

Note:

1) The deposition data given was established at the optimum current rating which would be approximately in the middle of the specified range.

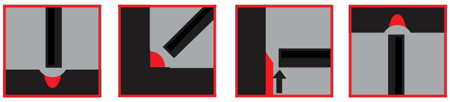
2) The mass of weld metal deposited per arc hour is a theoretical value which does not take into account welder efficiency.

Diameter (mm)	Mass of an Electrode (g)	Burn-off Time (sec)	Mass of Metal Deposited per Electrode (g)	Mass of Weld Metal Deposited per Arc Hour (g)	No. Electrodes per kg of Weld Metal	kg Weld Metal per kg of Electrodes
2,0	11,2	54,2	5,6	371	180	0,49
2,5	19,9	68,0	11,1	552	91	0,55
3,15	29,7	72,2	17,6	931	57	0,59
4,0	48,7	86,7	28,2	1 172	36	0,58
5,0	87,9	120,2	56,9	1 703	18	0,64

Data for Welding Horizontal Fillet Welds					
Diameter (mm)	**Throat Thickness (mm)**	**Current (A)**	**Arc Time (sec)**	**Bead Length per Electrode (mm)**	**Welding Speed (m/hr)**
2,0	1,5	65	39,5	139	12,7
2,5	2,8	85	55,1	198	13,6
3,15	3,5	125	61,1	202	11,9
4,0	4,0	165	69,0	207	10,8
5,0	5,0	230	105,7	313	10,7

Packing Data					
Diameter (mm)	**Electrode Length (mm)**	**Item Number (1 kg pack)**	**Item Number (multi-kg pack)**	**Pack Mass (kg)**	**Approx. No. Electrodes/kg**
2,0	300	W072001	W075001	3 x 4,0	89
2,5	350	W072002	W075002	3 x 5,0	50
3,15	350	W072003	W075003	3 x 5,0	34
4,0	350	W072004	W075004	3 x 5,0	21
5,0	450	–	W075005	3 x 6,0	11

ARCmate 6013



ARCmate 6013 is a standard general purpose rutile type electrode for welding mild steels in all positions using AC/DC power source. The electrode performs exceptionally when compared to other equivalent product and displays good properties such as good striking, arc stability, low spatter, easy re-striking and slag removal.

Applications

For general DIY welding of mild steels.

Classifications

AWS	A5.1	E6013
EN ISO	2560	E350 RC 11

Chemical Composition (Typical)

% Carbon	0,06	**% Sulphur**	<0,02	**% Chromium**	0,05
% Manganese	0,40	**% Phosphorous**	0,013	**% Molybdenum**	0,01
% Silicon	0,25	**% Nickel**	0,02	**% Vanadium**	0,02

Typical Mechanical Properties (All weld metal in the as welded condition)

Yield Strength	>400 MPa
Tensile Strength	>500 MPa
% Elongation on 50 mm	>25
Charpy V-Notch at +20˚C	>70 J
Charpy V-Notch at 0˚C	>40 J

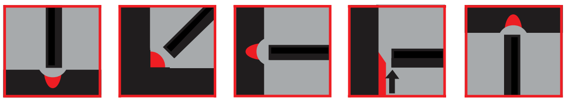
Typical Current Values (AC 50 OCV min or DC+/-)

Diameter (mm)	Current (A)
2,5	60 - 85
3,15	110 - 130
4,0	140 - 165

Packing Data

Diameter (mm)	Electrode Length (mm)	Item Number	Pack Mass (kg)
2,5	350	W075152	5,0
3,15	350	W075153	5,0
4,0	350	W075154	5,0
2,5	350	W072152	1,0
3,15	350	W072153	1,0

Transarc® 6013



Transarc® 6013 is a newly developed electrode from Afrox, produced locally at the world class manufacturing facility in Brits. The Brits consumables factory adopts the best manufacturing practices and standards and undergoes regular audits from approval bodies such as TÜV and SABS, ensuring that quality is not compromised and the highest standards are maintained on all the products.

Transarc® 6013 is a rutile electrode of a very good quality for welding mild steels. Transarc® 6013 has been developed and produced with a brand new formulation after extensive research.

Applications

Suitable electrode for mild steel welding, fillet, tack and butt welding, and for bridging large joint gaps and welding that requires a smooth and clean bead appearance.

Classifications		
AWS	A5.1	E6013
EN ISO	2560	E 350 RC 11

Typical Chemical Analysis (All weld metal)			
% Carbon	0,04 - 0,055	**% Molybdenum**	0,002
% Manganese	0,5 - 0,6	**% Nickel**	0,001
% Silicon	0,2 - 0,35	**% Vanadium**	0,018

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	507 MPa min
Tensile Strength	546 MPa
% Elongation on 50 mm	23 min

Typical Current Values (AC 50 OCV min or DC+/-)

Diameter (mm)	Current (A)
2,5	60 - 95
3,15	110 - 130
4,0	140 - 165

Packing Data

Diameter (mm)	Electrode Length (mm)	Item Number (1 kg pack)	Item Number (multi-kg pack)	Pack Mass (kg)
2,5	350	W072132	W075132	5,0
3,15	350	W072133	W075133	5,0
4,0	350	W072134	W075134	5,0

12

Afrox Afrolux

Afrolux is a heavily coated rutile iron powder electrode for high speed welding of H-V fillets and flat butt joints. Using the touch or free arc techniques, the electrode deposits a very neat, finely rippled weld from which the slag is easily removed. The arc is smooth and stable with very little spatter. Striking and restriking qualities are excellent. Afrolux has a weld metal recovery of approximately 160%.

Applications

Afrolux is eminently suitable for welding fillet and butt welds in mild steel for general fabrication work.

Technique

The best results are obtained using the touch welding technique with the electrode held at a sufficient angle to prevent the molten slag from crowding the arc. AC is recommended as it reduces arc blow, particularly at the high currents required with large diameter electrodes.

Re-drying Procedure

Normally re-drying of Afrolux is not necessary, however the molten slag of damp electrodes will tend to crowd the arc even when the correct technique is used. Damp electrodes should be re-dried at 100-120°C for 1-2 hours.

Classifications		
AWS	A5.1	E7024-1
EN ISO	2560-A	E 42 0 RR 13

Approvals
Lloyds Register of Shipping Grade D,BF,2m,2Ym,No
American Bureau of Shipping Grade 2
Bureau Veritas Grade 2

Typical Chemical Analysis (All weld metal)			
% Carbon	0,04 - 0,12	**% Sulphur**	0,025 max
% Manganese	0,6 - 1,2	**% Phosphorous**	0,025 max
% Silicon	0,2 - 0,6		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	420 MPa min
Tensile Strength	510 - 560 MPa
% Elongation on 50 mm	22 min
Charpy V-Notch at +20°C	80 J min
Charpy V-Notch at 0°C	60 J min
Charpy V-Notch at -18°C	40 J min

Typical Current Values (AC 50 OCV min or DC+/-)	
Diameter (mm)	**Current (A)**
2,5	70 - 115
3,15	120 - 155
4,0	160 - 225
5,0	220 - 335

Deposition Data

Note:

1) The deposition data given was established at the optimum current rating which would be approximately in the middle of the specified range.

2) The mass of weld metal deposited per arc hour is a theoretical value which does not take into account welder efficiency.

Diameter (mm)	Mass of an Electrode (g)	Burn-off Time (sec)	Mass of Metal Deposited per Electrode (g)	Mass of Weld Metal Deposited per Arc Hour (g)	No. Electrodes per kg of Weld Metal	kg Weld Metal per kg of Electrodes
2,5	30,3	63,2	32,7	1 139	48	0,61
3,15	66,9	77,0	54,1	1 944	25	0,61
4,0	102,4	84,9	108,4	2 755	16	0,62
5,0	157,7	91,0	164,3	3 694	8	0,63

Data for Welding Horizontal Fillet Welds

Diameter (mm)	Throat Thickness (mm)	Current (A)	Arc Time (sec)	Bead Length per Electrode (mm)	Welding Speed (m/h)
2,5	2,9	90	64,8	240	13,3
3,15	3,1	135	88,2	360	14,7
4,0	3,8	200	93,6	432	16,6
5,0	4,1	275	102,0	528	18,6

Packing Data

Diameter (mm)	Electrode Length (mm)	Approx. No. Electrodes/kg	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	350	30,0	3 x 4,0	W075202
3,15	450	16,0	3 x 5,0	W075203
4,0	450	11,0	3 x 5,0	W075204
5,0	450	7,0	3 x 5,0	W075205

Afrox 7018-1

Afrox 7018-1 is an AC/DC all-position basic coated hydrogen-controlled electrode of premium quality. It was designed for applications where fracture toughness and the most severe X-ray requirements in all positions are required. This electrode combines outstanding all-positional welding characteristics, excellent bead profile and appearance in both root and capping passes with a smooth stable arc and quick freezing weld metal. Its ability to operate at lower than normal currents and give a fully penetrating weld bead is of particular significance for root runs which are inaccessible for back gouging. These properties give the electrode outstanding welder appeal.

Applications

Afrox 7018-1 is used for the welding of a variety of carbon-manganese and low alloy steels used in the fabrication of pressure vessels, pipe work and in general structural fabrication work. It is recommended for applications where severe X-ray requirements and mechanical properties have to be met.

Technique

As with all basic hydrogen-controlled electrodes, as short an arc as possible should be kept at all times. When starting with a new electrode, the arc should be initiated a short distance ahead of the start or crater and worked back over this distance before continuing the weld in the required direction. On larger size joints, several stringer beads should be used where possible in preference to one large weaved bead to ensure optimum mechanical properties. DC- should be used for root passes where poor fit-up is a factor to be taken into account.

Re-drying Procedure

Hydrogen-controlled electrodes must be re-baked prior to use, the baking temperature required being governed by the maximum hydrogen content tolerable in the deposited weld metal. For a maximum of 5-10 ml H_2/100 g, re-bake at a temperature of 350-370˚C for 1-2 hours. (Please consult the section regarding the storage, handling and treatment of low hydrogen electrodes.)

Afrox 7018-1 is manufactured and tested in accordance with the requirements of AWS A5.01. Different class and schedules can be provided upon request.

Classifications

AWS	A5.1	E7018-1 H4
EN	2560-A	E 42 4 B 32 H5

Approvals

Lloyds Register of Shipping Grade DXVuO,BF,3m,3Ym,H15

American Bureau of Shipping Grade 3Y,3H

TÜV

Bureau Veritas Grade 3Y H5

Typical Chemical Analysis (All weld metal)

% Carbon	0,05 - 0,09	**% Sulphur**	0,025 max
% Manganese	1,3 - 1,5	**% Phosphorous**	0,025 max
% Silicon	0,25 - 0,45		

Typical Mechanical Properties (All weld metal)

As Welded		**Stress Relieved (630˚C for 8 hours)**	
0,2% Proof Stress	420 MPa min	**0,2% Proof Stress**	350 MPa min
Tensile Strength	510 - 570 MPa	**Tensile Strength**	485 MPa min
% Elongation on 50 mm	26 min	**% Elongation on 50 mm**	22 min
Charpy V-Notch at -29˚C	130 J min	**Charpy V-Notch at -29˚C**	80 J min
Charpy V-Notch at -46˚C	80 J min		

Typical Current Values (DC+/- for root welds or AC 70 OCV min)			
Diameter (mm)	**Downhand**	**Vertical-up**	**Overhead**
2,5	70 - 100	75 - 85	80 - 90
3,15	90 - 135	95 - 110	100 - 110
4,0	135 - 200	140 - 155	145 - 155
5,0	180 - 260	–	–

Deposition Data

Note:

1) The deposition data given was established at the optimum current rating which would be approximately in the middle of the specified range.

2) The mass of weld metal deposited per arc hour is a theoretical value which does not take into account welder efficiency.

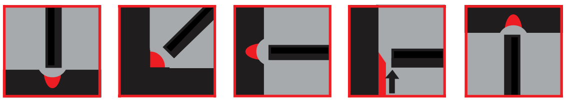
Diameter (mm)	Mass of an Electrode (g)	Burn-off Time (sec)	Mass of Metal Deposited per Electrode (g)	Mass of Weld Metal Deposited per Arc Hour (g)	No. Electrodes per kg of Weld Metal	kg Weld Metal per kg of Electrodes
2,5	21,6	64,2	13,6	761	74	0,62
3,15	33,4	70,0	21,3	1 094	47	0,63
4,0	52,0	71,9	34,0	1 700	30	0,65
5,0	100,3	100,3	67,7	2 428	15	0,67

Data for Welding Horizontal Fillet Welds					
Diameter (mm)	**Throat Thickness (mm)**	**Current (A)**	**Arc Time (sec)**	**Bead Length per Electrode (mm)**	**Welding Speed (m/h)**
2,5	3,0	85	62,0	165	9,6
3,15	4,2	125	73,0	215	10,6
4,0	5,0	175	80,0	225	10,1
5,0	6,0	225	106,2	287	9,7

Packing Data				
Diameter (mm)	**Electrode Length (mm)**	**Approx. No. Electrodes/kg**	**Pack mass (kg)**	**Item Number (multi-kg pack)**
2,5	350	46	3 x 4,0	W075282
3,15	350	30	3 x 4,0	W075283
4,0	350	19	3 x 4,0	W075284
5,0	450	10	3 x 6,0	W075285

7018-1 DriPac (2 kg)					
Diameter (mm)	**Electrode Length (mm)**	**Downhand**	**Vertical-up**	**Overhead**	**Item Number**
2,5	350	70 - 100	75 - 85	80 - 90	W075482
3,15	350	90 - 135	95 - 110	100 - 110	W075483
4,0	350	135 - 200	140 - 155	145 - 155	W075484
5,0	450	180 - 260	-	-	W075485

Transarc® 7018-1



Afrox Transarc® 7018-1 is an iron-powder low hydrogen type electrode for all-position welding of 490 MPa high tensile steel. It is designed for single and multiple pass applications. The product has good welder appeal and produces a stable arc with low spatter generation. Afrox Transarc® 7018-1 produces weld metals with excellent mechanical properties and impact toughness at low temperature (-45°C) and low diffusible hydrogen.

Applications

Its features make the product suitable for low alloy steels, medium carbon steels, heavy steel plates, cast steels, aluminium killed steel of LPG and especially for welding of steels with poor weldability.

The electrode is suitable for welding sulphur bearing steels and components to be virtuously enamelled.

Re-drying Procedure

Hydrogen-controlled electrodes must be re-baked prior to use, the baking temperature required being governed by the maximum hydrogen content tolerable in the deposited weld metal. For a maximum of 5-10 ml H_2/100 g, re-bake at a temperature of 350-370˚C for 1-2 hours.

Afrox Transarc® 7018-1 is manufactured and tested in accordance with the requirements of AWS A5.1 and EN ISO 2560-A.

Classifications		
AWS	A5.1	E7018-1 H4
EN ISO	2560-A	E 46 4 B 1 2 H5

Approvals
American Bureau of Shipping Grade 4Y400 H5

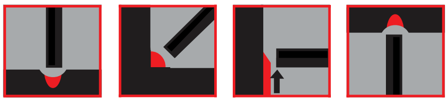
Typical Chemical Composition of Weld Metal (wt%)			
% Carbon	0,065	**% Sulphur**	0,007
% Manganese	1,40	**% Phosphorous**	0,02
% Silicon	0,60		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	460 MPa min
Tensile Strength	570 MPa
% Elongation on 50 mm	32 min
Charpy V-Notch J -45˚C	120 J min

Packing Data

Diameter (mm)	Electrode Length (mm)	Amps in Flat Position (A)	Amps in V&OH Position (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	350	80-110	70-100	5,0	W075232
3,2	350	90-130	80-120	5,0	W075233
4,0	350	140-180	120-160	5,0	W075234

Afrox 78MR



Specially formulated with a unique moisture resistant coating, 78MR is designed to reduce hydrogen at its primary source – moisture in the electrode coating. This means 78MR starts with a low initial moisture content and moisture regain, after extended exposure to the atmosphere, and is extremely low when compared with conventional hydrogen-controlled electrodes. Afrox 78MR is an AC/DC all-position basic coated hydrogen-controlled electrode which features excellent mechanical properties and low moisture regain rates after baking. The low moisture content of the coating and the high resistance to moisture re-absorption is a major benefit long recognised by manufacturers of critical components where avoidance of hydrogen induced cracking is of crucial importance. Afrox 78MR exhibits outstanding all positional welding characteristics with excellent bead profile and appearance. The arc is smooth and stable, giving a fully penetrating weld bead. The slag release in all positions is excellent and the electrode operates with minimal spatter on both AC and DC. Afrox 78MR is recommended for all structural applications where stringent mechanical properties and X-ray quality joints in all positions are required.

Applications

Afrox 78MR is recommended for welding a wide range of carbon-manganese and low alloy steels used in structural applications and for the construction of pressure vessels.

Technique

As with all hydrogen-controlled electrodes, as short an arc as possible should be kept at all times. When starting with a new electrode, the arc should be initiated a short distance ahead of the start of the weld or crater and worked back over this distance before continuing the weld in the required direction. On heavier sections, several stringer beads should be used in preference to one large weave bead to ensure optimum mechanical properties.

Re-drying Procedure

Hydrogen-controlled electrodes must be re-baked prior to use, the baking temperature required being governed by the maximum hydrogen content tolerable in the deposited weld metal. For 5-10 ml H_2/100 g, re-bake at a temperature of 250-270˚C for 1-2 hours, and for <5 ml H_2/100 g, a temperature of 370-400˚C for 1-2 hours. (Please consult the section regarding the storage, handling and treatment of low hydrogen electrodes).

Afrox 78MR is manufactured and tested in accordance with the requirements of AWS A5.1.

Classifications		
AWS	A5.1	E7018-1 H4 R
EN ISO	2560-A	E 424 B 12 H5

Approvals
Lloyds Register of Shipping Grade DXVuO,BF,3m,3Ym,H15
American Bureau of Shipping Grade 3Y,3H
Bureau Veritas Grade 3Y H5

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 - 0,09	**% Sulphur**	0,025 max
% Manganese	1,25 - 1,5	**% Phosphorous**	0,025 max
% Silicon	0,25 - 0,45		

Typical Mechanical Properties (All weld metal)	
Yield Strength	420 MPa min
Tensile Strength	510 - 650 MPa
% Elongation on 50 mm	26 min
Charpy V-Notch at -20˚C	120 J min
Charpy V-Notch at -29˚C	100 J min
Charpy V-Notch at -40˚C	80 J min

Typical Current Values (DC+/- or AC 70 OCV min)	
Diameter (mm)	**Current (A)**
2,5	70 - 100
3,15	100 - 150
4,0	140 - 200
5,0	160 - 285

Deposition Data

Note:

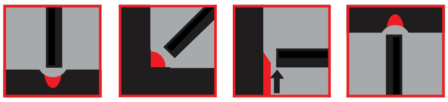
1) The deposition data given was established at the optimum current rating which would be approximately in the middle of the specified range.

2) The mass of weld metal deposited per arc hour is a theoretical value which does not take into account welder efficiency.

Diameter (mm)	Mass of an Electrode (g)	Burn-off Time (sec)	Mass of Metal Deposited per Electrode (g)	Mass of Weld Metal Deposited per Arc Hour (g)	No. Electrodes per kg of Weld Metal	kg Weld Metal per kg of Electrodes
2,5	22,2	66,5	13,7	742	73	0,61
3,15	34,3	71,3	21,5	1 084	47	0,62
4,0	54,6	78,5	34,5	1 582	29	0,63
5,0	108,5	114,3	72,0	2 270	14	0,66

Packing Data				
Diameter (mm)	**Electrode Length (mm)**	**Approx. No. Electrodes/kg**	**Pack mass (kg)**	**Item Number (multi-kg pack)**
2,5	350	45	3 x 4,0	W075272
3,15	350	29	3 x 4,0	W075273
4,0	350	18	3 x 4,0	W075274
5,0	450	9	3 x 6,0	W075275

Afrox Ferron 1



A basic coated AC/DC hydrogen-controlled electrode for use in all positions. Afrox Ferron 1 has a smooth, stable arc with good striking qualities, a slag which is easily removed and an excellent weld bead profile and appearance. The weld metal deposited is of high metallurgical and radiographic quality and complies with the requirements of the radiographic standard of AWS A5.1 grade 1.

Applications

Ferron 1 deposits weld metal capable of resisting cracking under conditions of high restraint and is suitable for welding CMn steels and low alloy steels in structural fabrications. The electrode is suitable for welding sulphur bearing steels and components to be vitreously enamelled.

Technique

As with all basic hydrogen-controlled electrodes, as short an arc as possible should be kept at all times. When starting with a new electrode, the arc should be initiated a short distance ahead of the start or crater and worked back over this distance before continuing the weld in the required direction. On larger size joints, several stringer beads should be used where possible in preference to one large weaved bead to ensure optimum mechanical properties.

Re-drying Procedure

Hydrogen-controlled electrodes must be re-baked prior to use, the baking temperature required being governed by the maximum hydrogen content tolerable in the deposited weld metal. For a maximum of 5-10 ml H_2/100 g, re-bake at a temperature of 350-370˚C for 1-2 hours. (Please consult the section regarding the storage, handling and treatment of low hydrogen electrodes).

Ferron 1 is manufactured and tested in accordance with the requirements of AWS A5.1.

Classifications		
AWS	A5.1	E7018 H8
EN	2560-A	E 42 3 B 32 H5

Approvals
Lloyds Register of Shipping Grade DXVudO,BF,3m,3Ym,H15
American Bureau of Shipping Grade 3Y, 3H

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 - 0,09	**% Sulphur**	0,025 max
% Manganese	1,0 - 1,45	**% Phosphorous**	0,025 max
% Silicon	0,3 - 0,75		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	420 MPa min
Tensile Strength	510 - 610 MPa
% Elongation on 50 mm	26 min
Charpy V-Notch at -20˚C	100 J min
Charpy V-Notch at -29˚C	90 J min

Typical Current Values (DC+/- or AC 70 OCV min)	
Diameter (mm)	**Current (A)**
2,5	70 - 100
3,15	100 - 140
4,0	145 - 180
5,0	190 - 280

Deposition Data

Note:

1) The deposition data given was established at the optimum current rating which would be approximately in the middle of the specified range.

2) The mass of weld metal deposited per arc hour is a theoretical value which does not take into account welder efficiency.

Diameter (mm)	Mass of an Electrode (g)	Burn-off Time (sec)	Mass of Metal Deposited per Electrode (g)	Mass of Weld Metal Deposited per Arc Hour (g)	No. Electrodes per kg of Weld Metal	kg Weld Metal per kg of Electrodes
2,5	22,4	70,3	14,0	716	72	0,62
3,15	35,6	79,9	22,3	1 002	45	0,62
4,0	50,6	71,1	33,3	1 686	31	0,65
5,0	99,8	101,5	69,0	2 447	15	0,69

Data for Welding Horizontal Fillet Welds					
Diameter (mm)	**Throat Thickness (mm)**	**Current (A)**	**Arc Time (sec)**	**Bead Length per Electrode (mm)**	**Welding Speed (m/h)**
2,5	2,5	85	64,2	146	8,2
3,15	3,1	125	75,0	186	8,9
4,0	5,0	175	69,6	204	10,6
5,0	5,9	225	96,6	258	9,6

Packing Data				
Diameter (mm)	**Electrode Length (mm)**	**Approx. No. Electrodes/kg**	**Pack mass (kg)**	**Item Number (multi-kg pack)**
2,5	350	45	3 x 4,0	W075312
3,15	350	28	3 x 4,0	W075313
4,0	350	20	3 x 4,0	W075314
5,0	450	10	3 x 6,0	W075315

AWS A5.1 Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

The welding electrodes covered by this specification are classified in terms of the following:

- Type of current
- Type of covering
- Welding position
- Mechanical properties of the weld metal in the as welded condition.

The method of classifying the electrodes is based on the use of a four-digit code preceded by a letter.

The digits signify the following:

First letter

'E' designates an arc welding electrode.

Digits 1 and 2

The minimum tensile strength of the weld metal in the as welded condition (x1 000), e.g. as follows:

E60XX

60 000 psi minimum (460 MPa min)

E70XX

70 000 psi mininum (500 MPa min)*

*Disparity exists between these two values. Please refer to specification.

Digits 3 and 4

This indicates the position of welding, the type of flux covering and the kind of welding current. For complete identification of the electrode, it is necessary to read these two digits together as detailed in the table below:

Classification	Position	Current	Coating Type
EXX10	All positions	DC+	Cellulose sodium
EXX11	All positions	AC or DC+	Cellulose potassium
EXX12	All positions	AC or DC-	Rutile sodium
EXX13	All positions	AC or DC+/-	Rutile potassium
EXX14	All positions	AC or DC+/-	Rutile iron powder
EXX15	All positions	DC+	Low hydrogen sodium
EXX16	All positions	AC or DC+	Low hydrogen potassium
EXX18	All positions	AC or DC+	Low hydrogen potassium iron powder
EXX18M	All positions	DC+	Low hydrogen iron powder
EXX19	All positions	AC or DC+/-	Rutile iron oxide
EXX20	Flat and horizontal	AC or DC-	High iron oxide
EXX22	Flat and horizontal	AC or DC-	High iron oxide
EXX24	Flat and horizontal	AC or DC+/-	Rutile iron powder
EXX27	Flat and horizontal	AC or DC-	High iron oxide iron powder
EXX28	Flat and horizontal	AC or DC+	Low hydrogen iron powder

Certain of the low hydrogen electrodes may also have optional designators as detailed below:

- A letter 'M' is used to specify electrodes with greater toughness, low moisture content both in the as received and exposed condition and specific diffusible hydrogen contents
- A letter 'R' is used to identify electrodes that meet the requirements of the specified absorbed moisture test
- An optional supplemental designator 'HZ' indicates an average diffusible hydrogen content of not more that 4, 8, or 16 ml H_2/100 g of deposited metal when tested
- Electrodes with the following optional supplemental designation shall meet the lower temperature Charpy V-Notch impact requirements specified.

AWS Classification	Electrode Designation	Average Minimum Charpy Impact Values
E7018	E7018-1	27 J at -46°C
E7024	E7024-1	27 J at -18°C

MIG/MAG Wires

Afrox MIG 9000 GoldFlo

Afrox MIG 9000 GoldFlo is a premium quality bronze coated MIG wire produced from high quality double deoxidised rod. The higher manganese and silicon levels ensure improved weld metal deoxidation, making Afrox MIG 9000 GoldFlo an excellent choice for welding on metal with a medium to high presence of mill scale or rust. The higher silicon levels promote a smooth bead surface and a flat fillet bead profile with equal leg length and uniform wetting is easily achieved.

The wire is designed for both single- and multi-pass welding in all positions. The bronze coating enhances the shelf life and also ensures good electrical conductivity with reduced friction during high speed welding.

Afrox MIG 9000 GoldFlo has excellent, smooth wire feedability and is suitable for welding with dip (short circuit), spray arc and pulsed arc transfer using Ar/CO_2 or CO_2 shielding gases.

Application

Afrox MIG 9000 GoldFlo is recommended for welding of mild and medium tensile strength steels and is an excellent choice for general steel construction, sheet metal applications, pressure vessel fabrication, structural welding and pipe welding.

Recommended Shielding Gas

Argoshield® Universal. Flow rates of 18-22 ℓ/min should be used.

Classifications

AWS/ASME-SFA	A5.18	ER 70S-6
EN ISO	14341 -A-	G 42 4 M21 3Si1

Approvals

TÜV, DB, BV, ABS, LR

Chemical Composition (Typical)

% Carbon	0,07	**% Sulphur**	0,004	**% Chromium**	0,038
% Manganese	1,45	**% Phosphorous**	0,013	**% Molybdenum**	0,06
% Silicon	0,85	**% Nickel**	0,023	**% Copper**	0,031

Typical Mechanical Properties (All weld metal in the as welded condition)

MIG 9000 GoldFlo	Using Argoshield®	Using CO_2
Yield Strength	452 MPa	420 MPa
Tensile Strength	560 MPa	525 MPa
% Elongation	27	31
Impact Energy, CVN	84 J min av @-30°C	72 J min av @-30°C

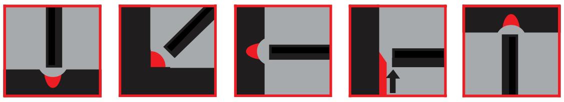
Welding Parameters

Diameter (mm)	Current	
	Amps (A)	Volts (V)
0,9	80 - 220	16 - 28
1,0	90 - 253	16 - 31
1,2	120 - 355	18 - 32,5
1,6	160 - 380	20 - 34

Packing Data
Afrox MIG 9000 GoldFlo

Diameter (mm)	Weight (kg)	Winding	Item Number
0,9 (spool - BS300)	15	Precision PLW	W033971
1,0 (spool - S300)	18	Precision PLW	W033972
1,2 (spool - S300)	18	Precision PLW	W033973
1,6 (spool - BS300)	18	Precision PLW	W033974
1,0 (drum)	250	-	W033992
1,2 (drum)	250	-	W033993
1,6 (drum)	250	-	W033994

Afrox MIG 6000/6000 Cert
Afrox TIG 70S-6



Afrox MIG 6000 and Afrox TIG 70S-6 are produced from high quality deoxidised rod. The products are copper coated for increased shelf life, which in the case of MIG/MAG wires, also facilitates good electrical conductivity and pick-up with reduced friction during high speed welding. MIG 6000 is a premium quality wire which is precision layer wound to provide positive uninterrupted feeding in semi-automatic and automated systems.

Welding Procedure

MIG 6000 is suitable for dip (short arc), spray arc and pulsed arc transfer welding using shielding gases such as Argoshield® 5, Argoshield® Light, Argoshield® Heavy and Argoshield® Universal as well as CO_2. Gas flow rates of 15 ℓ/min at low currents rising to 20 ℓ/min at high currents should be used. TIG 70S-6 rods should be used with a 2% thoriated non-consumable electrode with pure argon as a shielding gas at flow rates of 10-15 ℓ/min.

Identification

TIG 70S-6 – Red colour tip and hard stamped 70S-6.

MIG 6000 Cert in 1,0 and 1,2 mm & TIG 70S-6 are manufactured and tested in accordance with the requirements of AWS A5.01.

Classifications

AWS	A5.18	ER 70S-6
EN ISO	14341	G42 2 C1/M21 3Si1
EN ISO	636-A	W 42 3 W4Si1
EN ISO	636-B	W 49 A 4 W4Si1

Approvals

MIG 6000

Lloyds Register of Shipping Grade DXVud,BF,2S,2YS,H15

American Bureau of Shipping Grade 2SA

TÜV

Typical Chemical Analysis (All weld metal)

% Carbon	0,07 - 0,15	**% Sulphur**	0,035 max
% Manganese	1,4 - 1,85	**% Phosphorous**	0,03 max
% Silicon	0,8 - 1,15	**% Copper**	0,4 max (typical 0,18)

Typical Mechanical Properties (All weld metal in the as welded condition)

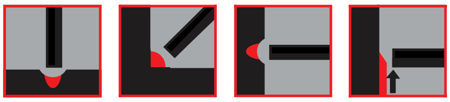
MIG 6000 with CO_2 as Shielding Gas	**As Welded**	**Stress Relieved 650°C/15 hr**	**Normalised 920°C/0,5 hr**
0,2% Proof Stress	430 MPa min	360 MPa min	315 MPa min
Tensile Strength	510 - 570 MPa	490 - 570 MPa	470 - 550 MPa
% Elongation on 50 mm	26 min	26 min	26 min
Charpy V-Notch at +20°C	110 J min	110 J min	80 J min
Charpy V-Notch at 0°C	80 J min	-	-
Charpy V-Notch at -20°C	47 J min	47 J min	47 J min

Typical Mechanical Properties (All weld metal in the as welded condition)	
TIG 70S-6 with Argon as Shielding Gas	**As Welded**
0,2% Proof Stress	420 MPa min
Tensile Strength	510 - 570 MPa
% Elongation on 50 mm	26 min
Charpy V-Notch at +20˚C	110 J min
Charpy V-Notch at -29˚C	50 J min
Charpy V-Notch at -46˚C	27 J min

Packing Data MIG 6000		
Diameter (mm)	**Approx. Length of Wire/kg (m)**	**Item Number**
0,8	245	W033900
0,9	186	W033901
1,0	160	W033902
1,2	110	W033903
1,6	63	W033905
The wire is layer wound onto wire basket spools having a nominal mass of 18 kg		

Packing Data TIG 70S-6		
Diameter (mm)	**Consumable Length (mm)**	**Item Number**
1,6	950	W030501
2,0	950	W030502
2,4	950	W030503
TIG rods are supplied in 5 kg tubes		

Afrox Megapac



Afrox Megapac is a bulk MIG/MAG wire system designed specifically to enhance the performance of automated welding systems. The wire is introduced into the drum by using a unique reverse twist coiling method, which ensures that the wire emerges from the container virtually straight. This facilitates the precise positioning of the robot, which in turn enhances weldability and accuracy, while reducing wear on liners and contact tips. In addition, the negative effects of the cast and/or helix which can be experienced with conventionally spooled reels is eliminated. Each Megapac contains approximately 230 kg of wire, which is equivalent to approximately 13 standard spools. With an estimated changeover time of 15 minutes a spool, this amounts to an added three hours production time for every Megapac used. Afrox Megapac not only offers reduced equipment downtime, but also vastly improves production efficiency. Megapac containers, which are 820 mm high with a diameter of 510 mm, occupy only a small area on the shop floor. The hood, through which the wire is fed from the drum, not only keeps the wire free from dust and dirt but also obviates the need for pay-off devices which are essential when other bulk packages are used. Megapac contains copper coated wire identical to MIG 6000.

Classifications		
AWS	A5.18	ER 70S-6
EN	14341	G42 4 C1/M21 3Si1

Approvals
Lloyds Register of Shipping DxVud,BF,2S,2YS,H15
American Bureau of Shipping 2SA
TÜV

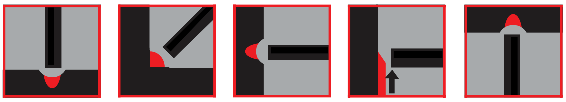
Typical Chemical Analysis (All weld metal)			
% Carbon	0,07 - 0,15	**% Sulphur**	0,035 max
% Manganese	1,4 - 1,85	**% Phosphorous**	0,03 max
% Silicon	0,8 - 1,15	**% Copper**	0,4 max (typical 0,18%)

Typical Mechanical Properties (All weld metal using CO_2 gas)	
0,2% Proof Stress	430 MPa min
Tensile Strength	510 - 570 MPa
% Elongation on 50 mm	26 min
Charpy V Notch at +20°C	110 J min
Charpy V-Notch at 0°C	80 J min
Charpy V-Notch at -20°C	47 J min

Packing Data	
Diameter (mm)	**Item Number**
0,9	W033951
1,0	W033952
1,2	W033953

Packing Data	
Description	**Item Number**
Megapac Liner (per metre)	W033982
Megapac Hood 510	W033985

Afrox MIG 3000 PLUS



Afrox MIG 3000 PLUS is a mild steel welding wire produced from high quality double deoxidised rod. The wire is copper coated for increased shelf life.

Welding Procedure

MIG 3000 PLUS exhibits a low spatter volume and is suitable for dip, spray arc and pulsed arc transfer welding using shielding gases such as Argoshield® 5, Argoshield® Light, Argoshield® Heavy and Argoshield® Universal or CO$_2$. Shielding gas flow rates of 15-20 ℓ/min should be used.

Classifications

AWS	A5.18	ER 70S-6
BS EN	14341	G42 4 C1/M21 3Si1

Typical Chemical Analysis (All weld metal)

% Carbon	0,07 - 0,15	**% Sulphur**	0,035 max
% Manganese	1,4 - 1,85	**% Phosphorous**	0,03 max
% Silicon	0,8 - 1,15		

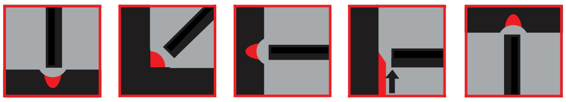
Typical Mechanical Properties (All weld metal using CO$_2$ gas)

Shielding Gas	CO$_2$
Testing Condition	As welded
0,2% Proof Stress	430 MPa min
Tensile Strength	510 - 570 MPa
% Elongation on 50 mm	26 min
Charpy V-Notch at +20˚C	110 J min
Charpy V-Notch at 0˚C	80 J min
Charpy V-Notch at -20˚C	47 J min

Packing Data

Diameter (mm)	Item Number
0,9 (plastic spool)	W033931
1,0 (plastic spool)	W033942
1,2 (plastic spool)	W033943

Afrox 250 kg ER70S-6 Drum



Afrox 250 kg ER70S-6 is a mild steel welding wire produced from high quality double deoxidised rod. The wire is copper coated for increased shelf life. Available in a 250 kg drum for increased production.

Welding Procedure

Afrox 250 kg ER70S-6 exhibits a low spatter volume and is suitable for dip, spray arc and pulsed arc transfer welding using shielding gases such as Argoshield® 5, Argoshield® Light, Argoshield® Heavy and Argoshield® Universal, or CO_2. Shielding gas flow rates of 15-20 ℓ/min should be used.

Classifications		
AWS	A5.18	ER 70S-6
BS EN	14341	G42 4 C1/M21 3Si1

Typical Chemical Analysis (All weld metal)			
% Carbon	0,07 - 0,15	**% Sulphur**	0,035 max
% Manganese	1,4 - 1,85	**% Phosphorous**	0,03 max
% Silicon	0,8 - 1,15		

Typical Mechanical Properties (All weld metal using CO_2 gas)	
Shielding Gas	CO_2
Testing Condition	As welded
0,2% Proof Stress	430 MPa min
Tensile Strength	510 - 570 MPa
% Elongation on 50 mm	26 min
Charpy V-Notch at +20°C	110 J min
Charpy V-Notch at 0°C	80 J min
Charpy V-Notch at -20°C	47 J min

Packing Data	
Diameter (mm)	**Item Number**
1,0 (250 kg drum)	W033962
1,2 (250 kg drum)	W033963

MIG & TIG Wires for CMn & Low Alloy Steels

AWS A5.18 Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding

The solid electrodes (and rods) covered by this specification are classified according the following attributes:

- Chemical composition of the electrode
- Mechanical properties of the weld metal.

Classification Designators

ER 70S-YX	
ER	Indicates a solid wire
70 or 48	The minimum tensile strength of the deposited weld metal. In all specified products in this standard, the minimum tensile strength is 70 000 psi or 480 MPa
S	Solid electrode/wire, a 'C' would indicate a metal cored wire
Y	This can be 2, 3, 4, 5, 6, 7 or 'G' as detailed in the table below
X	This final 'X' shown in the classification represents a 'C' or 'M' which corresponds to the shielding gas with which the metal cored wire is classified. The use of 'C' designates 100% CO_2 shielding, 'M' designates 75-80% Ar/CO_2. Solid wires are classified using CO_2

Chemical Composition Requirements for Solid Electrodes and Rods

Electrode Classification		**%C**	**%Mn**	**%Si**	**%S**	**%P**	**%Cu**	**Other**
US	**Metric**							
ER70S-2	ER48S-2	0,07	0,9 - 1,4	0,4 - 0,7	0,035	0,025	0,5	Ti 0,05 - 0,15, Zr 0,02 - 0,12, Al 0,05 - 0,15
ER70S-3	ER48S-3	0,06 - 0,15	0,9 - 1,4	0,45 - 0,75	0,035	0,025	0,5	
ER70S-4	ER48S-4	0,07 - 0,15	1,0 - 1,5	0,65 - 0,85	0,035	0,025	0,50	
ER70S-5	ER48S-5	0,07 - 0,19	0,9 - 1,4	0,3 - 0,6	0,035	0,025	0,5	Al 0,5 - 0,9
ER70S-6	ER48S-6	0,06 - 0,15	1,4 - 1,85	0,8 - 1,15	0,035	0,025	0,5	
ER70S-7	ER48S-7	0,07 - 0,15	1,5 - 2,0	0,5 - 0,8	0,035	0,025	0,5	
ER70S-G	ER48S-G	Not specified						

Single values are maximums. Please consult specification for definitive values

Please Note: AWS now makes provision for metric values. The specification containing equivalent metric values is indicated by AWS A5.18M

Flux & Metal Cored Wires

Afrox Coremax 71 Plus

Coremax 71 Plus is a gas shielded flux cored wire for welding carbon-manganese steels, having a tensile strength of up to 620 MPa and where impact properties of sub-zero may be required. It has low spatter levels and the slag is easy to remove. The wire is recommended for single- and multi-pass welding in all positions using a 75% Ar, 25% CO_2 argon based mixed gas (Afrox Fluxshield®) or CO_2.

Classifications		
AWS	A5.20	E71T-1M H8

Approvals
Det Norske Veritas; Lloyds Register of Shipping
Bureau Veritas; American Bureau of Shipping; TÜV

Typical Chemical Analysis (All weld metal)			
% Carbon	0,04	**% Sulphur**	0,01
% Manganese	1,32	**% Phosphorous**	0,02
% Silicon	0,42		

Typical Mechanical Properties (All weld metal using CO_2 gas)	
Yield Strength	540 MPa
Tensile Strength	580 MPa
% Elongation on 5d	28
Charpy V-Notch at -18˚C	65 J

Welding Data
(DC+) Shielding Gas: 75% Ar/25% CO_2 or CO_2

Diameter (mm)	Position	Current		Deposition Rates (kg/h)	Electrode Stick Out (mm)
		Amps (A)	Volts (V)		
1,2	Flat/horizontal	260	27	4,1	12
1,2	Vertical-up/ overhead	170 - 220	23 - 25	2,0 - 3,4	12

Packing Data

Diameter (mm)	Spool Mass (kg)	Item Number
1,2	15,0	W081230

Afrox S71T-11

S71T-11 is an open-arc (no shielding gas required) tubular wire which is exceptionally easy to use. It is recommended for use with smaller MIG machines or in areas where the provision of gas cylinders is not practical. S71T-11 has little tendency to burn through and is well suited for butt, fillet and lap joints on steel thicknesses of 1,6 mm to 10 mm. It is not recommended for welding steel thicknesses greater than 12 mm.

Classifications

AWS	A5.20	E71T-11
EN	17632-A	T 42 Z W N 1 H10

Typical Chemical Analysis (All weld metal)

% Carbon	0,18	**% Sulphur**	0,012
% Manganese	1,0	**% Phosphorous**	0,012
% Silicon	0,25	**% Aluminium**	0,8

Typical Mechanical Properties (All weld metal using CO_2 gas)

Yield Strength	430 MPa
Tensile Strength	520 MPa
% Elongation on 5d	23

Welding Data
(DC+) Shielding Gas: CO_2

Diameter (mm)	**Current**	
	Amps (A)	**Volts (V)**
0,8	50 - 200	12 - 24
0,9	70 - 220	13 - 27
1,2	90 - 310	16 - 35
Typical Values		

Packing Data

Diameter (mm)	**Spool Mass (kg)**	**Item Number**
0,9	4,5	W081009

Hobart Fabshield 4

Hobart Fabshield 4 is an outstanding high deposition self-shielded tubular wire that is used to weld mild and medium carbon steels. It is ideal for either single- or multi-pass welding, and provides outstanding performance with deposition rates of up to 20 kg/h and deposition efficiencies of 84% or better. This electrode produces a globular type transfer with an arc that is not affected by drafts or moderate wind. It is specifically designed to desulphurise the weld metal and resist cracking. The product is recommended for applications such as machine fabrication, certain ship equipment, industrial and heavy equipment repair.

Classifications

AWS	A5.20	E70T-4
EN	17632-A	T 46 Z W N 4 H10

Approvals

American Bureau of Shipping E70T-4 (AWS A5.20)

Canadian Welding Bureau E4802T-4-CH

Typical Chemical Analysis (All weld metal)

% Carbon	0,27	**% Phosphorous**	0,008
% Manganese	0,45	**% Aluminium**	1,36
% Silicon	0,3	**% Nickel**	0,01
% Sulphur	0,004		

Typical Mechanical Properties (All weld metal using CO$_2$ gas)

Yield Strength	476 MPa
Tensile Strength	635 MPa
% Elongation on 50 mm	22

Welding Data (DC+)

Diameter (mm)	Position	Current		Optimum Settings		Deposition Rates (kg/h)	Electrode Stick Out (mm)
		Amps (A)	Volts (V)	Amps (A)	Volts (V)		
2,0	Flat/horizontal	290 - 370	31	330	30	5,0 - 7,3	50,0
2,4	Flat/horizontal	250 - 500	28 - 34	400	31	4,0 - 12,7	65,0

Packing Data

Diameter (mm)	Pack Mass (kg)	Package	Item Number
2,0	22,0	Coil	W081033
2,4	22,0	Coil	W081011
2,4	270,0	Drum	W081012

Hobart Fabshield 21B

Hobart Fabshield 21B is a versatile tubular wire with excellent operator appeal because of its smooth arc, low spatter and overall ease of handling. With no shielding gas needed, it is a good choice for welding in hard-to-reach locations or where the provision of gas cylinders is not practical. It is a good wire for applications where windy or other adverse conditions prevail and where mechanical properties are of less concern. Fabshield 21B has little tendency to burn through and is well suited for butt, fillet and lap joints on steel thicknesses from 1,6-10 mm. It is not recommended for welding steel thicknesses greater than 12,7 mm. When welding on steels in the 10-19 mm thickness range, a preheat temperature of 160°C is advisable. The wire is recommended for single-pass and limited multiple-pass welding in all positions, using no shielding gas.

Classifications

AWS	A5.20	E71T-11
EN	17632-A	T 42 Z W N 1 H10

Approvals

American Bureau of Shipping E71T-11 (AWS A5.20)

Typical Chemical Analysis (All weld metal)

% Carbon	0,3	**% Sulphur**	0,003
% Manganese	0,49	**% Phosphorous**	0,009
% Silicon	0,15	**% Aluminium**	1,18

Typical Mechanical Properties (All weld metal using CO_2 gas)

Yield Strength	442 MPa
Tensile Strength	628 MPa
% Elongation on 50 mm	21

Welding Data (DC+)

Diameter (mm)	Position	Current		Optimum Settings		Deposition Rates (kg/h)	Electrode Stick Out (mm)
		Amps (A)	Volts (V)	Amps (A)	Volts (V)		
1,6	Flat/horizontal	125 - 300	19 - 20	230	17	0,5 - 3,3	12,0 - 19,0
1,6	Vertical/ overhead	125 - 250	15 - 19	175	16	0,7 - 2,1	12,0 - 19,0
2,0	Flat/horizontal	175 - 350	16 - 22	275	19	1,1 - 3,0	12,0 - 19,0

Packing Data

Diameter (mm)	Pack Mass (kg)	Package	Item Number
1,6	15,0	Spool	W081013
2,0	22,0	Coil	W081014

Hobart/Fabcor 86R

Hobart/Fabcor 86R is a gas shielded metal cored wire designed for semi-automatic, automatic and robotic welding of low and medium carbon steels. The wire is recommended for single and limited multi-pass welding in the flat and horizontal positions. The recommended shielding gas is Afrox Fluxshield® (75% Ar, 25% CO_2) at a gas flow rate of 17-24 ℓ/min. Metalloy 76 produces high quality welds with virtually no residual slag.

The product features lower spatter and higher strength levels. The higher manganese content gives increased deoxidisation and greater tolerance to mill scale and paint primers on the workpiece. Penetration is superior to that of solid wires, thereby minimising the cold lap problem on heavier sections of steels. Low spatter and low slag volume combine to greatly reduce clean-up costs.

Classifications

AWS	A5.18	E70C-6M H4
EN	17632-A	T 50 Z M M 2 H5

Approvals

Lloyds Register of Shipping 3S,3440SH15

American Bureau of Shipping 3SA, 3YSM

Det Norske Veritas 111 Y40MS

Bureau Veritas SA 3YM

Germanischer Lloyd 3Y40H5S

Canadian Welding Bureau E4801C-6-CH

Typical Chemical Analysis (All weld metal)

% Carbon	0,06	**% Sulphur**	0,019
% Manganese	1,64	**% Phosphorous**	0,012
% Silicon	0,75		

Typical Mechanical Properties (All weld metal using CO_2 gas)

Yield Strength	559 MPa
Tensile Strength	628 MPa
% Elongation on 50 mm	27
Charpy V-Notch at -18˚C	72 J

Welding Data (DC+)

Diameter (mm)	Position	Current		Optimum Settings		Deposition Rates (kg/h)	Electrode Stick Out (mm)
		Amps (A)	Volts (V)	Amps (A)	Volts (V)		
1,2	Flat/horizontal	200 - 350	27 - 35	300	32	2,7 - 7,0	12,0 - 19,0
1,6	Flat/horizontal	300 - 450	29 - 34	400	32	5,0 - 9,5	25,0 - 30,0

Packing Data

Diameter (mm)	Spool Mass (kg)	Item Number
1,2	15,0	W081029
1,6	15,0	W081028

Hobart Megafil 710M

Hobart Megafil 710M is a metallic flux cored wire designed to be used with Ar/CO_2 (Afrox Fluxshield®) for mild steel and 490 N/mm^2 high tensile steel. Its deposition rate is 10-30% higher than a solid wire. Multi-layer welding can be performed without removing slag. It is suitable for the multi-layer welding of thick plate welding in such applications as: steel structures, bridges, shipbuilding, vehicles and storage tanks, etc.

Classifications		
AWS	A5.18	E70C-6M H4
EN ISO	17632-A	T 46 6 M M 1 H5

Approvals
Lloyds Register of Shipping 3Y40S H5
American Bureau of Shipping 3Y400SA H5
DNV Y40MS(H5)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,04	**% Phosphorous**	0,008
% Manganese	1,48	**% Sulphur**	0,008
% Silicon	0,65	**% Copper**	0,15

Typical Mechanical Properties (All weld metal)	
Tensile Strength	586 MPa
Yield Strength	517 MPa
% Elongation	27
Impact Energy at -30°C	115 J
Impact Energy at -40°C	88 J

Welding Data (DC+)

Diameter (mm)	**Current**		**Flow Rate (ℓ/min)**	**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**			
1,2	200 - 300	28 - 38	15 - 25	16,0	W081071

Cored Wires for CMn & Low Alloy Steels

Hobart Megafil 713R

Hobart Megafil 713R is a seamless copper coated rutile flux cored wire with a higher filling degree resulting in a higher current carrying capacity and high deposition rate. The welding speed is increased which leads to a saving of time and reduction of costs. It can be used in all positions with only one welding parameter setting (24 V, wire feed = 9 m/min, wire dia. 1,2 mm). Hobart Megafil 713R is used for manual welding, as well as in fully mechanised. It is recommended that a mixed shielding gas be used and is characterised by low spatter loss, good slag removal and finely rippled, pore-free welds without undercut.

Storage

Keep dry and avoid condensation.

Classifications		
AWS	A5.20	E71T-1 CH4 / E71T-1M H4
EN	17632-A	T 46 4 PM 1 H5, T 46 2 P C 1 H5

Approvals
American Bureau of Shipping
Det Norske Veritas
TÜV
Lloyds Register of Shipping

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05	**% Silicon**	0,55
% Manganese	1,2	**% Nickel**	0,3

Typical Mechanical Properties (All weld metal)	
Yield Strength N/mm^2	545
Tensile Strength N/mm^2	490 - 620
% Elongation on A5	22 Min
Impact Energy at -40°C	81 J

Gas Test	Afrox Fluxshield®
Shielding Gas	Afrox Fluxshield®, Afrox CO_2
Materials	S(P)235-S(P)460, GP240-GP280 Shipbuilding steels A,B,D,E,AH32 to EH36

Packing Data	
Diameter (mm)	**Item Number**
1,2	W081070

AWS A5.20 Specification for Carbon Steel Electrodes for Flux Cored Arc Welding

In this specification, electrodes are classified on the basis of:

- Whether CO_2 is used as a shielding gas
- Suitability for single or multiple-pass application
- Type of current
- Welding position
- Mechanical properties of the deposited weld metal.

The system for identifying the electrode classification in AWS A5.20 follows, for the most part, the standard pattern used in other AWS filler metal specification.

Classification Designators

EXX-TWMJ HZ	
E	Designates an electrode
First X	This designator is either 6 or 7. It indicates the minimum tensile strength (in psi x 10 000) of the weld metal when the sample is prepared in the manner prescribed by AWS A5.20
Second X	Indicates the primary welding position for which the electrode is designed: 0 - flat and horizontal positions 1 - all positions
T	This designator indicates that the electrode is a flux cored electrode
W	This designator is a number from 1 through 14 or the letter ‘G’ with or without an ‘S’ following. The number refers to the usability of the electrode. The ‘G’ indicates that the external shielding, polarity and impact properties are not specified. The ‘S’ indicates that the electrode is suitable for single-pass welding only. Please see table below for details
M	An ‘M’ designator in this position indicates that the electrode is classified using 75-80% Ar-CO_2 shielding gas. When this designator does not appear, it signifies that the shielding gas used for classification is CO_2 or that the product is a self-shielded type
J	Optional supplementary designator. Designates that the electrode meets the requirements for improved toughness by meeting a Charpy impact value of 27 J at -40°C. Absence of the ‘J’ indicates normal impact requirements
HZ	Optional supplementary designator. Designates that the electrode meets the requirements of the diffusible hydrogen test, (i.e 4, 8 or 16 ml of H_2 per 100 g of deposited weld metal)

Wire Characteristics (Designator W)

AWS Classification a	External Shielding Medium	Current and Polarity
EXXT-1 (multiple-pass)	CO_2 b	DC, electrode positive
EXXT-2 (single-pass)	CO_2 b	DC, electrode positive
EXXT-3 (single-pass)	None	DC, electrode positive
EXXT-4 (multiple-pass)	None	DC, electrode positive
EXXT-5 (multiple-pass)	CO_2 b	DC, electrode positive
EXXT-6 (multiple-pass)	None	DC, electrode positive
EXXT-7 (multiple-pass)	None	DC, electrode negative
EXXT-10 (single-pass)	None	DC, electrode negative
EXXT-11 (multiple-pass)	None	DC, electrode negative
EXXT-G (multiple-pass)	c	c
EXXT-GS (single-pass)	c	c
a, b and c refer to specification		

Subarc Wires & Fluxes

Afrox Sub 70-1

Afrox Sub 70-1 is a copper coated CMn submerged arc welding wire for joining carbon-manganese steels. It is widely used in structural steel work, i.e. shipbuilding, construction work, etc. The wire is suitable for both single-pass and multi-pass welding, and for welding butt and fillet joints where maximum ductility is required.

Classifications		
AWS	A5.20	EL12
EN ISO	14171-A	S1

Typical Chemical Analysis (Wire)			
% Carbon	0,05 - 0,12	**% Phosphorous**	0,025 max
% Manganese	0,4 - 0,6	**% Sulphur**	0,025 max
% Silicon	0,07 max	**% Copper**	0,3 max

Packing Data	
Diameter (mm)	**Item Number (25 kg coil)**
2,4	W080012
3,15	W080013

Afrox Sub 70-2

Afrox Sub 70-2 is a copper coated low carbon, medium manganese wire that produces a higher tensile strength weld than Sub 70-1 depending on flux and procedure used. It is recommended for single- and multiple-pass welding.

Classifications		
AWS	A5.17	EM12K
EN ISO	14171-A	S2

Typical Chemical Analysis (Wire)			
% Carbon	0,08 - 0,15	**% Phosphorous**	0,025 max
% Manganese	0,8 - 1,2	**% Sulphur**	0,025 max
% Silicon	0,1 - 0,2	**% Copper**	0,3 max

Packing Data

Diameter (mm)	Item Number (25 kg coil)	Item Number (68 kg coils)	Item Number (300 kg pay-off drums)
2,4	W080052	-	W080062
3,2	W080053	W080067	W080063
4,0	W080054	W080068	-

Afrox Subarc S3Si

Subarc S3Si is a copper coated submerged arc welding wire containing 1,5% manganese and 0,3% silicon. It is recommended for use with basic fluxes such as HPF-N90 where exceptional sub-zero impact properties are required.

Classifications		
EN ISO	14171-A	S3Si
AWS	A5.17	EH12K

Typical Chemical Analysis (All weld metal)			
% Carbon	0,08 - 0,15	**% Phosphorous**	< 0,3
% Manganese	1,4 - 1,8	**% Sulphur**	< 0,01
% Silicon	0,2 - 0,35	**% Copper**	< 0,01

Packing Data

Diameter (mm)	Item Number (27 kg coil)
3,2	W078118
4,0	W078120

AWS A5.17 Specification for Carbon Steel Electrodes and Flux for Submerged Arc Welding

The welding electrodes and fluxes covered by the specification are classified according to the following attributes:

- The mechanical properties of the weld metal obtained with a combination of a particular flux and a particular classification of electrode
- The condition of heat treatment in which those properties are obtained
- The chemical composition of the electrode produced with a particular flux.

Classification Designators

FS XYZ-ECXXX	
F	Indicates a submerged arc welding flux
S	Indicates the flux contains crushed slag
X	Indicates the minimum tensile strength of weld metal made in accordance with the welding conditions given in the specification
Y	Designates the condition of heat treatment in which the tests were conducted. 'A' for as welded and 'P' for post weld heat treated
Z	Indicates the lowest temperature at which the impact strength of the weld metal meets or exceeds 27 J i.e. Z No impact requirements 0 0˚C 2 -20˚C 3 -30˚C 4 -40˚C 5 -50˚C 6 -60˚C
E	Indicates a solid electrode; EC indicates a composite electrode
XXX	Classification of the electrode used in producing the weld and given in the table below

Chemical Composition Requirements for Solid Electrodes

Electrode Classification	%C	%Mn	%Si	%S	%P	%Cu
EL8	0,1	0,25 - 0,6	0,07	0,03	0,03	0,35
EL8K	0,1	0,25 - 0,6	0,1 - 0,25	0,03	0,03	0,35
EL12	0,04 - 0,14	0,25 - 0,6	0,1	0,03	0,03	0,35
EM12	0,06 - 0,15	0,8 - 1,25	0,1	0,03	0,03	0,35
EM11K	0,07 - 0,15	1,0 - 1,5	0,65 - 0,85	0,03	0,025	0,35
EM12K	0,05 - 0,15	0,8 - 1,25	0,10 - 0,35	0,03	0,03	0,35
EM13K	0,06 - 0,16	0,9 - 1,4	0,35 - 0,75	0,03	0,03	0,35
EM14K	0,06 - 0,19	0,9 - 1,4	0,35 - 0,75	0,025	0,025	0,35
EM15K	0,10 - 0,20	0,8 - 1,25	0,1 - 0,35	0,03	0,03	0,35
EH10K	0,07 - 0,15	1,3 - 1,7	0,05 - 0,25	0,025	0,025	0,35
EH11K	0,06 - 0,15	1,4 - 1,85	0,8 - 1,15	0,03	0,03	0,35
EH12K	0,06 - 0,15	1,5 - 2,0	0,2 - 0,65	0,025	0,025	0,35
EH14	0,10 - 0,2	1,7 - 2,2	0,1	0,03	0,03	0,35

Example of AWS Classification:

F43 A2-EM12K is a complete designation for a flux-electrode combination. It refers to a flux that will produce weld metal which, in the as welded condition, will have a tensile strength of 430 to 560 MPa and Charpy V-Notch impact strength of at least 27 J at -20˚C when produced with an EM12K electrode under the conditions called for in this specification. The absence of an 'S' in the second position indicates that the flux being classified is a virgin flux.

Please note: AWS now makes provision for metric values. The specification containing equivalent metric values is indicated by AWS A5.17M

Submerged Arc Fluxes

Afrox HPF-A72 Submerged Arc Flux

Afrox HPF-A72 is an agglomerated flux with Mn and Si additions. HPF-A72 is a versatile flux with excellent weldability and easy slag removal; it is highly resistant to cracks and porosity and has a very good bead appearance. HPF-A72 is ideal for one-sided welding, double-sided welding, square edge joints, fillet welds and lap welds in structural and general engineering applications. It is recommended for welding inside grooves but is limited to material thicknesses below 25 mm. Due to the high oxidisation potential, it does not require any special base metal preparation and cleaning prior to welding.

Applications

Afrox HPF-A72 is used to weld gas bottles, truck wheels, structural shapes, pipes, joining plates, light boilermaking and parts with small diameters.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300°C at a flux depth of about 25 mm. For many applications, it is not necessary to re-dry the flux.

Classifications		
AWS	A5.17/ASME SFA 5.17	F7A2-EM12K

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05	**% Phosphorous**	0,018
% Manganese	1,5	**% Sulphur**	0,025
% Silicon	0,8		

Typical Mechanical Properties	
Yield Strength	426 MPa
Tensile Strength	519 MPa
% Elongation	29
Charpy V-Notch at -29°C	23 J

Flux Characteristics	
Maximum Welding Current	1 000 A
Polarity	DC or AC
Welding Speed	1 300 mm/min

Packing Data	
Pack Mass (bags/kg)	**Item Number**
25,0	W071403

Hobart SWX 110

Hobart SWX 110 are semi-basic agglomerated fluxes producing weld deposits with good mechanical properties at low temperatures. Hobart SWX 110 have excellent weldability, easy slag removal in deep grooves, good resistance to cracking and porosity and excellent bead appearance. Hobart SWX 110 flux can be used on multi-pass applications on unlimited thickness, with very little change in the chemical composititon of the weld metal.

Applications

Hobart SWX 110 can be used on structural steel, CrMo steel, high strength low alloy (HSLA) steels and quenched and tempered steels.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300°C at a flux depth of about 25 mm. For many applications, it is not necessary to re-dry the flux.

Classifications	
AWS A5.17/ASME SFA 5.17	
F6A2-EL12	F7A2-EM13K
F7A2-EM12K	F8A2-EA 2-A2
F6A2-EM12K	F9A2-EA 3-A3
F7P2-EM13K	F9P2-EA 3-A3

Chemical Analysis (All weld metal)

	EM12	EM12K	EM13K	EA2	EA3	EB2	EM12KS	EM13KS
% Carbon	0,7	0,05	0,08	0,03	0,05	0,08	0,03	0,067
% Manganese	0,91	1,3	1,51	1,17	1,7	1,38	1,02	1,08
% Silicon	0,13	0,36	0,57	0,23	0,33	0,35	0,22	0,321
% Sulphur	0,03	0,022	0,019	0,03	0,021	0,013	0,009	0,011
% Phosphorous	0,024	0,02	0,015	0,03	0,029	0,019	0,012	0,015
% Molybdenum	-	-	-	0,52	0,58	0,4	-	-
% Chromium	-	-	-	-	-	1,0	-	-
% Copper	-	-	-	-	-	-	0,027	0,083

Typical Mechanical Properties

	EM12	EM12K	EM13K	EA2	EA3	EB2	EM12KS	EM13KS
Yield Strength	393 MPa	426 MPa	410 MPa	499 MPa	565 MPa	655 MPa	408 MPa	430 MPa
Tensile Strength	476 MPa	519 MPa	525 MPa	577 MPa	655 MPa	720 MPa	490 MPa	530 MPa
% Elongation	30	29	30	2	26	23	27,8	26,5
Charpy V-Notch at -29°C	61 J	66 J	98 J	57 J	56 J	-	-	-
Charpy V-Notch at -18°C	-	-	-	-	-	51 J	-	-
Charpy V-Notch at -51°C	-	-	-	-	-	-	96 J	110 J
Charpy V-Notch at -62°C	-	-	-	-	-	-	56 J	84 J

Flux Characteristics	
Maximum Welding Current	800 A
Polarity	DC or AC
Basicity	1,4

Packing Data

Pack Mass (bags/kg)	Item Number
25,0	W071401 (HPF-N90)
25,0	W071402 (HPF-N90F)

Hobart SWX HF-N

Hobart SWX HF-N is totally neutral agglomerated flux, designed for welding with solid and tubular wires of the 400 series stainless steels. It can also be used with low alloy steel wires. It features clean slag removal with wires containing Nb and V, excellent recovery of the alloying elements from the tubular wires, such as Cr, Ni, Mo, Nb and V and accepts welding with twin-arc and oscillating technique, with currents up to 1 000 A. Hobart SWX HF-N flux should be used with wires containing at least 0,20% Si, in order to avoid porosity.

Applications

The main application of Hobart SWX HF-N is the rebuilding of steel mill roll with tubular and solid wires of the 400 series stainless steels. It can also be used to rebuild shafts, wheels and journals.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300°C at a flux depth of about 25 mm.

Typical Weld Metal Data

Product	Composition of Weld Metal Deposited											Hardness
	% C	% Mn	% Si	% S	% P	% Mo	% Cr	% Ni	% Nb	% W	% V	HRc
Afrox TA887-S	0,12	1,0	0,6	0,01	0,015	1,5	12,5	2,5	0,15	-	0,2	40
Afrox TA8620-S	0,12	0,8	0,4	0,01	0,015	0,2	0,5	0,4	-	-	-	21
Afrox TA861-S	0,15	0,9	0,5	0,01	0,015	0,6	1,7	-	-	-	-	32
Afrox TA 242-S	0,14	2,0	0,8	0,01	0,015	0,7	3,0	-	-	-	-	40
Afrox TA258-S	0,34	1,2	0,5	0,01	0,015	1,5	6,0	-	-	1,4	-	54
Afrox TA410-S	0,08	1,0	0,6	0,01	0,015	-	12,8	-	-	-	-	36
Afrox TA A250-S	0,19	1,0	0,5	0,01	0,015	-	12,3	-	-	-	-	50
Afrox TA 865-SMod	0,18	1,1	0,4	0,01	0,015	1,0	13,5	2,3	0,15	-	0,15	48
WASA 414MM-S	0,15	0,9	0,5	0,013	0,022	1,2	12,5	2,0	0,17		0,18	42 - 45
Lincore ER423L	0,15	1,2	0,4	0,01	0,02	1,0	11,5	2,0	-		0,15	42 - 45
Stoody Thermaclad 423L	0,15	1,2	0,5	0,012	0,022	1,0	11,7	2,0	-		0,15	43 - 45
EB3	0,1	0,96	0,16	0,01	0,019	1,08	2,15	-	-		-	-
EM-12K	0,1	0,88	0,19	0,019	0,02	-	-	-	-		-	-

Packing Data

Pack Mass (bags/kg)	Item Number
25,0	W071406

Oxy-Fuel & Gas Welding Rods

Afrox Copper Coated Rod (CCR)

A general purpose low carbon steel gas welding rod which is copper coated to reduce corrosion. It is recommended for oxy-acetylene welding of mild steel and is widely used in sheet metal work, the heating and ventilation industries, car body repairs, welder training schools and for low pressure piping and plumbing.

Typical Chemical Analysis (All weld metal)			
% Carbon	0,04 - 0,15	**% Sulphur**	0,035 max
% Manganese	0,35 - 0,60	**% Phosphorous**	0,04 max
% Silicon	0,03 max	**% Copper**	0,35 max

Typical Physical Properties	
Melting Range	1 490°C
Approximate Tensile Strength of Deposited Metal	386 MPa
Approximate Brinell Hardness	120 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Neutral
Flux	Not required

Packing Data
TIG (DC-)

Diameter (mm)	Consumable Length (mm)	Pack Mass (kg)	Item Number
1,6	750	5,0	W000040
2,5	750	5,0	W000045
3,2	750	5,0	W000041

Mechanically Certified Consumables

Mechanically certified electrodes and wires are required by fabricators building and repairing components destined primarily for the petrochemical industry. Certification takes place in terms of the American ANSI/AWS A5.01 specification. A short description of the requirements is detailed below.

The certification of the consumable is based on two aspects:

- The lot classification
- The level of testing.

The consumables are broken into four primary groups:

- Coated manual metal arc electrodes
- Solid wires and rods
- Flux and metal cored wires
- Fluxes for submerged arc welding and brazing.

Lot Classification (Class)

The lot classification basically specifies a number of aspects which take place during the manufacturing operation to closely monitor the quality and to be able to clearly identify a production batch of consumables. The classification system is given in the table below:

Classes					
MMA Electrodes	C1	C2	C3	C4	C5
Solid Wires	S1	S2	S3	S4	
Cored Wires	T1	T2	T3	T4	
Fluxes	F1	F2			

Generally, MMA electrodes produced by Afrox are manufactured to class C3, and MIG and TIG wires to class S1 and S3 respectively.

The definition for class C3 is:

A class C3 lot of electrodes is the quantity, not exceeding 45 000 kg, of any one size and classification (i.e. 7018-1) produced in 24 hours of consecutively scheduled production (consecutive normal working shifts). Class C3 electrodes shall be produced from covering (i.e. flux) identified by wet mix or controlled chemical composition and core wire identified by heat or cast number or chemically controlled composition.

The definition for class S1 is:

A class S1 lot of bare solid wires and rods is the manufacturer's standard lot, as defined in the manufacturer's QA programme (this in the case of Afrox is the heat or cast number which refers in terms of MIG 6000 and TIG 70S-6 to 100 000 kg of material).

The definition for class S3 is:

A class S3 lot of bare solid electrodes and rods, brazing and braze welding filler metal, and consumable inserts is the quantity of one size produced in one production cycle from one heat.

Level of Testing (Schedule)

The level of testing is selected by the purchaser and there are six levels or schedules, i.e. F, G, H, I, J and K. The most commonly used for both electrodes and wires is Schedule I. Schedule I requires the following tests to be carried out and certified for MMA electrodes:

- Chemical analysis
- Tensile properties (i.e. 0,2% proof stress, tensile strength and % elongation)
- Charpy V-Notch impact properties
- X-ray soundness
- Moisture content (of the flux coating).

The purchaser would therefore specify consumables to be supplied in terms of for example class C3 schedule I or class C4 schedule J, etc.

A list detailing the Afrox products currently mechanically certified in terms of ANSI/AWS A5,01 is given in the table below:

Packing Data (7018-1)				
Diameter (mm)	**Class**	**Schedule**	**Package Type**	**Item Number**
2,5	C3	I	Box	W075282
3,15	C3	I	Box	W075283
4,0	C3	I	Box	W075284
5,0	C3	I	Box	W075285

Packing Data (7018-1)				
Diameter (mm)	**Class**	**Schedule**	**Package Type**	**Item Number**
2,5	C5	K	Box	W087382
3,15	C5	K	Box	W087383
4,0	C5	K	Box	W087384
5,0	C5	K	Box	W087385

Packing Data (TIG 70S-6)				
Diameter (mm)	**Class**	**Schedule**	**Package Type**	**Item Number**
1,6	S3	K	Cardboard tube	W087501
2,0	S3	K	Cardboard tube	W087502
2,4	S3	K	Cardboard tube	W087503

PIPE WELDING ELECTRODES

Section 12 - Welding Consumables

Pipe Welding Electrodes 460
Hobart Pipemaster Pro-60 461
Hobart Pipemaster Pro-70 462

Hobart Pipemaster Pro-60

Pipemaster Pro-60 is a quick-starting, cellulosic mild steel electrode that provides outstanding arc stability, penetration and wash-in. It is ideal for welding in all positions and produces an X-ray quality weld with light slag that is easy to remove. Pipemaster Pro-60 can be used to weld the following API 5L steels: Grade A, B, X-42, X-46, X-52, X-56 and for the root pass on material up to X-80. It features enhanced weldability and increased mechanical properties.

Classifications		
AWS	A5.1	E6010
EN	2560	E 38 3 C 21

Approvals
American Bureau of Shipping Grade 3,3Y
Lloyds Register of Shipping Grade 3,3Y,No

Typical Chemical Analysis (All weld metal)			
% Carbon	0,08	**% Silicon**	0,15
% Manganese	0,45		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	413 MPa
Tensile Strength	496 MPa
% Elongation on 5d	27
Charpy V-Notch at -29°C	68 J

Typical Current Values and Deposition Data (AC 50 OCV min or DC+/-)

Diameter (mm)	Current (A)	Deposition Rates (kg/hr)
2,4	40 - 70	0,6
3,2	65 - 130	0,7
4,0	90 - 175	0,9

Packing Data

Diameter (mm)	Hermetically Sealed Steel Can (kg)	Item Number
2,4	22,7	W075172
3,2	22,7	W075173
4,0	22,7	W075174

Hobart Pipemaster Pro-70

Pipemaster Pro-70 is a quick-starting, cellulosic mild steel electrode that provides outstanding arc stability, penetration and wash-in. It is ideal for welding in all positions and produces an X-ray quality weld with light slag that is easy to remove. Pipemaster Pro-70 is ideal for vertical down welding on API 5L, 5LX and X-56 through X-65 pipes. It features enhanced weldability and increased mechanical properties.

Classifications		
AWS	A5.5	E7010-P1
EN	2560	E 42 3 Mo C Z 1

Approvals
American Bureau of Shipping Grade 3,3Y
Lloyds Register of Shipping Grade 3,3Y,No

Typical Chemical Analysis (All weld metal)			
% Carbon	0,1	**% Phosphorous**	0,01
% Manganese	0,5	**% Sulphur**	0,01
% Silicon	0,1	**% Nickel**	0,05
% Molybdenum	0,3	**% Chromium**	0,02

Typical Mechanical Properties (All weld metal in the as welded condition)	
Yield Strength	482 MPa
Tensile Strength	579 MPa
% Elongation on 5d	25
Charpy V-Notch at -29˚C	48 J

Typical Current Values and Deposition Data (DC+ only)

Diameter (mm)	Current (A)	Deposition Rates (kg/hr)
3,2	70 - 140	0,9
4,0	80 - 190	1,2
4,8	120 - 230	1,7

Packing Data

Diameter (mm)	Hermetically Sealed Steel Can (kg)	Item Number
3,2	22,7	W075163
4,0	22,7	W075164
4,8	22,7	W075165

LOW ALLOY STEELS

Section 12 - Welding Consumables

Low Alloy Steels 463

Welding of Low Alloy Steels 464

Low Alloy & Creep Resistant Electrodes for Manual Metal Arc Welding 476

Low Alloy & Creep Resistant Wires for Gas Metal Arc Welding & Gas Tungsten Arc Welding 483

Submerged Arc Wires 494

Submerged Arc Fluxes 495

Low Alloy & Creep Resistant Wires for Flux Cored Welding 500

Welding of Low Alloy Steels

Low alloy steels differ from plain carbon steels in that their characteristic properties are due to elements other than carbon and manganese, e.g. chromium, nickel, molybdenum, etc.

From the above statement, it is obvious that a wide range of steels, having different compositions and heat treatments, are available. Afrox welding consumables are available for welding three types of low alloy steels, with widely varying uses, i.e. creep resisting steels, high tensile steels and steels for use at low temperatures. The welding consumables, steels and procedures for welding these steel types are discussed separately.

Steels for Elevated Temperature Service

Creep is a property of great importance in materials used for elevated temperature applications. Creep is defined as the plastic deformation of steel occurring at an elevated temperature under constant load. Creep is a time dependent failure and occurs at stresses below the yield strength for the particular temperature to which the material is subjected.

Creep occurs in three stages:

- Primary creep (transient stage) – In this stage the creep rate is initially high and gradually decreases due to the effect of work hardening.
- Secondary creep (steady state creep) – The stage in which deformation continues at a constant rate, which results from a balance being maintained between the competing processes of work hardening and recovery.
- Tertiary creep – If the stress is sufficiently high in this stage, the creep rate accelerates until fracture occurs.

For practical purposes the resistance to creep is expressed by:

- Creep strength - The stress which, at a given temperature and after a given time, causes failure.
- Creep limit - The stress which, at a given temperature and after a given time, causes a certain amount of deformation, e.g. 1%.

Creep Resisting Steels

When materials are subject to elevated temperatures, the following properties are of major importance – the resistance of the materials to oxidation and the maintenance of an adequate level of tensile strength and creep resistance. Furthermore, the steels must be capable of operating at these elevated temperatures for an indefinite period. It is a well-known fact that chromium increases the strength and oxidation resistance of steel while molybdenum increases the red hardness of steel and its elevated temperature tensile properties. It is not surprising, therefore, that these two elements are the major alloying additions to these steel types. A wide range of creep resisting steels containing between 0,5 and 1% molybdenum and up to 12% chromium have been developed for use in the power generation and petroleum refining industries.

While the addition of chromium and molybdenum improves the elevated temperature properties of the steel, they also significantly increase the hardenability of the steel. It is therefore of the utmost importance that these steels be preheated prior to welding and maintained at the preheat temperature for the duration of welding. Immediately after welding, the fabrications should be stress relieved before cooling below the preheat temperatures. Typical preheat and stress relieving temperatures are given in the table which follows:

Table 1 Typical Preheat and Stress Relieving Temperatures

Nominal Composition	Alloy Name	Preheat (°C)	Interpass Temp (°C)	PWHT (°C)
0,5% Mo	P1	100 - 250	100 - 250	630 - 670 1 hr
1,25% Cr 0,5% Mo	P2, P11, P12	200 - 300	200 - 300	690 1-2 hr
1,25% Cr 0,5% Mo 0,25% V	CrMo V	200 - 300	200 - 300	690 1-2 hr
2,2% Cr 0,2% Mo 1,6% W Nb V N B Ni	P23	150 - 200	150 - 200	Not always required ASME 715-740 1 hr
2,5% Cr 1,0% Mo V Ti B	P24	150 - 200	150 - 200	Not always required ASME 715 - 740 1 hr
5,0% Cr 0,5% Mo	P5	200 min	200 min	AWS 732 - 760 1 hr EN DIN 725 - 745 2 hr
9,0% Cr 1,0% Mo	T9	200 min	200 min	AWS 732 - 760 1 hr BS EN 740 - 780 2 hr
9,0% Cr 1,0% Mo Nb V N	P91	150 min	200 - 300	AWS 760 2-3 hr BS EN 770 2-3 hr
9,0% Cr 1,0% Mo 1,0% W Nb V N	P911	200 - 300	200 - 300	AWS 760 2-3 hr BS EN 770 2-3 hr
12,0% Cr 1,0% Mo 0,5% W 0,3% V	X20	Up to 400 best 200 - 350	Up to 500	Slow cool to 120 and hold for 1-2 hr prior to PWHT. BS EN 750-770 3 hr
9,0% Cr 1,0% Mo 1,7% W Nb V N	P92	200 min	350 max	Slow cool to 100 prior to PWHT. BS EN 730-770 4 hr

Table 2 Typical Application for Creep Resistant Alloys

Nominal Composition	Alloy Name	Operating Temp (°C)	Applications
0,5% Mo	P1	450	Vessels and piping
1,25% Cr 0,5% Mo	P2, P11, P12	550	Steam generators, piping, turbine castings, steam chests, valve bodies, boiler superheaters, corrosion resistant to sulphur bearing crude oil at 250 - 450°C, resistance to hydrogen attack, coal liquefaction plant and NH_3 pressure vessels
1,25% Cr 0,5% Mo 0,25% V	CrMo V	580	Valve casings, steam turbines, boilers, pressure vessels
2,25% Cr 1,0% Mo	P22	600	Steam generators, piping, turbine castings, steam chests, valve bodies, boiler superheaters, corrosion resistant to sulphur bearing crude oil at 250 - 450°C, resistance to hydrogen attack, coal liquefaction plant and NH_3 pressure vessels
2,2% Cr 0,2% Mo 1,6% W Nb V N B Ni	P23	580	Water walls in ultra-super-critical boilers, power generating plants
2,5% Cr 1,0% Mo V Ti B	P24	580	Water walls in ultra-super-critical boilers, power generating plants
5,0% Cr 0,5% Mo	T5	600	Boiler superheaters, heat exchangers, piping, pressure vessels in oil refineries, corrosion resistance in superheated steam, hot hydrogen gas and high sulphur crude oils
9,0% Cr 1,0 Mo	T9	600	Reasonable corrosion resistance in superheated steam, hot hydrogen gas and high sulphur crude oils where higher performance than 5% Cr 0,5% Mo steels is required. Boiler superheater tubes, piping, pressure vessels in oil refineries and power plants
9,0% Cr 1,0% Mo Nb V N	P91	600	Headers, main steam piping, turbine casings in fossil fuel power plants. Coal liquefaction and gasification plants
9,0% Cr 1,0% Mo 1,0% W Nb V N	E911	600	Headers, main steam piping, boiler tubes, turbine casings in fossil fuel power plants. Coal liquefaction and gasification plants
12,0% Cr 1,0% Mo 0,5% W 0,3% V	X20	550	High pressure steam piping, headers, heat exchangers, turbine components
9,0% Cr 1,0% Mo 1,7% W Nb V N	P92	600	Headers, main steam piping, turbine casings in fossil fuel power plants

Basic hydrogen-controlled electrodes and wires of matching compositions are used for welding creep-resisting steels. A number of steels and matching Afrox consumables suitable for use at an elevated temperature are given in Table 3

Table 3 Afrox Electrodes and Wires Suitable for Welding High Temperature Steels According to DIN, BS and ASTM Specifications

Electrode	Base Metal Nominal	Alloy Steel Plates	Alloy Steel Tubes and Pipes	Steel Castings	Alloy Steel Forgings
Afrox KV2 MIG/TIG G2Mo FCW TM811-A1	0,5% Mo	DIN 17155 17Mn4 DIN 17155 19Mn6 DIN 17155 15Mn3 ASTM A204 A, B, C ASTM A302 A, B	DIN 17175 17Mn4 DIN 17175 19Mn5 BS 3059 243 ref CEW BS 3606 243, 245, 261 ASTM A209 TI, TIa, TIb ASTM A250 TI, TIa, TIb ASTM A335 PI ASTM A369 FPI	DIN 17245 GS-22 Mo4 BS 3100 BI BS 1504 245 ASTM A217 WCI ASTM A352 LCI	DIN 15Mo3 DIN 16Mo5 DIN 10MnMo 4 5 DIN 11MnMo 4 5 BS 10028-2 16Mo3 ASTM A204 A, B, C ASTM A336 FI
Afrox KV5 and KV5L MIG/TIG/SAW B2 FCW TM811-B2	1,25% Cr 0,5% Mo	DIN 17155 13 CrMo 44 BS 1501 620 BS 1501 621 ASTM A387 2, 12, 11 ASTM A213 T2, TII, T12	DIN 17175 13 CrMo 44 BS 3604 620-440 BS 3604 620-460 ref HFS, CFS BS 3604 621 ref HFC CFS, ERW, CEW ASTM A199 TII ASTM A356 6 ASTM A335 P2, PII, P12	DIN 17245 GS-17 CrMo 55 BS 3100 B2 ASTM A217, WC6, WCII Class 1, 2 and 3	BS 3604 620-440 BS 3059-620-540 ASTM A182 F2, FII, F12, Class 1 and 2 ASTM A336 F12, F11 FIIa, FIIb
Afrox KV3 and KV3L MIG/TIG/SAW B3 FCW TM911-B3	2,25% Cr 1,0% Mo	DIN I7155 I0 CrMo 9I0 BS I50I 622/515 ASTM A387 21, 22	DIN 17175 10 CrMo 910 BS I50I 622/51 5 BS 3059 622-490 ref SI, S2 ASTM AI99,T4,T22 ASTM A213 T22 ASTM A335 P22	DIN 17245 GS-18 CrMo 910 BS3100 B3 BS 1504 622 ASTM A217 WC9 ASTM A356 10	BS 3059 622-490 BS 1503 622-560 ASTM A182 F22 Class I and 2 ASTM A336 F22, F22a
Chromocord 5 MIG/TIG/SAW B6	5,0% Cr 0,5% Mo	ASTM A387 5	DIN 12CrMo 195 DIN X7CrMo 6 I DIN X I I CrMo 6 I BS 3604 625 HFS, CFS ASTM AI99 T5 ASTM A213 T5, T5b, ASTM A335 P5, P5b ASTM A369 FP5	ASTM A217 C5 ASTM A336 F5, F5a	BS 1503 625-520, 590 ASTM AI82 F5, F5a ASTM A336 F5, F5a

Table 3 (continued)

Electrode	Base Metal Nominal	Alloy Steel Plates	Alloy Steel Tubes and Pipes	Steel Castings	Alloy Steel Forgings
TBA	9,0% Cr 1,0% Mo	ASTM A387 9	ASTM A335, 9 ASTM A234, WP9 ASTM A199, T9 ASTM 213, T9 BS 3604, CFS & HFS 629-470, CFS 7 HSF 629-590 DIN XI2CrMo 9 I DIN X7CrMo 9 I	DIN GS-12CrMo 10 I ASTM A217 CI2 BS 1504 G629 BS 3100 G B6	ASTM AI82 F9 ASTM A336 F9
TBA	9,0% Cr 1,0% Mo Nb V N	ASTM A387, 91 DIN/BS EN XI OCrMoVNb 9 I BS 1503, 91 AFNOR NF A-492 I 3/A-492 I 8 TU Z 10 CDVNb 09-0 I	ASTM A213, T91 ASTM A335, P91	ASTM A217, CI2A ASTM A234, WP91 ASTM A369, FP91	ASTM AI82I, A336, F91

Steels with High Tensile Strength

High tensile alloy steels can be divided into two distinct groups, i.e. the low carbon quenched and tempered or low carbon martensitic types and the high carbon content alloy steels, which transform to high carbon martensite during quenching. In this section, only the first group will be discussed.

Low Carbon Martensitic Steel Types

The low carbon martensitic steel types exhibit an excellent combination of high strength (yield strength in the vicinity of 700 MPa), toughness, abrasion resistance, excellent HAZ structure resistant to hydrogen-induced cracking coupled with good weldability. These properties have led to steels of this type being used extensively in industries such as earth moving, mining, pressure vessel construction and for military applications.

These steels are low in carbon, e.g. 0,10% to 0,23% and are alloyed with elements such as nickel, chromium, vanadium, molybdenum, boron and in some cases titanium. The elements are balanced carefully to obtain the optimum hardenability and excellent mechanical properties with relatively low cost. In many cases, these steels are sold on the basis of their mechanical properties under a wide variety of proprietary brand names such as ROQ-tuf, T1, etc.

Hydrogen Cracking

Hydrogen-induced cold cracking, which occurs during the welding of high tensile steels, can be divided into two distinct areas:

- Cracking in the weld metal
- Cracking in the heat affected zone.

Generally, when the tensile strength of the deposited weld metal exceeds that of the parent material, cold cracking is most likely to occur in the weld metal. These cracks can either be longitudinal centre bead cracks or transverse cracks running perpendicularly through the weld bead into the base material. The direction of the cracks are perpendicular to the stresses imposed upon the joint by restraint and shrinkage of the weld metal during solidification.

Manufacturers of high tensile steels invariably provide adequate data on the preheat and maximum heat input necessary to avoid heat affected zone cracking of the base material. These requirements will be discussed briefly below. In many instances, however, the minimum preheat and interpass temperatures may be insufficient to avoid weld metal cracking.

The American Welding Society Structural Welding code D1.1 indicates that preheat and interpass temperatures should be high enough to prevent crack formation in highly restrained joints and provides the following temperatures which should be employed:

Table 4 Preheat and Interpass Temperatures

Steel Types	Thicknesses (mm)	Minimum Preheat Temp (°C)	Maximum Preheat Temperature (°C)
ASTM	Up to 19	10	205
A514	19 - 38	50	205
A517	38 - 64	80	230
A709	Over 64	107	230

In order to limit heat input, it is important that weld beads be deposited using the stringer technique and that weaving be limited to less than 2,5 times the electrode diameter (i.e. where the stringer bead technique is not possible). A general guide for maximum heat input values is as follows:

Table 5 Allowing Heat Input

Preheat Temperature (°C)	Maximum Heat Input (kJ/mm)			
	6 mm	12 mm	15 mm	32 mm
20	1,25	1,9	4	5
65	Unnecessary	1,65	2,4	4,3
95	Unnecessary	1,4	2,2	3
150	Unnecessary	1,3	2,1	2,6
200	Unnecessary	1,2	2	2,5

Notes on Welding High Carbon High Tensile Steels

Steels of this type can form very hard structures in the heat affected zone when welded. To avoid possible cracking problems, preheat temperatures up to approximately 300°C may be required, followed in some instances by post weld heat treatment. With regard to these steels, precautions similar to those for carbon- manganese steels should be followed. Steels in this category with a carbon equivalent above 0,5 may be welded with Afrox 309LMo, 312, 98 and 118.

Where high carbon, high tensile steels are to be welded with one of the austenitic type consumables recommended above, a lower preheat temperature would be required.

Table 6 Afrox Consumables for Welding Low Alloy Steels

Product	Materials to be Welded	Application
MIG/TIG Ni-I FCW TM811-Ni	ASTM A333 Gr 6 ASTM A334 Gr 6 ASTM A350 Gr LF2 & LF5 ASTM 352 Gr LCB & LCC (cast) API 5L, X65 BS 4360 Gr 43E, 50E, 55C, 55EE, 55F	For welding higher strength steel structures where PWHT is impracticable so that welds must possess an appropriate degree of toughness and crack resistance. The addition of about 1% Ni promotes microstructural refinement, with improved tolerance to procedural variations compared to plain CMn weld metal. Ni also increases the atmospheric weathering resistance and improves the electrochemical balance between weld metal and base metal, thus minimising preferential weld area corrosion in marine environments. For offshore oilfield sour service, a minimum of 1% Ni is commonly required.
Tenacito 70B TIG 80Ni2	ASTM A203 Gr A & B Plate ASTM A333 Gr 6 pipe ASTM A350 Gr LF I & LF2 forgings ASTM A352 Gr LC2 casting BS 1501-224 Gr 490B plate Hyplus 29 Corten	Fabrication of storage tanks, process plant and associated pipework where good fracture toughness from as-welded joints is demanded down to temperatures in the region of -60°C. The addition of about 2,5% Ni improves microstructural refinement and tolerance to procedural variations compared to plain CMn weld metal. It also promotes the formation of a stable patina as required for matching the characteristics of weathering steels, and is an alternative to using matching consumables.
Afrox 75	BS 150 I Gr 503, plate ASTM A203 Gr D, E & F plate ASTM A333 Gr 3 pipe BSI503 Gr 503 forging ASTM A350 Gr LF3 forging BS 1504 Gr 503 LT60 casting ASTM A352 Gr LC3 casting	Construction of cryogenic plant and associated pipework e.g. petrochemical industry, demanding resistance to weld brittle fracture when operating at temperatures down to -80°C in the manufacture, storage and distribution of volatile liquids and liquefied gas. It can be used for welding CMn and low alloy steel for critical applications demanding a combination of strength and reliable toughness down to temperatures in the region of -600°C.
Afrox 98	ASTM A553-BO Gr A C1.1 ASTM A67B-75 Gr C ASTM A656-79 type 1-7 ASTM A537-BO C1.2 DIN StE500, WstE 460, WstE 500, TstE 420, TstE 460, TstE 500 DIN 17100 5t 50-2 Mittal ROQ-tuf	High yield strength quenched and tempered steels, alloy steel plate, structural steels for bridges, high tensile quenched and tempered steels, pressure vessel plates, alloy steel MnMo and MnMoNi quenched and tempered steels, quenched and tempered CMn steel plates for structural applications, hot rolled structural steel plates and pressure vessel plates CMnSi type, fine grained structural steel, high temperature fine grained steel, low temperature fine grained steel and steels for general structural purposes, high strength roller quenched and tempered structural steel plates.
MIG/TIG D2	AISI 4130, 4140, 8630 BS 970 Gr 709M40 (EN 19) DIN 42CrMo4, 34CrMo4 ASTM A487 Gr 4B, 4D, 6A cast	Fabrication of higher strength steels for use in the stress relieved condition. For offshore oil well head process pipework and fittings, these low nickel consumables satisfy NACE MRO 175 requirements intended to ensure resistance to sulphide-induced stress corrosion cracking in sour service, combined with good sub-zero toughness.

Table 6 (continued)

Product	Materials to be Welded	Application
Afrox 118 Hoballoy 11018M MIG 6048	ASTM A514-77 ASTM A709-80 Gr 100, 100W ASTM A533-80 Gr Cl.2 DIN WstE460, WstE500, TstE 420, TstE 460, TstE 500 DIN 17100St60-2 Mittal ROQ-tuf	High yield strength quenched and tempered steels, alloy steel plate, structural steels for bridges, high tensile quenched and tempered steels, pressure vessel plates, alloy steel MnMo and MnMoNi quenched and tempered steels, quenched and tempered CMn steel plates for structural applications, hot rolled structural steel plates and pressure vessel plates CMnSi type, fine grained structural steel, high temperature fine grained steel, low temperature fine grained steel and steels for general structural purposes, high strength roller quenched and tempered structural steel plates.
OE-N127 MIG/TIG 120 FCW BI21 T5 K4	HY 80, Q I(N) Possibly HY I00 & Q2(N)	For welding a range of high strength low alloy steels, in particular for military applications by the MoD and US Navy for the construction and repair of naval craft and submarines. The consumable also has applications in general structural steel fabrications in HSLA steels, which may be used for cranes, earth-moving equipment, and other highly stressed structural components.

Steels for Low Temperature Service

As the temperature decreases the resistance to impact of steels decreases. This may be gradual in some cases or can occur in a narrow transition band. The ductile to brittle transition of steel, subject to impact loading, is influenced by a number of factors, which include:

- The carbon content – which should be as low as possible
- The degree of deoxidation – the steel should be fully killed
- The grain size – should be fine grained
- The alloy content – particularly the nickel level.

A number of these factors can be combined in steels to give the low temperature notch toughness required. In some cases carbon manganese steels, such as BS 4360 grades 40E and 43E, have specified minimum impact values at -50°C and below. Nickel bearing steels, however, are normally required to have impact properties at temperatures below -60°C. Acceptance criteria for low temperature steels with regard to impact properties are as follows:

Table 7 Acceptance Criteria for Low Temperature Steels with Regard to Impact Properties

Minimum average impact value at these temperatures are 27 J										
Specification	**Grade**	**Charpy V-Notch Impact Test at Temperature (°C)**								
		-20	**-30**	**-40**	**-50**	**-60**	**-80**	**-100**	**-110**	**-196**
Structural Steel Plate										
BS 4360-79	40E				X					
	43E				X					
	50D			X						
	50E				X					
	50F					X				
	50E				X					
	50F					X				
ASTM A633-79	Grade D				X					
DIN 17102	TStE 255-500				X					
Steel Plate for Boiler and Pressure Vessels										
BS 1501 Part I	164 Grade 360 LT 20	X								
	164 Grade 400 LT 20	X								
	223 Grade 460 LT 30		X							
	225 Grade 490 LT 50				X					
ASTM A662-79	Grade A			X						
	Grade B				X					
	503 3,5 % Ni						X			
BS 15012 Part 2-70	509 9,0 % Ni									X

Generally, these steels are supplied in the normalised, controlled rolled, normalised and tempered or quenched and tempered conditions.

Notes on Welding Steels for Low Temperature Service

When low temperature steels are to be welded, a number of factors should be kept in mind to ensure the metallurgical integrity of the joint:

- Preheating is not generally required
- Consumables must be selected which will ensure adequate strength and impact properties at the lowest recommended temperature. In all cases, the consumables should be of the basic coated hydrogen-controlled type
- Excessive heat inputs should be avoided as these may lead to coarse grained weld metal deposits and heat affected zones. High heat input positions such as vertical-up should be avoided where possible.

Table 8 Afrox Consumables for Welding SSAB Domex Cold Forming Steels

Steel Type	Description	Afrox Consumable
Domex 80W	Hot rolled weather resistant steel	MIG/TIG 80 Ni I Fluxofill 20
Domex 100 XF Domex 240 YP Domex 315 MC Domex 355 MC Domex 420 MC	Hot rolled extra high strength cold forming steel	Afrox 7018-1 MIG 9000 Glodflow TM 791 Coremax 71 Plus Afrox TIG 70S-6 Sub 70-2 SWX110160
Domex 460 MC Domex 500 MC	Hot rolled extra high strength cold forming steel	Afrox 98 Tenacito 70 B MIG/TIG 80 Ni I Fluxofill 20 Subarc S2Mo/SWX
Domex 550 MC Domex 600 MC Domex 650 MC Domex 700 MC	Hot rolled extra high strength cold forming steel	Afrox 118 MIG 6048 TIG 100 Fabcor 1100
Domex Wear	Wear plate	Afrox 7018-1 MIG 9000 Glodflow TIG 70S-6 TM 791 Coremax 71 Plus

Table 9 Afrox Consumables for Welding Mittal Low Alloy Steels

Steel Type	Description	Afrox Consumable
Wearplate 200 (Bennox) SAE/AISI 1055 (Cr, 30) MCR 24	Hot rolled high carbon steel plate for hardening and wear resistance	On account of the high carbon content, which increases the hardenability, high carbon steels are not readily weldable. Rapid cooling in the heat affected zone results in the formation of hard, brittle phases, which are susceptible to cracking. High carbon steels should only be welded using special procedures. An Afrox welding engineer should be consulted for advice on welding procedures
RB 390 RB 500	Armour plate	Afrox 307, 309L, 312 MIG/TIG 307Si, 309LSi, 312, 309MoL Coremax 309L, 309MoL Subarc 307Si, 309L/MK-SS
ROQ-last TH400 ROQ-last 500	Hot rolled quenched abrasion resistant steel	Afrox 7018-1 - depending on joint design Afrox 118 Hoballoy 11018M Metalloy 110 MIG 6048 TIG 100
ROQ-tuf AM700	Hot rolled roller quenched and tempered structural and pressure vessel steel	Afrox 118 Hoballoy 11018M Metalloy 110 MIG 6048

Table 10 Consumables for Welding SSAB Wear Resistant and Structural Steel Plates

Steel Type	Description	Afrox Consumable	
Hardox 400	Abrasion resistant plate	Afrox 7018-1 Afrolux MIG 6000 TIG 70S-6 TM 791 Coremax 71 Plus Sub 70-2/HPF-N90	
Hardox 450 Hardox 500	Abrasion resistant plate	Tenacito 70 B MIG/TIG 80 Ni1 TM811-N1 Sub 70-2/HPF-A72 Subarc S2Mo/HPF-NIIX	
Weldox 355	High strength structural plate	Afrox 7018-1 MIG 6000 TIG 70S-6 TM 791 Coremax 71 Plus Sub 70-2/HPF-N90	
Weldox 420 Weldox 460	Extra high strength structural plate	**For butt welds** Tenacito 70 B MIG/TlG 80 Nil TM811-N1 Subarc S2Mo/HPF-NIIX	**For other joints** Afrox 7018-1 MIG 6000 TIG 70S-6 TM 791 Coremax 71 Plus Sub 70-2/HPF-N90
Weldox 500	Extra high strength structural plate	**For butt welds** Afrox 98	**For other joints** Afrox 7018-1 MIG 6000 TIG 705-6 TM 791 Coremax 71 Plus Sub 70-2/HPF-N90
Weldox 700	Extra high strength structural plate	**For butt welds** Afrox 118 Hoballoy 11018M MIG 6048 TIG 100	**For other joints** Rockweld CI MIG/TIG 80 Ni1 TM811-N1 Subarc S2Mo/HPF-NIIX
Weldox 900 Weldox 960 Weldox 1100	Extra high strength structural plate	**For butt welds** OE-N127 MIG/TlG 120 BI21 T5 K4	**For other joints** Afrox 118 Hoballoy 11018M MIG 6048 TIG 100

Classification for Low Alloy Consumables

Welding consumables are commonly classified under either the American (AWS) or European (EN) systems. The following is a summarised outline of the classifications for low alloy electrodes.

Under AWS, the following classifications apply:

AWS A5.5	Low Alloy Steel Electrodes for Shielding Metal Arc Welding
AWS A5.28	Low Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS A5.29	Low Alloy Steel Electrodes for Flux Cored Arc Welding
AWS A5.23	Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding

Under the Euronorm classifications, low alloys can fall under three types of classification: Creep Resistant Steels, High Strength Low Alloy Steels, and Non-Alloyed Fine Grained Steels:

EN ISO 3580	Covered Electrodes for Manual Metal Arc Welding of Creep Resistant Steels
EN ISO 21952	Wire Electrodes, Wires, Rods and Deposits for Gas Shielded Arc Welding of Creep Resistant Steels
EN ISO 17634	Tubular Cored Electrodes for Gas Shielded Metal Arc Welding of Creep Resistant Steels
EN ISO 24598	Solid Wire Electrodes, Tubular Cored Electrodes and Electrode Flux Combinations for Submerged Arc Welding of Creep Resistant Steels
EN ISO 757	Covered Electrodes for Manual Metal Arc Welding of High Strength Steels
EN ISO 16834	Wire Electrodes, Wires, Rods and Deposits for Gas Shielded Arc Welding of High Strength Steels
EN ISO 2560	Covered Electrodes for Manual Metal Arc Welding of Non-Alloy and Fine Grained Steels
EN ISO 14341	Wire Electrodes, Wires, Rods and Deposits for Gas Shielded Arc Welding of Non-Alloy and Fine Grained Steels
EN ISO 636	Rods, Wires and Deposits for Tungsten Inert Gas Welding of Non-Alloy and Fine Grained Steels
EN ISO 17632	Tubular Cored Electrodes Gas Shielded Metal Arc Welding of Non-Alloy and Fine Grained Steels
EN ISO 756	Solid Wires, Solid Wire-Flux and Tubular Wire Flux Combinations for Welding of Non-Alloy and Fine Grained Steels

For detailed information about the classification of consumables to the above specifications, please contact the product manager at Afrox MPG marketing on +27 (0) 11 490 0400.

AWS A5.01 Filler Material Procurement Guidelines

The specification covers the testing and classification of welding consumables from a procurement point of view and outlines how customers should specify what product testing and quality control they require. The first section covers the classification of 'lots' or batch sizes and testing. The second section covers product testing. In all instances when a customer orders a product, they should state on the order the lot classification and testing schedule they require.

Lot Classification

This covers electrodes, solid wires and tubular wires with the suffix 'C' for covered electrodes, 'S' for solid wires, 'F' for submerged arc welding, brazing and braze welding and 'T' for tubular wires. See Table 11 below for details.

Table 11 Lot Classifications

Lot Classification	Requirements
Covered Electrodes	
C1	Manufacturer's standard lot as defined in its quality system
C2	A lot of one size not exceeding 45 350 kg of any size produced in 24 hrs of consecutively scheduled production
C3	A lot of one size not exceeding 45 350 kg produced in 24 hrs of consecutively scheduled production. The flux to be identified by wet mix or controlled chemical composition and core wire identified by heat number or controlled chemical composition
C4	A lot of any one size produced from one wet mix and one heat of core wire
C5	A lot of one size produced from one dry blend of flux and one heat of core wire
Solid Wire	
S1	A lot as defined in the manufacturer's quality assurance programme
S2	A lot not exceeding 45 350 kg of one size, form and temper produced in 24 hrs of consecutively scheduled production from one heat or from material identified by controlled chemical composition
S3	A lot of one size produced from one heat in one production cycle
S4	A lot not exceeding 45 350 kg of one size, form and temper produced under one production schedule from one heat or from material identified by controlled chemical composition
Tubular Electrodes	
T1	A lot as defined in the manufacturer's quality assurance programme

Table 11 (continued)

Lot Classification	Requirements
T2	A lot not exceeding 45 350 kg of one size produced in 24 hrs of consecutively scheduled production. The strip to be identified by one heat or from material identified by controlled chemical composition. The core ingredients to be identified by dry blend
T3	A lot of one size produced from one heat and one dry batch or dry blend of core ingredients
T4	A lot not exceeding 45 350 kg of one size produced under one production schedule from tube or strip identified by heat number or controlled chemical composition the core ingredients to be identified by dry blend or controlled chemical composition
Submerged Arc Fluxes	
F1	A lot as defined in the manufacturer's quality assurance programme
F2	A lot produced from the same combination of raw materials in one production cycle

Testing Schedule

AWS A5.01 specifies the level of testing as follows:

Table 12 Testing Schedule for Low Alloy Electrodes

Schedule	Requirements
F	The manufacturer's standard testing level
G	Test of the material from any production run of the product within the 12 months preceding the data of the purchase
H	Chemical analysis only for each lot shipped
I	See Table 13
J	All tests called for in the AWS filler metal specification, for each lot shipped. See Table 15
K	All tests specified by the purchaser, for each lot shipped

Table 13 Schedule I Tests for Low Alloy Electrodes

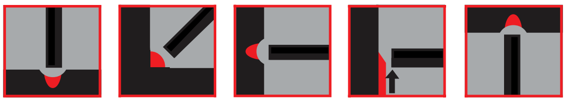
AWS Classification	Chemical Analysis	Tensile Test	Impact Test	Soundness X-Ray	Moisture Test
A5.5 MMA	Y	Y	Y	Y	Y
A5.28 MMA/TIG	Y	Y	N	Y	N
A5.23 SAW	Y	Y	Y	Y	N
A5.29 FCW	Y	Y	Y	Y	N

Table 14 Schedule J Tests for Low Alloy Electrodes

AWS Classification	Chemical Analysis	Tensile Test	Impact Test	Soundness X-Ray	Fillet Weld Test
A5.5 MMA	Y	Y >3,2 mm	Y >3,2 mm for flux type 18	N	Y >3,2 mm
A5.28 MIG/TIG	Y	Y	N - CrMo Y - Others	Y	N
A5.23 SAW	Y - Solid wire and flux wire combination N-composite, test weld metal	Y - Wire flux combination only	Y - Wire flux combination only	Y - Wire flux combination only	N
A5.29 FCW	Y	Y - Except G	N - CrMo Y - Others Except K5	Y - Except G	Y for EXIT N - Others

Low Alloy & Creep Resistant Electrodes for Manual Metal Arc Welding

Afrox KV2



Afrox KV2 is a basic coated hydrogen controlled electrode for all position welding of high tensile low alloy steels and creep resisting steels containing 0,5 molybdenum for service up to 450°C. The ease of operation and stability of the arc make this electrode eminently suitable for use in difficult to weld positions. The electrode deposits weld metal of high metallurgical and radiographic qualities in all positions.

Approvals
TÜV, EN 13479, CE (C880-CPD-0035)

Classifications		
AWS	A5.5	E7018-A1 H4
EN ISO	3580-A	E Mo B 22 H5

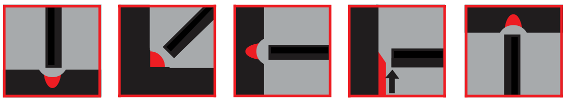
Typical Chemical Analysis			
% Carbon	0,05 - 0,09	**% Sulphur**	0,025 max
% Manganese	0,75 - 0,9	**% Phosphorous**	0,025 max
% Silicon	0,45 max	**% Molybdenum**	0,4 - 0,6

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	390 MPa min
Tensile Strength	480 MPa min
% Elongation on 50 mm	25 min
Charpy V-Notch at +20°C	120 J min

Packing Data (DC+ only)				
Diameter (mm)	**Current (A)**	**Electrode Length (mm)**	**Pack Mass (kg)**	**Item Number**
2,5	65 - 95	300	3 x 4,0	W075512
3,15	85 - 130	350	3 x 4,0	W075513
4,0	120 - 180	350	3 x 4,0	W075514
2,5 (DriPac)	65 - 95	300	3 x 4,0	W075516
3,15 (DriPac)	85 - 130	350	3 x 4,0	W075517
4,0 (DriPac)	120 - 180	350	3 x 4,0	W075518

Classifications Afrox KV2 (DriPac)		
AWS	A5.5	E7018-A1
EN ISO	3580-A	E Mo B 22 H5

Afrox KV5
Afrox KV5L



Afrox KV5 and KV5L are basic coated DC type, hydrogen controlled all position electrodes depositing weld metal containing 1,25% chromium and 0,5% molybdenum. The deposits from these electrodes are characterised by excellent radiographic and metallurgical qualities which, together with exceptional weldability, make these ideally suited for positional welding. The product was developed to weld a wide variety of 1,25 Cr, 0,5 Mo creep resisting steels.

Approvals
TÜV, EN 13479, CE (C880-CPD-0035)

Classifications Afrox KV5		
AWS	A5.5	E8018-B2 H4
EN ISO	3580-A	E Cr Mo1 B H5

Classifications Afrox KV5L		
AWS	A5.5	E7018-B2L H4
EN ISO	3580-A	E Cr Mo1 B H5

Typical Chemical Analysis

	Afrox KV5	**Afrox KV5L**		**Afrox KV5**	**Afrox KV5L**
% Carbon	0,05 - 0,1	0,05 max	**% Phosphorous**	0,025 max	0,025 max
% Manganese	0,5 - 0,9	0,5 - 0,9	**% Chromium**	1,0 - 1.3	1,0 - 1,3
% Silicon	0,45 max	0,45 max	**% Molybdenum**	0,04 - 0,6	0,04 - 0,6
% Sulphur	0,025 max	0,025 max			

Typical Mechanical Properties
(All weld metal in the stress relieved condition to AWS A5.5)

	Afrox KV5	**Afrox KV5L**
Stress Relieving Temp.	690°C for 1 hr	690°C for 1 hr
0,2% Proof Stress	460 MPa min	390 MPa min
Tensile Strength	550 - 650 MPa	520 MPa min
% Elongation on 50 mm	22 min	19 min
Charpy V-Notch at +20°C	90 J min	-
Charpy V-Notch at 0°C	70 J min	-
Vickers Hardness	190 - 200 HV	-

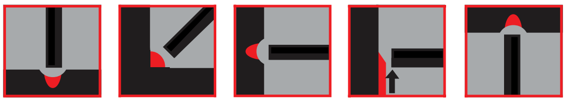
Packing Data
(DC+ only)

Diameter (mm)	**Current (A)**	**Electrode Length (mm)**	**Pack Mass (kg)**	**Item Number Afrox KV5**	**Item Number Afrox KV5L**
2,5	65 - 95	300	3 x 3,0	W075542	W075572
3,15	80 - 130	350	3 x 4,0	W075543	W075573
4,0	120 - 180	350	3 x 4,0	W075544	W075574
5,0	185 - 250	450	3 x 6,0	W075545	-
2,5 (DriPac)	65 - 95	300	3 x 3,0	W075546	W075576
3,15 (DriPac)	80 - 130	350	3 x 4,0	W075547	W075577
4,0 (DriPac)	120 - 180	350	3 x 4,0	W075548	-
5,0 (DriPac)	185 - 250	450	3 x 6,0	W075549	W075579

Classifications Afrox KV5 (DriPac)		
EN ISO	3580-A	E Cr Mo1 B H5

Classifications Afrox KV5L (DriPac)		
EN ISO	3580-A	E Cr Mo1 B H5

Afrox KV3



Afrox KV3 is a basic coated DC type hydrogen controlled all position electrode depositing weld metal containing 2,25% chromium and 1% molybdenum. The deposits from these electrodes are characterised by excellent radiographic and metallurgical qualities which, together with exceptional weldability, make these electrodes ideally suited for positional welding. Afrox KV3 is recommended for welding a wide variety of 2,25 Cr, 1 Mo creep resisting steels.

Approvals
TÜV, EN 13479, CE (C880-CPD-0035)

Classifications		
AWS	A5.5	E9018-B3 H4
EN ISO	3580-A	E Cr Mo2 B 22 H5

Typical Chemical Analysis			
% Carbon	0,05 - 0,1	**% Phosphorous**	0,025 max
% Manganese	0,5 - 0,9	**% Chromium**	2,0 - 2,5
% Silicon	0,45 max	**% Molybdenum**	0,9 - 1,2
% Sulphur	0,025 max		

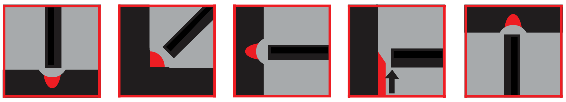
Typical Mechanical Properties (All weld metal in the stress relieved condition to AWS A5.5)	
Stress Relieving Temp.	690°C for 1 hr
0,2% Proof Stress	530 MPa min
Tensile Strength	630 - 720 MPa
% Elongation on 50 mm	20 min
Charpy V-Notch at +20°C	120 J min

Packing Data (DC+ only)

Diameter (mm)	Current (A)	Electrode Length (mm)	Pack Mass (kg)	Item Number
2,5	60 - 95	300	3 x 3,0	W075522
3,15	85 - 130	350	3 x 4,0	W075523
4,0	120 - 180	350	3 x 4,0	W075524
2,5 (DriPac)	60 - 95	300	3 x 3,0	W075526
3,15 (DriPac)	85 - 130	350	3 x 4,0	W075527
4,0 (DriPac)	120 - 180	350	3 x 4,0	W075528
5,0 (DriPac)	185 - 250	450	3 x 6,0	W075529

Classifications Afrox KV3 (DriPac)		
EN ISO	3580-A	E Cr Mo2 B 22 H5

Oerlikon Tenacito 70B



Oerlikon Tenacito 70B is a basic all position electrode containing 2,5% nickel for welding notch tough steels. It has good slag removal and a regular bead appearance. It is recommended for use in applications requiring low temperature toughness down to -60°C and is also suited for welding weathering steels.

Re-drying

Only dry electrodes should be used. Re-drying should be carried out at 300 - 350°C for 2 hours.

Classifications

AWS	A5.5	E8018-C1
EN ISO	2560-A	E 42 6 2Ni B H5

Typical Chemical Analysis

% Carbon	0,06	**% Nickel**	2,4
% Manganese	1,0	**% Copper**	<0,09
% Silicon	0,4		

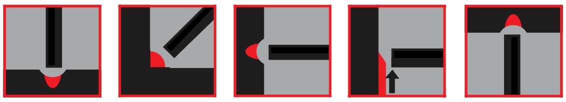
Typical Mechanical Properties (All weld metal in the as welded condition)

	As Welded	PWHT 580°C/15 hr
Yield Strength	440 MPa	420 MPa
Tensile Strength	520 - 620 MPa	500 - 600 MPa
% Elongation on 5d	>24	>26
Charpy V-Notch at +20°C	>160	>160
Charpy V-Notch at -40°C	>90	>80
Charpy V-Notch at -60°C	>70	>50
Charpy V-Notch at -80°C	>40	>30
Charpy V-Notch at -100°C	-	-

Packing Data (DC+)

Diameter (mm)	Current (A)	Electrode Length (mm)	Pack Mass (kg)	Item Number
3,15	90 - 135	350	5,0	W112023
4,0	140 - 185	450	5,0	W112024
5,0	185 - 240	450	5,0	W112025

Afrox 88 (88D3)



Afrox 88 (88D3) is a basic coated manganese molybdenum electrode recommended for use in all positions with the exception of vertical down. The electrode features a smooth and stable arc and gives excellent penetration. The slag release in all positions is excellent and the electrode operates with minimum spatter levels on both AC and DC. The product is used for the construction of boilers, pressure vessels and reactors commonly used in the petrochemical industry.

Classifications

AWS	A5.5	E8018-D3 H4
EN ISO	2560-B	E5516-3M3 H5

Typical Chemical Analysis

% Carbon	0,12 max	**% Sulphur**	0,03 max
% Manganese	1,0 - 1,8	**% Phosphorous**	0,03 max
% Silicon	0,8 max	**% Molybdenum**	0,4 - 0,65

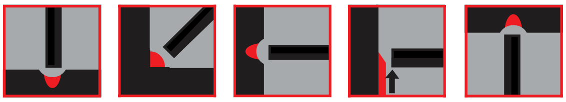
Typical Mechanical Properties (All weld wetal in the as welded condition)

0,2% Proof Stress	460 MPa min
Tensile Strength	550 MPa min
% Elongation on 50 mm	19 min
Charpy V-Notch at -51°C	27 J min

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Current (A)	Electrode Length (mm)	Pack Mass (kg)	Item Number
3,15	90 - 135	350	3 x 4,0	W075453
3,15	135 - 200	380	3 x 6,0	W075454
4,0	180 - 260	450	3 x 6,0	W075455

Afrox 98



Afrox 98 is a basic coated hydrogen controlled electrode for all position welding of high tensile low alloy steels. The electrode deposits a weld metal containing approximately 1,5% nickel and 0,3% molybdenum which apart from having good tensile properties, is extremely tough and ductile. Afrox 98 produces weld metal of the highest radiographic and metallurgical qualities in all positions. The product is recommended for welding a range of fine grained structural steels, low temperature steels and quenched and tempered steels, having an ultimate tensile strength of up to approximately 750 MPa.

Classifications

AWS	A5.5	E9018-G H4
EN ISO	2560 - A	E 50 5 1NiMo B H5

Typical Chemical Analysis

% Carbon	0,04 - 0,08	**% Phosphorous**	0,025 max
% Manganese	0,7 - 1,2	**% Molybdenum**	0,2 - 0,35
% Silicon	0,5 max	**% Nickel**	1,4 - 1,8
% Sulphur	0,025 max		

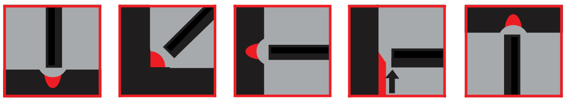
Typical Mechanical Properties (All weld metal in the as welded condition)

0,2% Proof Stress	540 - 620 MPa
Tensile Strength	620 MPa min
% Elongation on 50 mm	24 min
Charpy V-Notch at -51°C	45 J min

Packing Data

Diameter (mm)	Current (A)	Electrode Length (mm)	Pack Mass (kg)	Item Number
3,15	90 - 135	350	3 x 4,0	W075423
4,0	120 - 175	350	3 x 4,0	W075424
5,0	170 - 245	450	3 x 5,0	W075425

Afrox 118



Afrox 118 is a basic hydrogen controlled electrode for all position welding of high tensile low alloy steels. The electrode deposits a weld metal containing approximately 2% nickel and 0,4% molybdenum which, apart from having good tensile properties, is extremely tough and ductile. Afrox 118 produces weld metal of the highest radiographic and metallurgical qualities in all positions. Afrox 118 is recommended for welding a range of fine grained structural steels.

Classifications

AWS	A5.5	E11018-G H4
EN ISO	2560-A	E505 2 Ni B (nearest) H5

Typical Chemical Analysis

% Carbon	0,06 - 0,1	**% Phosphorous**	0,025 max
% Manganese	1,3 - 1,8	**% Molybdenum**	0,25 - 0,5
% Silicon	0,5 max	**% Nickel**	1,70 - 2,5
% Sulphur	0,025 max		

Typical Mechanical Properties (All weld metal in the as welded condition)

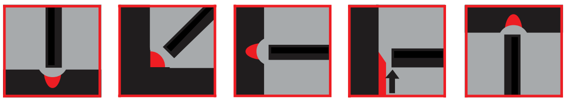
0,2% Proof Strength	670 MPa min
Tensile Strength	760 MPa min
% Elongation on 50 mm	20 min
Charpy V-Notch at -51°C	45 J min

Packing Data

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	90 - 145	3 x 4,0	W075443
4,0	380	135 - 200	3 x 4,0	W075444
5,0	450	180 - 260	3 x 5,0	W075445

Low Alloy & Creep Resistant Wires for Gas Metal Arc Welding & Gas Tungsten Arc Welding

MIG/TIG D2



MIG/TIG D2 is a low alloy solid wire, with Mn and Mo additions, designed for welding low alloy steels with high tensile strength. For use in the stress relieved condition. Often used in oil process pipework and fittings where resistance to sulphide-induced stress corrosion cracking is important.

Classifications		
AWS	A5.28	ER 90S-D2/ER 80S-D2 (depending on gas used)
MIG		
EN ISO	14341-A	G 50 5 M G4Mo
EN ISO	14341-B	G57 P 5 M G4 M31 (nearest)
TIG		
EN ISO	636-A	W 50 2 WO
EN ISO	636-B	W 57 P 2 W4M3 (nearest)

Typical Mechanical Properties (All weld metal in the as welded condition)		
	MIG	**TIG**
Tensile Strength	650 MPa	630 MPa
Yield Strength	560 MPa	520 MPa
% Elongation on 5d	22	26
Charpy V-Notch at +20°C	150 J	200 J
Charpy V-Notch at 0°C	120 J	-
Charpy V-Notch at -20°C	90 J	-

Typical Chemical Analysis			
% Carbon	0,08	**% Sulphur**	0,01
% Manganese	1,8	**% Molybdenum**	0,5
% Silicon	0,7	**% Copper**	0,12
% Phosphorous	0,01		

Packing Data
MIG (DC+)

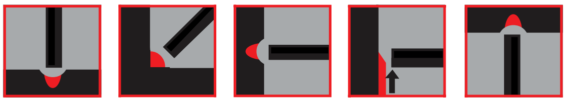
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,0	230	25	15,0	W078210
1,2	280	26	15,0	W078212

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
2,0	100	12	5,0	W078204
2,4	100	12	5,0	W078206

Suggested gas for welding: Argoshield® 5 (MIG), Argon (TIG)

MIG/TIG 80 Ni1



MIG/TIG 80 Ni1 is designed for welding low alloy steels with 1% Ni and fine grain steels as well as for low temperature applications that require good sub-zero toughness.

Classifications

AWS	A5.28	ER 80S-Ni1
MIG		
EN ISO	14341-A	G 46 4 M G3 Ni 1
EN ISO	14341-B	G49 A 4 GN 2 (nearest)
TIG		
EN ISO	636-A	W 50 4 W 3Ni 1
EN ISO	636-B	W 57 A 4 WN2 (nearest)

Typical Chemical Analysis

% Carbon	0,1	**% Sulphur**	0,01
% Manganese	1,1	**% Nickel**	1,0
% Silicon	0,6	**% Molybdenum**	0,1
% Phosphorous	0,01	**% Copper**	0,12

Typical Mechanical Properties (All weld metal in the as welded condition)

	MIG	TIG
Tensile Strength	600 MPa	600 MPa
Yield Strength	530 MPa	500 MPa
% Elongation on 5d	26	26
Charpy V-Notch at -20°C	130 J	130 J
Charpy V-Notch at -40°C	80 J	80 J

Packing Data

MIG (DC+)

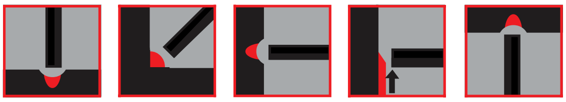
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	**Volts (V)**		
1,0	230	25	15,0	W078224

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	**Volts (V)**		
2,0	120	14	5,0	W078230
2,4	120	14	5,0	W078232

Suggested shielding gas: Argoshield® 5 (MIG), Argon (TIG)

TIG 80Ni2 / MIG 80Ni2



TIG/MIG 80Ni2 is designed for welding low alloy steels with 2% Ni and fine grain steels as well as for low temperature applications that require good sub-zero toughness.

Classifications		
AWS	A5.28	ER 80S-Ni2
EN ISO	636-A	W 50 6 W2Ni2
EN ISO	636-B	W 57 A 6 WN5 (nearest)
EN ISO	14341-A	G 46 M G2 Ni2

Typical Chemical Analysis			
% Carbon	0,1	**% Sulphur**	0,01
% Manganese	1,0	**% Nickel**	2,3
% Silicon	0,55	**% Copper**	0,12
% Phosphorous	0,01		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	620 MPa
Yield Strength	530 MPa
% Elongation on 5d	26
Charpy V-Notch at -20°C	130 J
Charpy V-Notch at -40°C	80 J
Charpy V-Notch at -60°C	50 J

Packing Data
TIG

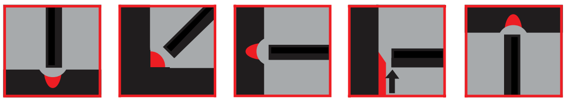
Diameter (mm)	Pack Mass (kg)	Item Number
2,4	5,0	W078238

Suggested gas for welding: Argon

Packing Data
MIG

Diameter (mm)	Pack Mass (kg)	Item Number
1,2	15,0	W078233
1,6	15,0	W078272

MIG 120



MIG 120 is a solid wire suitable for welding of low alloyed steels and high yield strength Cr-Ni-Mo steels. Excellent mechanical properties, with tensile strength of 840 MPa. Not recomended for applications that require PWHT.

Classifications		
AWS	A5.28	ER 120S-I
EN ISO	12534	G 79 4 M Mn4Ni 2 Mo

Typical Chemical Analysis			
% Carbon	0,07	**% Chromium**	0,10
% Manganese	1,7	**% Nickel**	2,3
% Silicon	0,5	**% Molybdenum**	0,5
% Phosphorous	0,007	**% Copper**	0,08
% Sulphur	0,007		

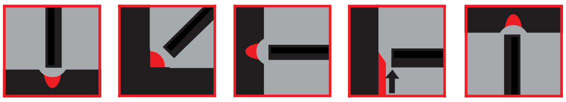
Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	840 MPa
Yield Strength	790 MPa
% Elongation on 5d	16
Charpy V-Notch at -20°C	140 J
Charpy V-Notch at -30°C	100 J
Charpy V-Notch at -40°C	90 J

Packing Data (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,20	280	26	15,0	W078196

Suggested gas for welding: Argoshield® 5

Afrox MIG 6048



Afrox 6048 is a low alloy steel welding wire containing nickel, molybdenum and vanadium. The wire, which is copper coated, is suitable for use in all positions. Afrox 6048 is recommended for welding a range of fine grained structural steels and low alloy quenched and tempered steels having an ultimate tensile strength of up to 930 MPa. The wire may be used with Argoshield® 5, Argoshield® Light, Argoshield® Heavy and Argoshield® Universal as well as CO_2 at flow rates of 14-16 ℓ/min. Argon-based shielding gases are recommended.

Classifications		
AWS	A5.28	ER 110S-G and ER 100S-G
EN ISO	16834-A	W 69 4M Mn3Ni1 CrMo
EN ISO	16834-B	W 76 A 4M N4M2 (nearest)

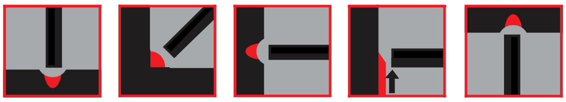
Typical Chemical Analysis			
% Carbon	0,08 - 0,1	**% Chromium**	0,3 - 0,4
% Manganese	1,6 - 1,8	**% Nickel**	1,4 - 1,6
% Silicon	0,5 - 0,7	**% Molybdenum**	0,25 - 0,3
% Phosphorous	0,15 max	**% Copper**	0,35 max
% Sulphur	0,018 max	**% Vanadium**	0,09 - 0,11

Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	>690 MPa
0,2% Proof Stress	>770 MPa
% Elongation on 5d	>17
Charpy V-Notch at -40°C	>47 J

Packing Data (DC-)				
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,0	230	25	15,0	W078192
1,2	280	26	15,0	W033188
1,2	280	26	350,0	W033189

Suggested shielding gas: Argoshield® 5, Argoshield® Light, Argoshield® Heavy, Argoshield® Universal, 100% CO_2

MIG/TIG G2Mo



MIG/TIG G2Mo is a low alloy solid wire, with 0,5% Mo, designed for welding low alloy steels such as type ASTM A335 grade P1 and similar. Suitable for pipelines and pressure vessels with operating temperatures of approximately 500°C.

Classifications

AWS	A5.28	ER 70S-A1
EN ISO	21952-A	G/W MoSi
EN ISO	21952-B	G/W 52 M IM3 (nearest)
EN ISO	636-A	W 2Mo

Typical Chemical Analysis

% Carbon	0,09	**% Sulphur**	0,01
% Manganese	1,2	**% Molybdenum**	0,5
% Silicon	0,6	**% Copper**	0,15
% Phosphorous	0,01		

Typical Mechanical Properties (In PWHT condition)

	MIG	**TIG**
Tensile Strength	620 MPa	630 MPa
Yield Strength	500 MPa	520 MPa
% Elongation on 5d	25	26
Charpy V-Notch at +20°C	150 J	200 J
Charpy V-Notch at 0°C	130 J	-
Charpy V-Notch at -20°C	90 J	80 J

Packing Data
MIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,0	230	25	15,0	W033187
1,2	280	26	15,0	W033186

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	100	12	5,0	W030533
2,0	100	12	5,0	W030534
2,4	100	12	5,0	W030535

Suggested gas for welding: Argoshield® 5 (MIG), Argon (TIG)

MIG/TIG B2

MIG/TIG B2 is a low alloy solid wire, with 1,25% Cr and 0,5% Mo, designed for welding low alloy steels with high tensile strength and creep resistant steels. For welding ASTM A387 grade 11 and 12 and similar types employed for pipelines and pressure vessels with operating temperatures of approximately 500ºC.

Classifications		
AWS	A5.28	ER 80S-B2
EN ISO	21952-A	G/W CrMo1Si (nearest)
EN ISO	21952-B	G/W 55 M ICM3

Typical Chemical Analysis			
% Carbon	0,08	**% Sulphur**	0,01
% Manganese	0,6	**% Chromium**	1,3
% Silicon	0,6	**% Molybdenum**	0,5
% Phosphorous	0,01	**% Copper**	0,12

Typical Mechanical Properties (In PWHT condition)		
	***MIG**	***TIG**
Tensile Strength	570 MPa	590 MPa
Yield Strength	460 MPa	490 MPa
% Elongation on 5d	23	25
Charpy V-Notch at +20ºC	150 J	250 J
* After PWHT of 1 hour at 690°C		

Packing Data
MIG (DC+)

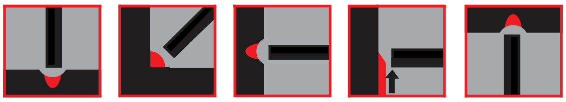
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,8	140	22	15,0	W078280
1,0	230	25	15,0	W078282
1,2	280	26	15,0	W078284
1,6	300	26	15,0	W078286

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W078274
2,0	100	12	5,0	W078276
2,4	100	12	5,0	W078278

Suggested shielding gas: Argoshield® 5 (MIG), Argon (TIG)

TIG B2L



TIG B2L contains 1,25% Cr and 0,5% Mo, and is designed for welding low alloy steels with high tensile strength and creep resistant steels. For welding ASTM A387 grade 11 and 12 and similar types for pipelines and pressure vessels with operating temperatures of about 500ºC. This low carbon version of the B2 type is preferred where as welded repairs are done or where PWHT is not viable.

Classifications

AWS	A 5.28	ER 70S-B2L
EN ISO	21952-B	W 52 M CML 1

Typical Chemical Analysis

% Carbon	0,03	**% Sulphur**	0,01
% Manganese	0,6	**% Chromium**	1,3
% Silicon	0,6	**% Molybdenum**	0,5
% Phosphorous	0,01	**% Copper**	0,15

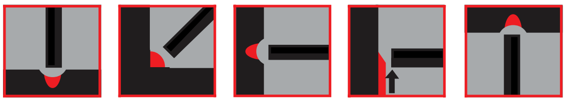
Typical Mechanical Properties (All weld metal in the as welded condition)

Tensile Strength	550 MPa
Yield Strength	470 MPa
% Elongation on 5d	23
Charpy V-Notch at +20ºC	250 J

Packing Data

Diameter (mm)	Pack Mass (kg)	Item Number
1,6	5,0	W078275
2,4	5,0	W078279

MIG/TIG B3



MIG/TIG B3 is a low alloy solid wire, with 2,5% Cr and 1% Mo, designed for welding low alloy steels with high tensile strength and creep resistant steels. For welding ASTM A387 grade 21 and 22 and similar types employed for pipelines and pressure vessels with operating temperatures of approximately 550°C.

Classifications		
AWS	A5.28	ER 90S-B3
EN ISO	21952-A	G/W CrMo2Si (nearest)
EN ISO	21952-B	G/W 62 M 2CIM2

Typical Chemical Analysis			
% Carbon	0,08	**% Sulphur**	0,01
% Manganese	0,6	**% Chromium**	2,5
% Silicon	0,6	**% Molybdenum**	1,0
% Phosphorous	0,01	**% Copper**	0,15*
* For MIG 0,12%			

Typical Mechanical Properties (In PWHT condition)			
		***MIG**	***TIG**
Tensile Strength		670 MPa	650 MPa
Yield Strength		570 MPa	570 MPa
% Elongation on 5d		20	22
Charpy V-Notch at +20°C		170 J	230 J
* After PWHT of 1 hour at 690°C				

Packing Data
MIG (DC+)

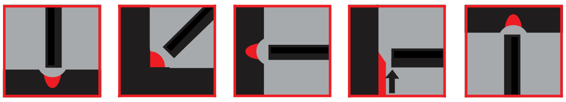
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	280	26	15,0	W078312

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W078304
2,0	100	12	5,0	W078306
2,4	100	12	5,0	W078308

Suggested shielding gas: Argoshield® 5 (MIG), Argon (TIG)

MIG/TIG B6



MIG/TIG B6 is a low alloy solid wire, with 5% Cr and 0,5% Mo, designed for welding creep resistant steels, for service temperatures up to 600ºC. For welding ASTM A335 grade P5 and similar types that are employed in the chemical industry and in the ammonia synthesis process.

Classifications		
AWS	A5.28	ER 80S-B6
EN ISO	21952-A	G/W CrMo5Si
EN ISO	21952-B	G/W 55 M 5CM (nearest)

Typical Chemical Analysis			
% Carbon	0,07	**% Sulphur**	0,008
% Manganese	0,5	**% Chromium**	5,8
% Silicon	0,4	**% Molybdenum**	0,55
% Phosphorous	0,008	**% Copper**	0,10*
* For MIG 0,12%			

Typical Mechanical Properties (In PWHT condition)		
	***MIG**	***TIG**
Tensile Strength	620 MPa	620 MPa
Yield Strength	500 MPa	500 MPa
% Elongation on 5d	25	25
Charpy V-Notch at +20ºC	70 J	200 J
* After PWHT of 1 hour at 745°C		

Packing Data
MIG (DC+)

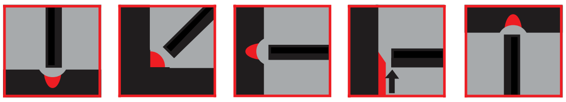
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	280	26	15,0	W078324

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W078326
2,4	100	12	5,0	W078330

Suggested gas for welding: Argoshield® 5 or Stainshield® Plus (MIG), Argon (TIG)

MIG/TIG B8



MIG/TIG B8 is a low alloy copper coated solid wire, with 9% Cr and 1% Mo, designed for welding creep resistant steels, for service temperatures up to 600°C. For welding ASTM A387 grade 9 and similar types that are employed in the chemical industry and in the ammonia synthesis process.

Classifications		
AWS	A5.28	ER 80S-B8
EN ISO	21952-A	G/W CrMo9
EN ISO	21952-B	G/W 55 M 9CIM (nearest)

Typical Chemical Analysis			
% Carbon	0,07	**% Sulphur**	0,008
% Manganese	0,5	**% Chromium**	9,0
% Silicon	0,004#	**% Molybdenum**	1,0
% Phosphorous	0,008	**% Copper**	0,1*
# For MIG 0,008%		* For MIG 0,12%	

Typical Mechanical Properties (In PWHT condition)		
	***MIG**	***TIG**
Tensile Strength	670 MPa	670 MPa
Yield Strength	530 MPa	530 MPa
% Elongation on 5d	24	24
Charpy V-Notch at +20°C	60 J	250 J
* After PWHT of 1 hour at 745°C		

Packing Data
MIG (DC+)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,2	280	26	15,0	W078348

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	100	12	5,0	W078340
2,4	100	12	5,0	W078342

Suggested gas for welding: Argoshield® 5 or Stainshield® Plus (MIG), Argon (TIG)

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Submerged Arc Wires

Subarc S2Mo

Subarc S2Mo is a copper coated solid wire for submerged arc welding with 1% Mn and 0,5% Mo content to be used for the welding of creep resistant low alloy Mo steel keeping high yield values even after heat treatment. Generally used on boilers and pressure vessels.

Classifications		
AWS	A5.23	E A2
EN ISO	24598-A	SMo
EN ISO	24598-B	SU I M3 (nearest)

Typical Chemical Analysis			
% Carbon	0,1	**% Sulphur**	0,01
% Manganese	1,1	**% Molybdenum**	0,55
% Silicon	0,1	**% Copper**	0,15
% Phosphorous	0,01		

Packing Data (DC+/AC)				
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
2,4	350	28	27,0	W078122

Suggested flux: Afrox Flux HPF-N11X

Submerged Arc Fluxes

Hobart SWX 120

Hobart SWX 120 is an agglomerated aluminate-basic type flux for general fabrication. It is slightly Mn alloying and has excellent slag detachability. It can be used for single and multi-wire applications on mild and medium tensile steels and produces weld metal with good impact toughness down to -50°C.

Applications

Applications include general construction, pressure vessel fabrication, heavy beams, double jointing of pipes, heavy equipment, tank building structural bridge fabrication, ship building, and sewage and water pipes.

Classifications

EN ISO	14174	SA AB 1 57 AC H5

Flux Characteristics

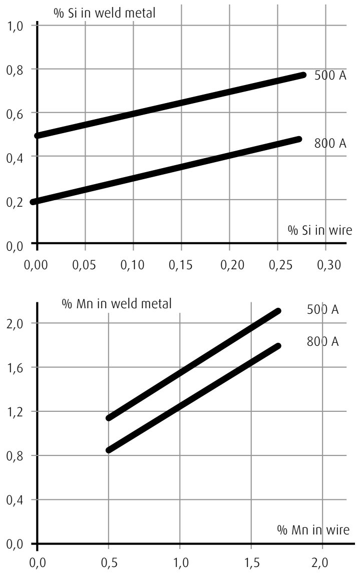
Flux Type	Aluminate-Basic
Basicity Index	1.9 (Boniszewski)
Alloy Transfer	Slightly Mn alloying
Density	1,2 Lg/Lt
Grain Size	0,2-2,0 mm 10-70 mesh
HDM	<5 ml/100 g weld metal
Current	DC+/AC
Re-drying Unopened Bag	Not required
Re-drying Opened Bag	300-350°C for 2 hours
Storage of Dried Flux	150 ± 250°C in a heated hopper

Flux Main Components

Al_2O_3+MnO	CaO+MgO	SiO_2+TiO_2	CaF_2
~35%	~25%	~20%	~20%

Metallurgical Behaviour

The diagrams show the typical weld metal analysis in relation to wire analysis for Si & Mn.



Single wire, Ø4,0 mm, DC+, 30 V, 60 cm/min

Flux Wire-Combination Classifications

With Wire		EN ISO 14171-A	AWS A5.17 & A5.23	Re/Rp 0,2 MPa	Rm MPa	A %	CVN J				
							0°C	-20°C	-30°C	-40°C	-46°C
EM 13K	AW	S 38 4 AB S2	F7A4-EM13K	420	500	26	130	110		65	
S2	AW	S 38 a AB S2Si	F7A5-EM12K	420	500	26	130	110		60	
S3Si EH12K*	AW	S 42 4 AB S3Si	F7A6-EH12K	450	560	28		110			50
	SR[1]		F7P6-EH12K	440	550	28		110			40
S2Mo-EA2	AW	S 46 2 AB S2Mo	F7A4-EA2-A4	510	590	24	90	70		50	
	SR[1]						70	40			
	TR	S 4T 2 AB S2Mo	F7P4-EA2-A4	470	560	24		50			
S4-EH14*	AW	S 46 4 AB S4	F7A4-EH14	520	620	21		80		60	
	SR[2]		F7P4-EH14	480	580	27		90		65	
S3NiMo0.2-ENi5	AW	S 50 4 AB S3NiMo0.2	F8A6-ENi5-Ni5	570	640	24		90	75	65	40
S2NiCu	AW	S 46 3 AB S2NiCu		485	570	26		70	55		

Packing Data

Pack Mass (kg bags)	Item Number
25,0	W078121

Hobart HA-495

Hobart HA-495 is an agglomerated aluminate-rutile type active flux. It allows for high speed welding even over millscale and light rust. It provides excellent bead wetting action and very good slag removal helping to reduce clean-up time and improve productivity. The flux performs well up to 1 000 A using both DC or variable balance square-wave AC (VBAC) currents this allows flexibility in selecting productive procedures and torch configurations (single, twin, tandem, etc.).

Applications

Applications include joining carbon steels up to 25 mm thickness, single and two pass groove welds, high speed fillet welds, welding over millscale or light rust, thin wall pressure vessels and tanks, thin structural steels and railcars.

Classifications		
EN ISO	14174	SA AR 1 88 AC

Flux Main Components			
SiO_2	**Al_2O_2+TiO_2**	**MnO+FeO**	**CaO+Mg+CaF_2**
~5%	~60%	~15%	~20%

Flux Characteristics	
Flux Type	Aluminate-Rutile
Basicity Index	~0,8 (Boniszewski)
Alloy Transfer	Si & Mn alloying
Density	1,2 Lg/Lt
Grain Size	0,2-1,6 mm 10-65 mesh
HDM	<8 ml/100 g weld metal
Current	DC+/DC-/AC
Re-drying Unopened Bag	Not required
Re-drying Opened Bag	300-350°C for 2 hours
Storage of Dried Flux	150 ± 250°C in a heated hopper

Flux Wire-Combination Classifications

With Wire	EN ISO 14171-A	AWS A5.17	Re/Rp 0,2 MPa	Rm MPa	A %	CVN J				
						0°C	-20°C	-30°C	-40°C	-46°C
S1-EL12 AW		F7A0-EL12	524	600	26		34			
S2Si-EM12K AW		F7A2-EM12K	579	648	22		41	34		

Metric and imperial values are typical of AWS testing. AW: as welded, all weld metal. SR: stress relieved, all weld metal. TR: two-run.

Packing Data	
Pack Mass (kg bags)	**Item Number**
25,0 Aluminium/PE bag	W071403

Hobart SWX HF-N

Hobart SWX HF-N is an agglomerated fluoride-basic type flux. The slag is self-pealing at high currents and temperatures and works well when the weld metal contains difficult elements such as niobium and vanadium. Hobart SWX HF-N is suitable for twin arc, single and multi-layer applications and for stringer or oscillating welding. It is designed to perform with a wide range of cored or solid wires.

Applications

Applications include continuous caster rollers, crusher rollers for the mining and forestry industry, sugar mills, etc.

Chemical Composition All Weld Metal - Typical Values

Product	Chemical Composition (%)											
	C	Si	Mn	Cr	Ni	Mo	Cu	V	Nb	N	W	Co
TA 242-S Mod	0,14	0,8	2,0	3,0		0,75						
TA 810-S	0,28	0,7	1,0	5,5		3,5						
TA 8620-S	0,06	0,8	1,4	0,5	0,4	0,2						
TA 865-S Mod	0,18	0,4	1,1	13,5	2,3	1,0	0,15		0,15			
TA 875-S	0,13	0,4	1,2	12,5	2,4	1,4		0,2		0,1		2,0
TA 952-S	0,27	0,6	1,2	12,8	0,6	1,8		0,19	0,18		1,4	
TA A250-S	0,19	0,6	0,8	13,5	2,0	1,0						
TA A2JL-S	0,04	0,8	1,8	0,7								

Flux Characteristics

Flux Type	Fluoride-Basic
Basicity Index	2,6 (Boniszewski)
Alloy Transfer	None
Density	1,2 Lg/Lt
Grain Size	0,2-2,0 mm 10-70 mesh
Current	DC+
Re-drying Unopened Bag	Not required
Re-drying Opened Bag	300-350°C for 2 hours
Storage of Dried Flux	150 ± 250°C in a heated hopper

Flux Main Components

AlO_2+MnO	CaO+MgO	SiO_2+TiO_2	CaF_2
~19%	~34%	~18%	~29%

Packing Data

Pack Mass (kg bags)	Item Number
25,0	W071406

Hardness – Typical Values HRc

With Wire	As Deposited			After Tempering			
	Layer 1	Layer 2	Layer 3	Time	510°C	565°C	620°C
TA 242-S Mod	29	38	39				
TA 810-S	45	48	52	8	58	58	48
TA 8620-S	12	19	21	6	19	16	15
TA 865-S Mod				6	47	43	35
	45	46	48	10	43	37	32
				20	42	36	31
TA 875-S	45	45	45				
TA 952-S	40	45	49	8	52	50	43
TA A250-S					33	28	24
	44	46	48	6	32	28	23
					32	23	22
TA A2JL-S				6	29	23	21
	40	40	35	10	25	22	19
				20	22	22	19

OP 121TT

OP 121TT is a fully basic agglomerated submerged-arc welding flux that is widely used for the welding of structural and fine grained low alloy steels requiring high integrity welds with low temperature impact and CTOD fracture toughness properties. OP 121TT flux, in combination with a range of Oerlikon submerged-arc wires, in particular with OE-SD3, is established for the welding of offshore structures such as oil platform jackets, piles, decks and modules giving a high level of consistency and mechanical property performance. The flux is widely used for the welding of thick section components in the offshore, nuclear and pressure vessel industries. The flux exhibits a low hydrogen content in the as manufactured condition and gives a high resistance to moisture pick up during exposure under workshop conditions. The flux promotes a very stable arc characteristic during use with excellent slag detachment. The weld is of a uniform, even profile with regular fine ripple formation and smooth toe blending. OP 121TT flux is suitable for use with DC+ or AC and is ideal for single wire, tandem arc (DC+/AC) and other multi-arc systems using up to 1 000 A with single wire welding. Grain size according to EN760: 2 - 20.

Re-drying

Re-dry at 300-350°C for 2-4 hours.

Classifications		
AWS	A5.23	F11A8-EG-EG
OE	SD3	2NiCrMo

Chemical Analysis			
% Carbon	0,07	**% Chromium**	0,6
% Manganese	1,4	**% Nickel**	2,2
% Silicon	0,4	**% Molybdenum**	0,5

Typical Mechanical Properties (As welded)	
Tensile Strength MPa	760 - 900
Yield Strength MPa	≥720
% Elongation on 5a	≥18

Packing Data

Pack Mass (kg)	Item Number
25,0	W124503

Hobart SWX 150

Hobart SWX 150 is a non-alloying agglomerated fluoride-basic type flux for low-alloy high strength materials. It has excellent slag detachability and can be used for single and multi-wire applications. It produces weld metal of high purity with good impact toughness down to -60°C. When used with creep resistant alloys, the high purity weld metal will meet X Factor requirements.

Applications

Applications include pressure vessel fabrication, nuclear applications, off shore constructions and high strength applications.

Classifications

EN ISO	14174	SA FB 1 55 AC H5

Flux Characteristics

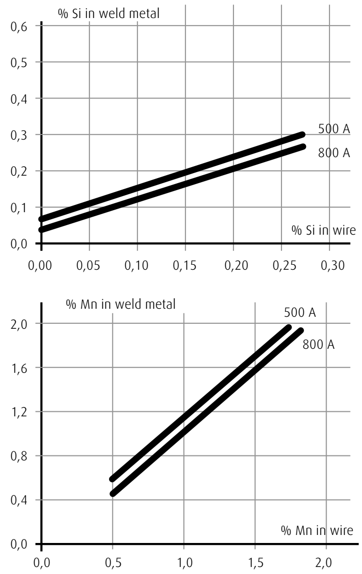
Flux Type	Fluoride-Basic
Basicity Index	2,7 (Boniszewski)
Alloy Transfer	None
Density	1,1 Lg/Lt
Grain Size	0,2-2,0 mm 10-70 mesh
HDM	<5 ml/100 g weld metal
Current	DC+/AC
Re-drying Unopened Bag	Not required
Re-drying Opened Bag	300-350°C for 2 hours
Storage of Dried Flux	150 ± 250°C in a heated hopper

Flux Main Components

Al_2O_3+MnO	CaO+MgO	SiO_2+TiO_2	CaF_2
~20%	~35%	~15%	~25%

Metallurgical Behaviour

The diagrams show the typical weld metal analysis in relation to wire analysis for Si & Mn.



Single wire, Ø4,0 mm, DC+, 30 V, 60 cm/min

Flux Wire-Combination Classifications

With Wire		EN ISO 14171-A	AWS A5.17 & A5.23	Re/Rp 0,2 MPa	Rm MPa	A %	CVN J					
							0°C	-20°C	-30°C	-40°C	-50°C	-60°C
EH 10K	AW SR[1]	S 42 5 FB S3 S 42 5 FB S3	F7A6-EH10K	450	540	24				100	70	
S3Si	SR[1]	S 38 6 FB S3Si	F7P8-EH12K	410	500	28				110		70
EB2R	SR[2] SR[1]	S S CrMo1 FB	F8P2-EB2R-B2R	480 480	590 580	22 22		110 110	90 90			
EB3R*)	SR[2] SR[3]	S S CrMo2 FB	F8P2-EB3R-B3R	530 500	630 590	22 22		110 110	90 90			
P91	SR[4]	S S CrMo91 FB		560	670	20	50					
S3Ni2.5CrMo	AW	S 79 6 FB S3Ni2.5CrMo		820	880	18				90		40

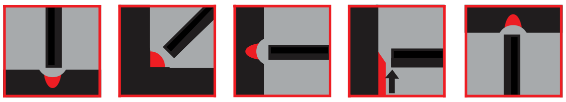
AW: as welded, all weld metal. SR: stress relieved, all weld metal. SR1: PWHT 620°C (1150°F)/1h. SR2: PWHT 690°C (1275°F)/1h. SR3: 665°C (1 230°F)/20h.
SR4: PWHT 760°C (1 400°F)/3h.
*) Step cooling data available.

Packing Data (DC+/AC)

Pack Mass (kg bags)	Item Number
25,0	W071405

Low Alloy & Creep Resistant Wires for Flux Cored Welding

FabCO 811A1



FabCO 811-A1 deposits a weld metal containing 0,5% Mo, and is designed for welding creep resistant steels for service up to 500°C. FabCO 811-A1 offers good weldability in all positions, with a fast freezing slag that removes easily. The wire is recommended for single and multi-pass welding in all positions using either 100% CO_2 or Fluxshield® shielding gases.

Classifications		
AWS	A5.29	E81T1-A1 H8

Typical Chemical Analysis 100% CO_2			
% Carbon	0,06	**% Sulphur**	0,011
% Manganese	0,96	**% Phosphorous**	0,012
% Silicon	0,32	**% Molybdenum**	0,47

Typical Mechanical Properties 100% CO_2 DC+				
	As welded	**PWHT 1hr @ 595°C**	**PWHT 1hr @ 630°C**	**PWHT 4hr @ 650°C**
Yield Strength	565 MPa	570 MPa	565 MPa	563 MPa
Tensile Strength	654 MPa	642 MPa	641 MPa	637 MPa
% Elongation	25	25	25	26
Charpy V-Notch CO°C	40 J	38 J	N/A J	30 J

Packing Data

Diameter (mm)	Current		Deposition Rate (kg/hr)	Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)			
1,2 All Position	21	115	1,2	15 (spool)	W081018
	26	**200**	2,8		
	28	250	4,0		

Bold indicates optimum parameters for welder appeal.
Suggested shielding gas: 100% CO_2 or Afrox Fluxshield®

Hobart FabCO 115

FabCO 115 is a high strength, flux cored wire that is comparable to a low alloy E11018M electrode but with higher deposition rates. It is used primarily for welding A514, A517, HY100 and similar quenched and tempered high strength, low alloy steels, producing a low hydrogen deposit with basic slag which helps to minimise cracking. FabCO 115 has high impact values at low temperatures and provides a modified globular metal transfer. For use with 100% CO_2 shielding gas only.

Classifications		
AWS	A5.29	E110T5-K4

Chemical Analysis			
% Carbon	0,04	**% Sulphur**	0,014
% Manganese	1,5	**% Chromium**	0,42
% Silicon	0,41	**% Nickel**	2,37
% Phosphorous	0,012	**% Molybdenum**	0,42

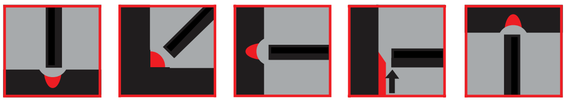
Typical Mechanical Properties (All weld metal PWHT 48 hr @ 104°C)	
Tensile Strength	>690 MPa
0,2% Proof Stress	>770 MPa
% Elongation on 5d	>17
Charpy V-Notch at -40°C	>47 J

Packing Data
(DC-)

Diameter (mm)	Current		Stick Out (mm)	Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)			
2,4	290 - 525	25 - 32	25,0	27,2	W078188

Suggested gas for FCW welding: 100% CO_2

Fabcor 1100



Fabcor 1100 is a gas shielded metal cored wire designed for use in semi-automatic applications requiring high strength weld deposits, particularly those in which high resistance to cracking and good toughness is a requirement. It is recommended for single and multi-pass welding in the flat and horizontal positions using Fluxshield® as a shielding gas at flow rates of 14-24 ℓ/min.

Fabcor 1100 is recommended for welding quenched and tempered steels such as ROQ-tuf and T1.

Classifications		
AWS	A5.29	E110C-K4

Chemical Analysis 75% Ar 25% CO_2			
% Carbon	0,07	**% Nickel**	1,92
% Manganese	1,52	**% Molybdenum**	0,47
% Silicon	0,52	**% Chromium**	0,18
% Phosphrus	0,004	**% Sulphur**	0,007

Typical Mechanical Properties (All weld metal PWHT 48 hr @ 104°C)	
Yield Stress	725 MPa
Tensile Strength	810 MPa
% Elongation on 50 mm	19
Charpy V-Notch at -50°C	58 J

Packing Data (DC+)

Diameter (mm)	Position	Current		Optimum Settings		Deposition Rates (kg/hr)	Electrode Stick Out (mm)
		Amps (A)	Volts (V)	Amps (A)	Volts (V)		
1,6	Flat/Horizontal	275 - 450	26 - 30	350	28	3,2 - 9,1	19 - 25

Packing Data

Diameter (mm)	Pack Mass (kg)	Item Number
1,6	15,0 (spool)	W081027

STAINLESS STEEL

Section 12 - Welding Consumables

Stainless Steel 503

Welding of Stainless Steel 504

Stainless Steel Electrodes 540

Stainless Steel Wires for MIG & TIG Welding 547

Stainless Steel Consumables for Submerged Arc Welding 564

Stainless Steel Wires for Flux Cored Welding 571

Welding of Stainless Steel

Stainless steels is a group of high alloy steels, which contain at least 12% chromium. In general, these steels are alloyed with a number of other elements which make them resistant to a variety of different environments. In addition, these elements modify the microstructure of the alloy which in turn has a distinct influence on their mechanical properties and weldability.

Stainless steels can be broadly classified into five groups as detailed below:

- Austenitic stainless steels which contain 12 - 27% chromium and 7 - 25% nickel
- Ferritic stainless steels which contain 12 - 30% chromium with a carbon content below 0,1%
- Martensitic stainless steels which have a chromium content of between 12 and 18% with 0,15 - 0,30% carbon
- Ferritic-austenitic stainless steels which contain 18 - 25% chromium, 3 - 5% nickel and up to 3% molybdenum
- Martensitic-austenitic steels which have 13 - 16% chromium, 5 - 6% nickel and 1 - 2% molybdenum. The first four of these groups will be discussed in detail below.

Austenitic Stainless Steels

This is by far the largest and most important group in the stainless steel range. These steels, which exhibit a high level of weldability, are available in a wide range of compositions such as the 19/9 AISI 304 types, 25/20 AISI 310 types and 19/12/2 AISI 316 types, which are used for general stainless steel fabrications, elevated temperature applications and resistance to pitting corrosion respectively.

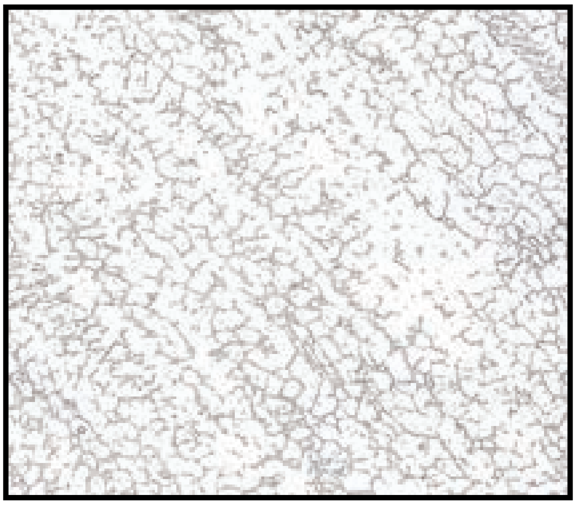
As the name implies, the microstructure of austenitic stainless steel consists entirely of fine grains of austenite in the wrought condition. When subjected to welding, however, a secondary ferrite phase is formed on the austenite grain boundaries, in the heat affected zone and in the weld metal. The extent of the formation of this secondary phase is dependent on the composition of the steel or filler material and the heat input during welding.

While delta ferrite formation can have negative effects on the resistance to corrosion and formation of sigma phase at operating temperatures between 500°C and 900°C, delta ferrite in weld metal is necessary to overcome the possibility of hot cracking.

In general, austenitic welding consumables deposit a weldment containing 4 - 12% delta ferrite. For special applications, i.e. when dissimilar steels are welded under conditions of high restraint, austenitic consumables having weld metal delta ferrite contents as high as 40%, may be required. The delta ferrite can be calculated using the procedure given at the end of this section with the aid of the Schaeffler diagram.

The carbon content of austenitic stainless steels is kept at very low levels to overcome any possibility of carbide precipitation, where chromium combines with available carbon in the vicinity of the grain boundaries to produce an area depleted in chromium, which thus becomes susceptible to intergranular corrosion.

The titanium and niobium stabilised AISI 321 and 347 steels together with ELC (extra low carbon) grades are available to further overcome this problem.



Typical microstructure of Afrox group 1 weld metal showing a structure of delta ferrite in austenite

Ferritic Stainless Steels

These steels which contain 12 - 30% chromium with carbon content below 0,10% do not exhibit the good weldability of the austenitic types. The steels, which become fully ferritic at high temperatures and undergo rapid grain growth, lead to brittle heat affected zones in the fabricated product. No refinement of this coarse structure is possible without cold working and recrystallisation. In addition, austenite formed at elevated temperatures may form martensite upon transformation, which can cause cracking problems. The brittleness and poor ductility of these materials have limited their applications in the as welded condition.

Ferritic stainless steels are also subject to intergranular corrosion as a result of chromium depletion from carbide precipitation. Titanium and niobium stabilised ferritic steels and steels with extra low interstitials (i.e. C, N) are available to overcome this problem.

As this material has a coefficient of expansion lower than that of carbon manganese steels, warpage and distortion during welding is considerably less. They are magnetic, however, and therefore subject to magnetic arc blow. Ferritic stainless steels cannot be hardened by conventional heat treatment processes.

Martensitic Stainless Steels

Martensitic stainless steels contain between 12 - 18% chromium with 0,15 - 0,30% carbon. As a result of their composition, these steels are capable of air hardening and thus special precautions should be taken during welding to overcome possible cracking. Cold cracking, as a result of hydrogen, which is experienced with alloy steels, can also occur in martensitic stainless steels and thus hydrogen-controlled consumables must be used.

Martensitic steels, because of their lower chromium content and responsiveness to heat treatment, have limited applications for corrosion resistance but are successfully used where their high strength and increased hardness can be utilised, e.g. turbine blades, cutlery, shafts, etc.

As in the case of ferritic stainless steels, the martensitic types have a lower coefficient of expansion than mild steels and are magnetic.

Duplex Stainless Steel

These are the most recently developed group of stainless steels and have a mixed metallurgical structure of nearly equal amounts of austenite and ferrite.

The composition ranges from 21 - 25% chromium, 5 - 7% nickel, approximately 3% molybdenum and 0,17% nitrogen.

They have excellent corrosion resistance especially to pitting, crevice and stress corrosion cracking. Their main applications are found in saltwater conditions where pressure and elevated temperatures are present.

Handling of Stainless Steels

To prevent stainless steel sheets and plates from becoming contaminated with grease, oil and carbon steel, all storage areas must be kept clean and free from grinding or welding dust from other operations in the shop. Any oil spills from machinery and equipment must be cleaned and removed as soon as they happen. Lifting straps and grabs that encounter stainless steel either must be made of stainless steel or be covered to protect against contamination. Storage shelves should be made of wood and wood should be used as spacers between sheets and plates also to prevent contamination.

Preparation

All stainless steels need to be prepared without contamination. Any sources of free iron, rust, carbon or hydrogen, etc. can cause welding or corrosion problems. Ideally, all stainless steel fabrication should be done in an area where no other types of steels or materials are processed. The following guidelines should be followed when preparing stainless steels:

- Thermal cutting should be done with the appropriate process (i.e. plasma arc, laser or arc air, not oxy-fuel)
- If machining is performed, it should be done without overheating the base metal, which could cause oxidation
- Grinding should be done with the correct grade of grinding disc and with discs segregated for use only on stainless steel
- All hand tools should be segregated and only used on stainless steel (e.g. files, deburring knives)
- All wire brushes should be made of stainless steel and used only on stainless steel.

Preweld Cleaning

Regardless of the type of stainless steel to be used, it is imperative that the base metal be properly cleaned before welding. In most cases, this involves:

- Wire brush or grind to remove any oxidation (which may be present on hot rolled parts)
- Chemically clean all surfaces that were machine-cut with cutting fluids
- Remove all oil, grease, moisture, etc.
- Wipe all surfaces to be welded with acetone or isopropyl alcohol.

Welding Preparation

- Weld in an area segregated from the welding of other alloys, especially carbon steels and low alloy steels
- Cover welding tables with stainless steel, aluminium or other material to protect the stainless steel parts from contamination
- Use vices, hold-down fixtures and tools, clamps, etc., made of stainless steel or covered with protective material (stainless steel tape).

Re-drying of Electrodes Prior to Welding

Austenitic materials are generally insensitive to the presence of hydrogen, however, since moisture in the electrode coating can lead to porosity in the weld metal, it is recommended that the electrodes be re-baked at 350 - 370°C for 1 - 2 hours prior to use.

Start porosity is generally indicative of damp electrodes. These electrodes should be removed from service immediately and re-dried. Porosity is more common in fillet welds than in butt welds where pores only occur at high moisture contents.

Procedure for Welding Stainless Steels

The procedure for welding stainless steels does not differ greatly from that of welding mild steel. The material being handled, however, is expensive and exacting conditions of service are usually required which necessitate extra precautions and attention to detail.

Stainless steels can be welded using either AC or DC, using as short an arc as possible, to overcome any possibility of alloy loss across the arc. When using AC, a slightly higher current setting may be required.

When welding in the flat position, stringer beads should be used and if weaving is required, this should be limited to two times the electrode diameter. The heat input, which can adversely affect corrosion resistance and lead to excessive distortion, should be limited by using the correct electrode diameter to give the required bead profile and properties at the maximum travel speed. In all cases, the heat input should be limited to 1,5 kJ/mm (MMA and MIG).

Specific points to be noted for the different stainless steel types are given below.

Austenitic Steels

As austenitic stainless steels have a coefficient of expansion 50% greater than carbon manganese steels, distortion and warping can be a problem. Welding currents should therefore be kept as low as possible with high travel speeds. Tacking should be carried out at approximately half the pitch used for mild steel and welding should be balanced and properly distributed. Preheating should not be applied and post weld heat treatment of this material is seldom required after welding. Austenitic stainless steels are normally welded with electrodes of matching composition to the base material.

Ferritic Steels

The need for preheating is determined largely by composition, desired mechanical properties, thickness and conditions of restraint. Preheat, when employed, is normally in the 150 - 250°C range. Some ferritic stainless steels can form chromium carbides at the ferrite grain boundaries during welding. For these types a post weld heat treatment of 700 - 800°C will restore the corrosion properties of the material. For mildly corrosive applications, and where the presence of nickel bearing weld metal can be tolerated, an austenitic steel electrode is recommended. This would tend to alleviate many of the toughness problems of ferritic stainless steel weld metal and could negate the need for post weld heat treatment (i.e.

in many cases the narrow notch sensitive heat affected zone could be tolerated).

Martensitic Steels

These steels require a preheat of 200 - 400°C followed by slow cooling after welding. This should be followed if possible by a post weld heat treatment at 650 - 800°C. Austenitic stainless steel electrodes are normally used for welding this material.

Duplex Stainless Steels

With the ever-increasing demand for duplex stainless steel process equipment, fabricators have developed procedures for the welding and fabrication of these grades. A lot of data on these procedures as well as practical experiences have become available. When fabricating duplex stainless steels, special attention should be paid to heat treatment and welding. Unsuitable heat treatment can result in precipitation of intermetallic phases and deterioration of toughness and corrosion resistance. Although most welding methods can be used to weld duplex steels, they require special procedures for the retention of properties after welding. Below you will find some general guidelines for welding duplex stainless steels.

Duplex stainless steels have good hot cracking resistance, therefore hot cracking of the duplex weld metal is seldom a concern. The problems most typical of duplex stainless steels are associated with the heat affected zone (HAZ), not with the weld metal. The HAZ problems are not hot cracking, but rather a loss of corrosion resistance and toughness, or of post weld cracking. To avoid these problems, the welding procedure should focus on minimising total time at temperature in the 'red hot' 500 - 790ºC range for the whole procedure rather than managing the heat input for any one pass. Experience has shown that this approach can lead to procedures that are both technically and economically optimal.

Duplex stainless steels require good joint preparation. For duplex stainless steels, a weld joint design must facilitate full penetration and avoid autogenous regions in the weld solidification. It is best to machine rather than grind the weld edge preparation to provide uniformity of the root face or gap. When grinding must be done, special attention should be given to the uniformity of the weld preparation and the fit-up. Any grinding burr should be removed to maintain complete fusion and penetration. For an austenitic stainless steel, a skilled welder can overcome some deficiencies in joint preparation by manipulation of the welding torch. For a duplex stainless steel, these techniques can cause a longer than expected exposure in the harmful temperature range, leading to results outside of those of the qualified procedure.

Duplex stainless steels can be welded to other duplex stainless steels, to austenitic stainless steels, and to carbon and low alloy steels. Duplex stainless steel filler metals with increased nickel content relative to the base metal are most frequently used to weld duplex stainless steels to other duplex grades. When welding duplex stainless steels to austenitic grades, the austenitic filler metals with low carbon and molybdenum content intermediate between the two steels are typically used. AWS E309LMo/ER309LMo is frequently used for these joints. The same filler metal or AWS E309L/ER309L is commonly used to join duplex stainless steels to carbon and low alloy steels. As austenitic stainless steels have lower strength than duplex grades, welded joints made with austenitic filler metals may not be as strong as the duplex base metal. When welding the highly alloyed austenitic stainless steels, nickel-based fillers are used. The nickel-based filler metals are not normally used for duplex stainless steels, but if they are, they should be free of niobium (columbium). Although not thoroughly documented, there have been suggestions that the ENiCrMo-3 filler (625) has been less than satisfactory, possibly because of interaction of the niobium from the filler with the nitrogen from the duplex base metal.

Table 1 summarises filler metals frequently used to weld duplex stainless steels to dissimilar metals. These examples show the AWS bare wire designation (ER), but depending on the process, joint geometry and other considerations, electrodes (AWS designation E) and flux cored wire may be considered.

Table 1 Welding Consumables used for Dissimilar Metal Welding

	2304	2205	25Cr	Superduplex
2304	2304 ER2209	ER2209	ER2209	ER2209
2205	ER2209	ER2209	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N
25Cr	ER2209	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N
Superduplex	ER2209	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N
304	ER309LMo ER2209	ER309LMo ER2209	ER309LMo ER2209	ER309LMo
316	ER309LMo ER2209	ER309LMo ER2209	ER309LMo ER2209	ER309LMo ER2209
Carbon steel Low alloy steel	ER309L	ER309L	ER309L	ER309L

Procedure for Welding Clad Steels

The use of a clad material, consisting of a mild or low alloy steel backing faced with stainless steel, usually from 10 - 20% of the total thickness, combines the mechanical properties of an economic backing material with the corrosion resistance of the more expensive stainless steel facing. This facing usually consists of austenitic stainless steel of the 18% chromium, 8% nickel and 18% chromium, 10% nickel type, with or without additions of molybdenum, titanium and niobium, or a martensitic stainless steel of the 13% chromium type.

The backing should be welded first, at the same time making sure that the root run of the mild steel electrode does not come into contact with the alloyed cladding. This can be achieved in two ways, either by cutting the cladding away from both sides of the root, or welding with a close butt preparation and a sufficiently large root face.

After welding the mild steel side, the root run should be back grooved and the stainless clad side welded with a stainless electrode of matching composition. The use of a more highly alloyed electrode (e.g. Afrox 309L) for the initial root run on the clad side is advisable. This applies particularly to preparations in which the backcutting of the cladding makes pick-up from the mild steel difficult to avoid. For the best resistance to corrosion, at least two layers of stainless weld metal on the clad side are recommended.

The welding of material which is clad or lined with 13% Cr (martensitic) steels usually requires a preheat of 250°C and the use of austenitic electrodes of appropriate type. Welding should be followed by a post weld heat treatment, though satisfactory results can be obtained without these precautions if, during welding, heat dissipation is kept to a minimum. This will help to temper the heat affected zone by utilising the heat build-up from adjacent weld runs.

Procedure for Welding Stainless Steels to Mild or Low Alloy Steels

Situations frequently arise when it becomes necessary to weld an austenitic stainless steel to a CMn or low alloy ferritic steel. In selecting a suitable electrode, the effect of dilution of the weld metal by the base material must be considered.

The weld metal may be diluted from 20 - 50% depending on the welding technique used, root runs in butt joints being the most greatly affected since all subsequent runs are only in partial contact with the base material and share dilution with neighbouring runs. If a CMn or low alloy steel electrode is used to weld stainless to CMn steel, the pick-up of chromium and nickel from the stainless steel side of the joint could enrich the weld metal by up to 5% chromium and 4% nickel. This would result in a hardenable crack-sensitive weld.

Austenitic stainless steel electrodes are therefore used for joining dissimilar metal combinations of stainless materials to CMn and low alloy ferritic steels. However, the correct type, which has sufficient alloying to overcome the effects of dilution from the mild or low alloy steel side of the joint, must be selected since if the weld metal does not start with an adequate alloy content the final weld may contain less than 17% chromium and 7% nickel. Weld metal with lower chromium and nickel content is crack sensitive. Also, if as a result of dilution the weld metal is incorrectly balanced with nickel and chromium, there may not be sufficient ferrite present in the weld metal to prevent fissuring and subsequent cracking.

For these reasons, the austenitic stainless steel electrodes such as Afrox 312 or 309LMo, etc. should be used, as their composition has been specially balanced to ensure that the total alloy content is adequate to accommodate dilution effects and their ferrite content is sufficient to provide high resistance to hot cracking.

Post Weld Cleaning of Stainless Steels

Following welding, the weld and surrounding heat affected zone (HAZ) should be properly cleaned, to ensure that the entire weldment has full corrosion resistance.

Depending upon the application, one or more of the following may be necessary:

- Chip or grind to remove all slag, scale and heavy oxide
- Remove all spatter
- Grind any arc strikes
- Wire brush to remove all traces of slag
- Wire brush to remove discolouration
- Grind and/or repair any crevices and pits
- Ensure all wire brushes are stainless steel, and are segregated for use only on stainless steels
- Segregate all tools for use on stainless steel, and do not allow them to become contaminated with carbon steel.

If the weldment is not properly cleaned, slag, entrapped foreign particles, and even discoloured oxides (light blue or straw-coloured or darker) may cause corrosion, depending on the environment.

Further treatments could include:

- Chemical cleaning
- Pickling – use of an acid to attack and remove contamination, oxidised areas, etc.
- Passivation – chemical treatment to form chromium rich passive oxide layer on the surface
- Mechanical polishing – to remove crevices and produce a smooth surface
- Electropolishing (following mechanical polishing) – produces the smoothest surface finish to avoid crevices and pits. This also renders the surface less reactive than chemical passivation.

Effects of Alloying Elements and Impurities in Stainless Steels

Carbon (C)

- A strong austenite former
- Added to some high strength alloys for hardening and strengthening effects.

Manganese (Mn)

- Austenite former.

Silicon (Si)

- A ferrite former
- Used to increase the corrosion resistance of austenitic steels
- Used to improve high temperature scaling resistance
- Used to improve resistance of high temperature steels to carburisation

- Promotes wetting by weld metal at 0,1 - 0,8%.

Chromium (Cr)

- A ferrite former
- Primary contributor to resistance to scaling and corrosion
- In the stainless steels, this element is used with little or no effect on high temperature strength and creep strength
- 12% chromium minimum essential for passivation.

Nickel (Ni)

- An austenite former
- Used to improve the general corrosion resistance against non-oxidising liquids
- Sometimes added in small amounts to straight chromium grades to improve the mechanical properties.

Molybdenum (Mo)

- A ferrite former
- Used to improve high temperature strength and creep resistance
- Used to improve general corrosion resistance of steels in non-oxidising media, and the resistance to pitting corrosion in all media.

Copper (Cu)

- Used to improve corrosion resistance of stainless steel in environments which are reducing rather than oxidising.

Niobium (Nb)

- A strong carbide former, used to stabilise austenitic stainless steels against the harmful precipitation of chromium carbides in the range of 480 - 820°C
- A strong ferrite former
- Added to some high strength alloys for hardening and strengthening effects
- Added to some martensitic straight chromium stainless steels to tie up the carbon and hence reduce the hardening tendency of the steels.

Titanium (Ti)

- A strong carbide former. Used to stabilise austenitic stainless steels against the harmful precipitation of chromium carbides in the range of 480 - 820°C
- A strong ferrite former
- Added to some high strength heat resisting alloys for its hardening and strengthening effects.

Cobalt (Co)

- Added to various alloys to impart strength and creep resistance at high temperatures.

Tungsten (W)

- Improves the high temperature strength and creep resistance of some high temperature alloys.

Nitrogen (N)

- A strong austenite former
- Used to minimise grain grown in high chromium straight chromium steels at high temperatures.

Types of Corrosion

Uniform Surface Corrosion

This occurs when the general corrosion resistance of a steel is inadequate to withstand the attack of the corrosive medium. It is then necessary to choose another steel having higher corrosion resistance, i.e. usually one of higher alloy content.

Pitting Corrosion

Certain chemicals, such as chlorides and some organic acids, cause localised pitting of the steel surface. The presence of molybdenum in the stainless steel has been found to reduce this tendency.

Stress Corrosion

Some stainless steels having high residual stresses remaining after fabrication will, in certain cases, fail very rapidly due to stress corrosion. The most satisfactory method of preventing this is to solution treat the fabrication. Another method involves redesigning to reduce the stress concentration. If neither of these methods is possible or economical, a change to a higher alloy material may provide the solution. The use of duplex austenitic ferritic stainless steels can also be effective in preventing stress corrosion cracking.

Weld Decay/Sensitisation

If unstabilised CrNi steels are heated to 500 - 900°C and allowed to cool slowly, they become more easily prone to corrosion. Such a condition may occur in the heat affected zone of a weld when a band is formed parallel to the weld where corrosion resistance is greatly reduced. This is due to the chromium in the grain boundary areas combining with the carbon. The subsequent precipitation of chromium carbides leaves a chromium depleted alloy in the grain boundaries of much lower corrosion resistance. When the steel is immersed in a corrosive medium, these depleted areas are eaten out and the grains of metal simply fall apart.

Titanium or niobium additions are frequently made to stainless steels to act as ‘stabilisers’. These elements have a greater affinity for carbon than has chromium and combine with it to form harmless titanium or niobium carbides. In this way, the grain boundaries are not depleted of chromium and retain their corrosion resistance.

Unstabilised steel that has been welded may have corrosion resistance restored by quenching from 1 100°C. This method is limited by size considerations and the tendency to distort during the heat treatment.

An even better method of avoiding carbide precipitation is to reduce the carbon content in the steel to such a low level that negligible carbide formation is possible at any temperature. A carbon level of less than 0,03% is effective in achieving this. Such extra low carbon steels are not subject to harmful carbide precipitation during welding and also display superior impact properties at low temperatures.

Welding electrodes are available with either extra low carbon content (L grade, i.e. 308L, 316L) or containing niobium to stabilise the higher carbon weld deposit against weld decay. Titanium, used to stabilise wrought material, i.e. AISI 321, is not suitable for stabilising weld metal since much of it is oxidised during transfer across the arc. It is lost to the slag and is replaced by niobium as a stabiliser in electrodes.

Oxidation

Steels for heat resistance must possess one or both of two properties – resistance to oxidation or scaling, and the retention of correct shape under stress at elevated temperatures, i.e. AISI 310.

The scaling or oxidation resistance of these steels is derived primarily from chromium, which is increasingly effective from 8% upwards. Nickel also improves oxidation resistance but only when present in large amounts. It is, however, more effective in promoting dimensional stability under stress at elevated temperatures, that is, it imparts creep resistance. Other elements contributing to creep resistance are titanium, niobium, molybdenum, cobalt and tungsten.

Sigma Phase Embrittlement

A feature, which occurs when some stainless steels are exposed to temperatures in the range of 450 - 900°C, is the formation of sigma phase. This is a brittle constituent which develops from the ferrite in the 'duplex' austenitic type of stainless steels, and results in loss of ductility and toughness in steel, especially with 312 and 2209.

Sulphur Attack

Sulphidation may occur in nickel bearing steel exposed to high-temperature atmospheres containing sulphurous gases.

The nickel is attacked and forms nickel sulphide causing cracking of the steel. Under such conditions, plain chromium steels must be used.

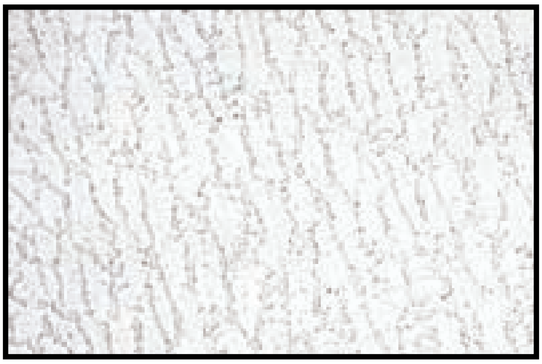
Schaeffler, DeLong and WRC - 1992 Diagrams

A useful method of assessing the general metallurgical characteristics of any stainless steel weld metal is by means of the Schaeffler, DeLong and WRC – 1992 diagrams. The various alloying elements are expressed in terms of nickel or chromium equivalents, i.e. elements such as nickel tend to form austenite and elements like chromium which tend to form ferrite. By plotting the total values for the nickel and chromium equivalents on these diagrams, a point can be found indicating the main phases present in the stainless steel in terms of ferrite percentage and ferrite number, respectively. This provides certain information as to its behaviour during welding.

The Schaeffler diagram indicates that the comparatively low-alloyed steels are hardenable since they contain the martensitic phase in the as welded state. As the alloying elements increase, the austenite and ferrite phases become more stable and the alloy ceases to be quench hardenable. Steels with a relatively high level of carbon, nickel and manganese become fully austenitic (austenite area), while those with more chromium, molybdenum, etc. tend to be fully ferritic (ferrite area).

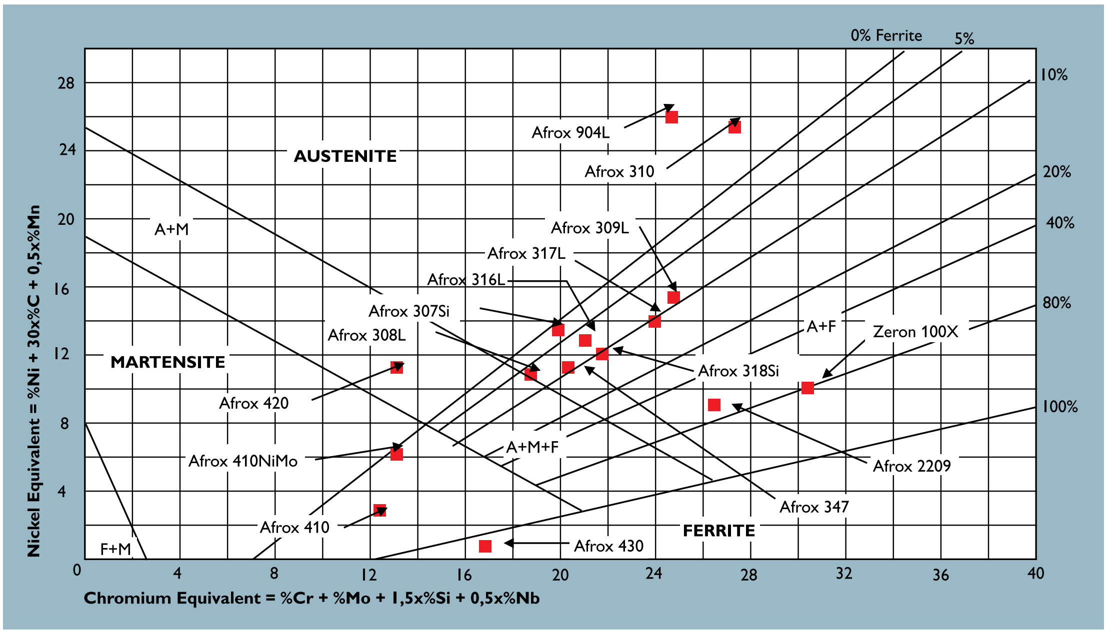
There is also an important intermediate region of 'duplex' compositions indicated as A + F on the diagram. In this region the welds contain both austenite and ferrite. This leads to the general classification of stainless steels into austenitic, ferritic and martensitic, according to which phase is predominant.

The DeLong and WRC diagrams are used to determine the amount of ferrite present in the deposited weld metal. The amount of ferrite is indicated either as the percentage of ferrite present in the microstructure or as a ferrite number. As previously mentioned ferrite, whilst detrimental to corrosion resistance, is necessary in small amounts to prevent hot cracking and is usually present in the range 4-12FN.

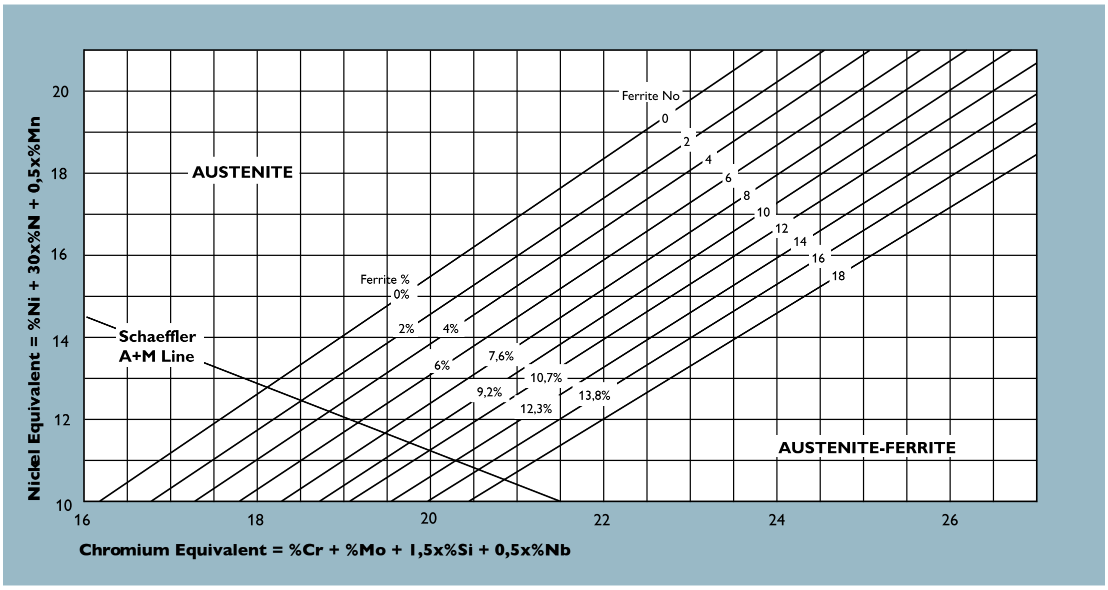


The fully austenitic weld metal of Afrox 904L

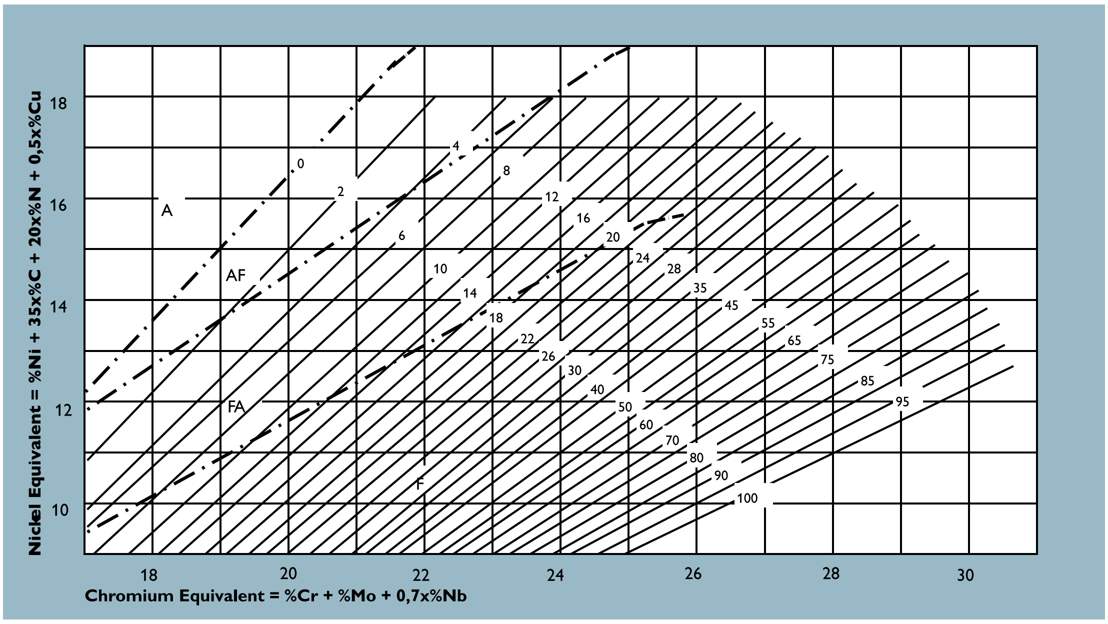
Schaeffler Diagram



DeLong Diagram



WRC-1992 Diagram



Electrode Selection Chart

Suggested Afrox electrodes for fabrication of CrNi and CrNiMo stainless steels:

Chemical Analysis of AISI Stainless Steels

AISI Type Number	Carbon (% max)	Manganese (% max)	Silicon (% max)	Chromium (%)	Nickel (%)	Other Elements (%)	Weld with Electrode Type
201	0,15	5,5 - 7,5	1,0	16,0 - 18,0	3,5 - 5,5	N2 0,25 max	Supranox 308L Afrox 308L
202	0,15	7,5 - 10,0	1,0	17,0 - 19,0	4,0 - 6,0	N2 0,25 max	Supranox 308L Afrox 308L
301	0,15	2,0	1,0	16,0 - 18,0	6,0 - 8,0		Supranox 308L Afrox 308L
302	0,15	2,0	1,0	17,0 - 19,0	8,0 - 10,0		Supranox 308L Afrox 308L
302B	0,15	2,0	3,0	17,0 - 19,0	8,0 - 10,0		Supranox 308L Afrox 308L
303	0,15	2,0	1,0	17,0 - 19,0	8,0 - 10,0	S 0,15 min	Supranox 308L Afrox 308L
303E	0,15	2,0	1,0	17,0 - 19,0	8,0 - 10,0	Se 0,15 min	Supranox 308L Afrox 308L
304	0,08	2,0	1,0	18,0 - 20,0	8,0 - 12,0		Supranox 308L Afrox 308L
304L	0,03	2,0	1,0	18,0 - 20,0	8,0 - 20,0		Supranox 308L Afrox 308L
305	0,12	2,0	1,0	17,0 - 19,0	10,0 - 13,0		Supranox 308L Afrox 308L
308	0,08	2,0	1,0	19,0 - 21,0	10,0 - 12,0		Supranox 308L Afrox 308L
309	0,20	2,0	1,0	22,0 - 24,0	12,0 - 15,0		Supranox 309L Afrox 309L
309S	0,08	2,0	1,0	22,0 - 24,0	12,0 - 15,0		Supranox 309L Afrox 309L
310	0,25	2,0	1,5	24,0 - 26,0	19,0 - 22,0		Inox 310 Afrox 310
310S	0,08	2,0	1,5	24,0 - 26,0	19,0 - 22,0		Inox 310 Afrox 310
314	0,25	2,0	3,0	23,0 - 26,0	19,0 - 22,0		Inox 310 Afrox 310
316	0,08	2,0	1,0	16,0 - 18,0	10,0 - 14,0	Mo 2,0 - 3,0	Supranox 316L Afrox 316L
316L	0,03	2,0	1,0	16,0 - 18,0	10,0 - 14,0	Mo 2,0 - 3,0	Supranox 316L Afrox 316L
317	0,08	2,0	1,0	18,0 - 20,0	11,0 - 15,0	Mo 3,0 - 4,0	Supranox 317
321	0,08	2,0	1,0	17,0 - 19,0	9,0 - 12,0	Ti 5 x C min	Inox 347
347	0,08	2,0	1,0	17,0 - 19,0	9,0 - 13,0	Nb + Ta 10 x C min	Inox 347
904	0,025	2,5	0,5	19,5 - 21,5	24,0 - 26,0	Mo 4,5 - 5,2, Cu 1,2 - 2,0	Afrox 904L
2209	0,03	2,0	0,9	21,5 - 23,5	7,5 - 9,5	Mo 2,5 - 3,5, N 0,08 - 0,2, Cu 0,75 max	Inox 4462
2507	0,03	2,0	1,0	24,0 - 26,0	8,5 - 10,5	Mo 3,5 - 4,5, N 0,2 - 0,3, Cu 0,5 max	TBA
2553	0,04	1,5	1,0	24,0 - 27,0	7,5 - 8,5	Mo 2,9 - 3,9, N 0,18 - 0,25, Cu 1,5 - 2,5 max	TBA
Zeron® 100	0,04	1,0	1,0	24,5 - 26,0	9,0 - 10,0	Mo 3,5 - 4,0, W 0,5 - 1,0, N 0,2 - 0,3, Cu 0,5 - 1,0	TBA

Columbus Steel 3CR12 can be welded with any of the following consumables: Afrox 308L, 309L, 316L, Afrox E3CR12

AWS Classifications for Stainless Steel Welding Consumables

Stainless steel welding consumables may be classified according to the American Welding Society (AWS) as follows:

- AWS A5.4 SMAW/MMA electrodes
- AWS A5.9 GMAW/MIG, GTAW/TIG and SAW wires and rods
- AWS A5.22 FCAW electrodes.

AWS 5.4 for Covered Electrodes

Generally, the electrodes are designated by an 'E' for electrode and then by a series of numbers to designate the alloy type. These numbers generally follow the same numbering system as the base metals such as 309 or 316. These numbers are followed by a suffix indicating current polarity and positions. Therefore, the designation for a 308 electrode will be as follows:

AWS A5.4 E308L-17

There may be other designators, which indicate specific alloying elements such as L which indicates a low carbon grade, H, which indicates a high carbon grade, Si, which indicates higher silicon content, and Mo, which indicates the addition of molybdenum to the alloy. The final two digits indicating polarity and position are as follows:

AWS Classification	Welding Current	Welding Position
EXXX(X)-I5	DCEP	All
EXXX(X)-25	DCEP	H, F
EXXX(X)-16	DCEP or AC	All
EXXX(X)-17	DCEP or AC	All
EXXX(X)-26	DCEP or AC	H, F

AWS A5.9 for Solid Wires

Wire or rods for welding stainless steels are designated by the letters 'ER' for electrode rod followed by the same alloy designators as in AWS A5.4. Thus, a low carbon 308 wire with higher silicon levels will have the following designation:

AWS A5.9 ER.308LSi

AWS A5.22 for Flux Cored Electrodes

The designations indicate the chemical composition of the undiluted deposited weld metal, position of welding, external shielding medium and type of current. The 'E' designator is used for the FCAW process - both for gas shielded and self-shielded - whilst the 'R' designator is used for the GTAW/TIG process. These filler materials are generally used for root pass welding of stainless steel pipes, without the use of back shielding gas. Thus, a 308 flux cored electrode will have the following designation:

AWS A5.22 E308LT 1-4

The 'T' designator indicates a tubular wire and the digit following the 'T' indicates the position of welding, with 1 indicating all-position and 0 for flat and horizontal only. The final digit indicates the type of shielding medium as follows:

1 indicates 100% carbon dioxide
3 indicates non- or self-shielded
4 indicates 75 - 80% argon 20 - 25% CO_2
5 indicates 100% argon

AWS A5.0 1 Filler Material Procurement Guidelines

The specification covers the testing and classification of welding consumables from a procurement point of view and outlines how customers should specify what product testing and quality control they require. The first section covers the classification of 'lots' or batch sizes and testing. The second section covers product testing. In all instances, when a customer orders product, they should state on the order the lot classification and testing schedule they require.

Lot Classification

This covers electrodes, solid wires and tubular wires with the suffix 'C' for covered electrodes, 'S' for solid wires, 'F' for submerged arc welding, brazing and braze welding and 'T' for tubular wires. See table overleaf for details.

AWS Lot and Testing Schedules for Welding Consumbles

Lot Classification	Requirements
Covered Electrodes	
C1	Manufacturer's standard lot as defined in its quality system
C2	A lot of one size not exceeding 45 350 kg of any size produced in 24 hr of consecutively scheduled production
C3	A lot of one size not exceeding 45 350 kg produced in 24 hr of consecutively scheduled production. The flux to be identified by wet mix or controlled chemical. Composition and core wire identified by heat number or controlled chemical composition
C4	A lot of any one size produced from one wet mix and one heat of core wire
C5	A lot of one size produced from one dry blend of flux and one heat of core wire
Solid Wire	
S1	A lot as defined in the manufacturer's quality assurance programme
S2	A lot not exceeding 45 350 kg of one size, form and temper produced in 24 hr of consecutively scheduled production from one heat or from material identified by controlled chemical composition
S3	A lot of one size produced from one heat in one production cycle
S4	A lot not exceeding 45 350 kg of one size, form and temper produced under one production schedule from one heat or from material identified by controlled chemical composition
Tubular Electrodes	
T1	A lot as defined in the manufacturer's quality assurance programme
T2	A lot not exceeding 45 350 kg of one size produced in 24 hr of consecutively scheduled production. The strip to be identified by one heat or from material identified by controlled chemical composition. The core ingredients to be identified by dry blend
T3	A lot of one size produced from one heat and one dry batch or dry blend of core ingredients
T4	A lot not exceeding 45 350 kg of one size produced under one production schedule from tube or strip identified by heat number or controlled chemical composition. The core ingredients to be identified by dry blend or controlled chemical composition
Submerged Arc Fluxes	
F1	A lot as defined in the manufacturer's quality assurance programme
F2	A lot produced from the same combination of raw materials in one production cycle

Testing Schedule

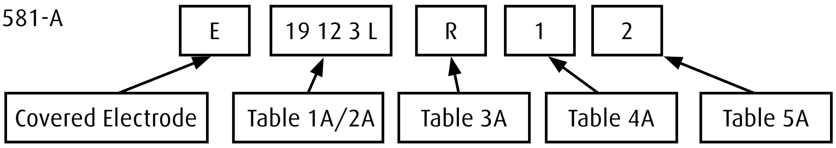
AWS A5.0 1 specifies the level of testing as follows:

Schedule	Requirements
F	The manufacturer's standard testing level
G	Tests of the material from any production run of the product within the 12 months preceding the date of purchase
H	Chemical analysis only for each lot shipped
I	In the case of stainless steel, schedule I calls for chemical analysis only
J	All tests called for in the AWS filler metal specification, for each lot shipped. In all cases, this includes chemical analysis. Covered electrodes 3,2 mm and above require tensile and fillet weld tests
K	All tests specified by the purchaser, for each lot shipped

EN ISO Classifications of Manual Metal Arc (MMA) Stainless Steel Welding Consumables

Covered electrodes for MMA welding are covered by EN ISO 3581 as set out below:

EN ISO 3581-A



EN ISO 3581-B

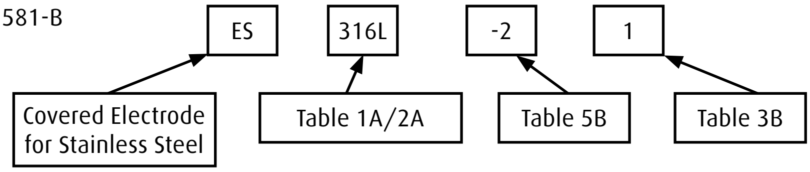


Table 1A Chemical Composition Requirements

Symbol classification by chemical composition [a] (%)												
Nominal Composition [b,c,d] (EN ISO 3581-A)	Alloy Type [d] (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
—	409Nb	0,12	1,0	1,0	0,04	0,03	11,0 - 14,0	0,6	0,75	0,75	0,5 - 1,5	—
13	(410)	0,12	1,0	1,5	0,03	0,025	11,0 - 14,0	0,6	0,75	0,75	—	—
(13)	410	0,12	0,9	1,0	0,04	0,03	11,0 - 14,0	0,7	0,75	0,75	—	—
13 4	(410NiMo)	0,06	1,0	1,5	0,03	0,025	11,0 - 14,5	3,0 - 5,0	0,4 - 1,0	0,75	—	—
(13 4)	410NiMo	0,06	0,90	1,0	0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	0,75	—	—
17	(430)	0,12	1,0	1,5	0,03	0,025	16,0 - 18,0	0,6	0,75	0,75	—	—
(17)	430	0,1	0,9	1,0	0,04	0,03	15,0 - 18,0	0,6	0,75	0,75	—	—
—	430Nb	0,1	1,0	1,0	0,04	0,03	15,0 - 18,0	0,6	0,75	0,75	0,5 - 1,5	—
19 9	(308)	0,08	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
(19 9)	308	0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
19 9 H	(308H)	0,04 - 0,08	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
(19 9 H)	308H	0,04 - 0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
19 9 L	(308L)	0,04	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
(19 9 L)	308L	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 12,0	0,75	0,75	—	—
(20 10 3)	308Mo	0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	0,75	—	—
—	308LMo	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	0,75	—	—
—	349	0,13	1,0	0,5 - 2,5		0,04	0,03	18,0 - 21,0	8,0 - 10,0	0,35 - 0,65	0,75	—

Table 1A (continued)

Symbol classification by chemical composition [a] (%)

Nominal Composition [b,c,d] (EN ISO 3581-A)	Alloy Type [d] (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
19 9 Nb	(347)	0,08	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	8 x C - 1,1	—
(19 9 Nb)	347	0,08	1,0	0,5 - 2,5	0,04 0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	8 x C - 1,0	—	—
—	347L	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	8 x C - 1,0	—
19 12 2	(316)	0,08	1,2	2,0	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,0 - 3,0	0,75	—	—
(19 12 2)	316	0,08	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
(19 12 2)	316H	0,04 - 0,08	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
(19 12 3 L)	316L	0,04	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
19 12 3 L	(316L)	0,04	1,2	2,0	0,03	0,025	17,0 - 20,0	10,3 - 13,0	2,5 - 3,0	0,75	—	—
—	316LCu	0,04	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 16,0	1,2 - 2,75	1,0 - 2,5	—	—
—	317	0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	12,0 - 14,0	3,0 - 4,0	0,75	—	—
—	317L	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	12,0 - 14,0	3,0 - 4,0	0,75	—	—
19 12 3 Nb	(318)	0,08	1,2	2,0	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,5 - 3,0	0,75	8 x C - 1,1	—
(19 12 3 Nb)	318	0,08	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	6 x C - 1,0	—
19 13 4 N L	—	0,04	1,2	1,0 - 5,0	0,03	0,025	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	0,75	—	0,02
—	320	0,07	0,6	0,5 - 2,5	0,04	0,03	19,0 - 21,0	32,0 - 36,0	2,0 - 3,0	3,0 - 4,0	8 x C - 1,0	—
—	320LR	0,03	0,3	1,5 - 2,5	0,02	0,015	19,0 - 21,0	32,0 - 36,0	2,0 - 3,0	3,0 - 4,0	8 x C - 0,4	—
22 9 3 N L	(2209)	0,04	1,2	2,5	0,03	0,025	21,0 - 24,0	7,5 - 10,5	2,5 - 4,0	0,75	—	0,08 - 0,2
(22 9 3 N L)	2209	0,04	1,0	0,5 - 2,0	0,04	0,03	21,5 - 23,5	7,5 - 10,5	2,5 - 3,5	0,75	—	0,08 - 0,02
25 7 2 N L [c]	—	0,04	1,2	2,0	0,035	0,025	24,0 - 28,0	6,0 - 8,0	1,0 - 3,0	0,75	—	0,2
25 9 3 Cu N L	(2593)	0,04	1,2	2,5	0,03	0,025	24,0 - 27,0	7,5 - 10,5	2,5 - 4,0	1,5 - 3,5	—	0,1 - 0,25
25 9 4 N L [d]	(2593)	0,04	1,2	2,5	0,03	0,025	24,0 - 27,0	8,0 - 11,0	2,5 - 4,5	1,5	—	0,2 - 0,3
—	2553	0,06	1,2	0,5 - 1,5	0,04	0,03	24,0 - 27,0	6,5 - 8,5	2,9 - 3,9	1,5 - 2,5	—	0,1 - 0,25
(25 9 3 Cu N L)	2593	0,04	1,0	0,5 - 1,5	0,04	0,03	24,0 - 27,0	8,5 - 10,5	2,9 - 3,9	1,5 - 3,0	—	0,08 - 0,25
18 15 3 L	—	0,04	1,2	1,0 - 4,0	0,03	0,025	16,5 - 19,5	14,0 - 17,0	2,5 - 3,5	0,75	—	—
18 16 5 N L [c]	—	0,04	1,2	1,0 - 4,0	0,035	0,025	17,0 - 20,0	15,5 - 19,0	3,5 - 5,0	0,75	—	0,2
20 25 5 Cu N L	(385)	0,04	1,2	1,0 - 4,0	0,03	0,025	19,0 - 22,0	24,0 - 27,0	4,0 - 7,0	1,0 - 2,0	—	0,25

Table 1A (continued)

Symbol classification by chemical composition [a] (%)												
Nominal Composition [b,c,d] (EN ISO 3581-A)	Alloy Type [d] (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
20 16 Mn N L [c]	—	0,04	1,2	5,0 - 8,0	0,035	0,025	18,0 - 21,0	15,0 - 18,0	2,5 - 3,5	0,75	—	0,2
25 22 2 N L	—	0,04	1,2	1,0 - 5,0	0,03	0,025	24,0 - 27,0	20,0 - 23,0	2,0 - 3,0	0,75	—	0,2
27 31 4 Cu L	—	0,04	1,2	2,5	0,03	0,025	26,0 - 29,0	30,0 - 33,0	3,0 - 4,5	0,6 - 1,5	—	—
18 8 Mn [c]	—	0,2	1,2	4,5 - 7,5	0,035	0,025	17,0 - 20,0	7,0 - 10,0	0,75	0,75	—	—
18 9 Mn Mo [c]	(307)	0,04 - 0,14	1,2	3,0 - 5,0	0,035	0,025	18,0 - 21,5	9,0 - 11,0	0,5 - 1,5	0,75	—	—
(18 9 Mn Mo)	307	0,04 - 0,14	1,0	3,3 - 4,75	0,04	0,03	18,0 - 21,5	9,0 - 10,7	0,5 - 1,5	0,75	—	—
20 10 3	(308Mo)	0,1	1,2	2,5	0,03	0,025	18,0 - 21,0	19,0 - 12,0	1,5 - 3,5	0,75	—	—
23 12 L	(309L)	0,04	1,2	2,5	0,03	0,025	22,0 - 25,0	11,0 - 14,0	0,75	0,75	—	—
(23 12 L)	309L	0,04	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	—	—
(22 12)	309	0,15	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	—	—
23 12 Nb	(309Nb)	0,1	1,2	2,5	0,03	0,25	22,0 - 25,0	11,0 - 14,0	0,75	0,75	8 x C - 1,1	—
—	309LNb	0,04	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	0,7 - 1,0	—
(23 12 Nb)	309Nb	0,12	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	0,7 - 1,0	—
—	309Mo	0,12	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	2,0 - 3,0	0,75	—	—
23 12 2 L	(309LMo)	0,04	1,2	2,5	0,03	0,025	22,0 - 25,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
(23 12 2 L)	309LMo	0,04	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	2,0 - 3,0	0,75	—	—
29 9 [c]	(312)	0,15	1,2	2,5	0,035	0,025	27,0 - 31,0	8,0 - 12,0	0,75	0,75	—	—
(29 9)	312	0,15	1,0	0,5 - 2,5	0,04	0,03	28,0 - 32,0	8,0 - 10,5	0,75	0,75	—	—
16 8 2	(16-8-2)	0,08	0,06	2,5	0,03	0,025	14,5 - 16,5	7,5 - 9,5	1,5 - 2,5	0,75	—	—
(16 8 2)	16-8-2	0,1	0,6	0,5 - 2,5	0,03	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	0,75	—	—
25 4	—	0,15	1,2	2,5	0,03	0,025	24,0 - 27,0	4,0 - 6,0	0,75	0,75	—	—
—	209	0,06	1,0	4,0 - 7,0	0,04	0,03	20,5 - 24,0	9,5 - 12,0	1,5 - 3,0	0,75	—	0,1 - 0,3
—	219	0,06	1,0	8,0 - 10,0	0,04	0,03	19,0 - 21,5	5,5 - 7,0	0,75	0,75	—	0,1 - 0,3
—	240	0,06	1,0	10,5 - 13,5	0,04	0,03	17,0 - 19,0	4,0 - 6,0	0,75	0,75	—	0,1 - 0,3
22 12	(309)	0,15	1,2	2,5	0,03	0,025	20,0 - 23,0	10,0 - 13,0	0,75	0,75	—	—
25 20	(310)	0,06 - 0,2	1,2	1,0 - 5,0	0,03	0,025	23,0 - 27,0	18,0 - 22,0	0,75	0,75	—	—

Table 1A (continued)

Symbol classification by chemical composition [a] (%)											
Nominal Composition [b,c,d] (EN ISO 3581-A)	**Alloy Type [d] (EN ISO 3581-B)**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**Cu**	**Nb + Ta**	**N**
(25 20)	310	0,08 - 0,2	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	0,75	—	—
25 20 H	(310H)	0,35 - 0,45	1,2	2,5	0,03	0,025	23,0 - 27,0	18,0 - 22,0	0,75	0,75	—	—
(25 20 H)	310H	0,35 - 0,45	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	0,75	—	—
—	310Nb	0,12	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,0	0,75	0,75	0,70 - 1,0	—
—	310Mo	0,12	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,0	2,0 - 3,0	0,75	—	—
18 36	(330)	0,25	1,2	2,5	0,03	0,025	14,0 - 18,0	33,0 - 37,0	0,75	0,75	—	—
(18 36)	330	0,18 - 0,25	1,0	1,0 - 2,5	0,04	0,03	14,0 - 17,0	33,0 - 37,0	0,75	0,75	—	—
—	330H	0,35 - 0,45	1,0	1,0 - 2,5	0,04	0,03	14,0 - 17,0	33,0 - 37,0	0,75	0,75	—	—
—	383	0,03	0,9	0,5 - 2,5	0,02	0,02	26,5 - 29,0	30,0 - 33,0	3,2 - 4,2	0,6 - 1,5	—	—
(20 25 5 Cu N L)	385	0,03	0,9	1,0 - 2,5	0,03	0,02	19,5 - 21,5	24,0 - 26,0	4,2 - 5,2	1,2 - 2,0	—	—
—	630	0,05	0,75	0,25 - 0,75	0,04	0,03	16,0 - 16,75	4,5 - 5,0	0,75	3,25 - 4,0	0,15 - 0,3	—

a Single values shown in this table are maximum values

b Covered electrodes not listed in this table, but those which the user wishes to classify to this system, can be similarly symbolised and prefixed with the letter Z

c The sum of P and S may not exceed 0,05%, except for 25 7 2 N L; 18 16 5 N L; 20 16 3 Mn N L; 18 8 Mn; 18 9 Mn Mo and 29 9

d A designation in parentheses [e.g., (308L) or (19 9 L)] indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one not in parentheses. A given product, by having a more restricted chemical composition that fulfils both sets of designation requirements, may be assigned both designations independently

Table 2A Mechanical Property Requirements

Nominal Composition (EN ISO 3581-A)	Alloy Symbol (EN ISO 3581-B)	Minimum Proof Strength ($R_{p0,2}$)	Minimum Tensile Strength (R_m MPa)	Minimum Elongation [a] (%)	Post Weld Heat Treatment
—	409Nb	—	450	13	[b]
13	(410)	250	450	15	[c]
(13)	410	—	450	15	[d]
13 4	(410NiMo)	500	750	15	[e]
(13 4)	410NiMo	—	760	10	[f]
17	(430)	300	450	15	[g]
(17)	430	—	450	15	[b]
—	430Nb	—	450	13	[b]
19 9	(308)	350	550	30	none
(19 9)	308	—	550	30	
19 9 H	(308H)	350	550	30	
(19 9 H)	308H	—	550	30	
19 9 L	(308L)	320	510	30	
(19 9 L)	308L	—	510	30	
—	308Mo	—	550	30	
—	308LMo	—	520	30	
—	349	—	690	23	
19 9 Nb	(347)	350	550	25	
(19 9 Nb)	347	—	520	25	
—	347L	—	510	25	
19 12 2	(316)	350	550	25	
(19 12 2)	316	—	520	25	
—	316H	—	520	25	
19 12 3 L	(316L)	320	510	25	
(19 12 3 L)	316L	—	490	25	
—	316LCu	—	510	25	
—	317	—	550	20	
—	317L	—	510	20	
19 12 3 Nb	(318)	350	550	25	
(19 12 3 Nb)	318	—	550	20	
19 13 4 N L	—	350	550	25	
—	320	—	550	28	
—	320LR	—	520	28	
22 9 3 N L	(2209)	450	550	20	
(29 9 3 N L)	2209	—	690	15	
25 7 2 N L	—	500	700	15	
25 9 3 Cu N L	—	550	620	18	
25 9 4 N L	—	550	620	18	
—	2553	—	760	13	
—	2593	—	760	13	
18 15 3 L	—	300	480	25	
18 16 5 N L	—	300	480	25	
20 25 5 Cu N L	—	320	510	25	

Table 2A (continued)

Nominal Composition (EN ISO 3581-A)	Alloy Symbol (EN ISO 3581-B)	Minimum Proof Strength ($R_{p0,2}$)	Minimum Tensile Strength (R_m MPa)	Minimum Elongation [a] (%)	Post Weld Heat Treatment
20 16 3 Mn N L	—	320	510	25	none
25 22 2 N L	—	320	510	25	
27 31 4 Cu L	—	240	500	25	
18 8 Mn	—	350	500	25	
18 9 Mn Mo	(307)	350	500	25	
(18 9 Mn Mo)	307	—	590	25	
20 10 3	—	400	620	20	
—	309	—	550	25	
23 12 L	(309L)	320	510	25	
(23 12 L)	309L	—	510	25	
23 12 Nb	(309Nb)	350	550	25	
(23 12 Nb)	309Nb	—	550	25	
—	309Mo	—	550	25	
23 12 2 L	(309LMo)	350	550	25	
(23 12 2 L)	309LMo	—	510	25	
—	309LNb	—	510	25	
29 9	(312)	450	650	15	
(29 9)	312	—	660	15	
16 8 2	(16-8-2)	320	510	25	
(16 8 2)	16-8-2	—	520	25	
25 4	—	400	600	15	
—	209	—	690	15	
—	219	—	620	15	
—	240	—	690	25	
22 12	—	350	550	25	
25 20	(310)	350	550	20	
(25 20)	310	—	550	25	
25 20 H	(310H)	350	550	10 [h]	
(25 20 H)	310H	—	620	8	
—	310Nb	—	550	23	
—	310Mo	—	550	28	
18 36	(330)	350	510	10 [h]	
(18 36)	330	—	520	23	
—	330H	—	620	8	
—	383	—	520	28	
—	385	—	520	28	
—	630	—	930	6	[i]

NOTE: All weld metal can have elongation and toughness lower than those of the parent metal

a Gauge length is equal to five times the test specimen diameter

b 760 - 790°C for 2 hr. Furnace cooling at a rate not exceeding 55°C/hr down to 595°C then air cooling to ambient

c 840 - 870°C for 2 hr. Furnace cooling down to 600°C then air cooling

d 730 - 760°C for 1 hr. Furnace cooling at a rate not exceeding 110°C/hr down to 315°C then air cooling to ambient

e 580 - 620°C for 2 hr. Air cooling

f 595 - 620°C for 1 hr. Air cool to ambient

g 760 - 790°C for 2 hr. Furnace cooling down to 600°C then air cooling

h These electrodes have high carbon in the all weld metal for service at high temperatures. Room temperature elongation has little relevance to such applications

i 1 025 - 1 050°C for 1 hr. Air cool to ambient, followed by precipitation hardening at 610 - 630°C for 4 hr then air cool to ambient

Table 3A Symbol for Type of Covering

Symbol	Type of Covering
R	Rutile
B	Basic

Table 3B Symbol for Type of Covering

Symbol	Type of Covering
5	Basic DC
6	Rutile AC+DC (Except 46 -DC only)
7	High silica rutile AC/DC (Except 47 -DC)

Table 4A Symbol for Effective Electrode Efficiency and Type of Current
(Classification according to nominal composition)

Symbol	Effective Electrode Efficiency (%)	Type of Current [a]
1	≤105	AC and DC
2	≤105	DC
3	>105 but ≤125	AC and DC
4	>105 but ≤125	DC
5	>125 but ≤160	AC and DC
6	>125 but ≤160	DC
7	>160	AC and DC
8	>160	DC

[a] In order to demonstrate operability on alternating current, tests shall be carried out with load voltages higher than 65 V (AC means alternating current; DC means direct current)

Table 5A Symbol for Welding Position
(Classification according to nominal composition)

Symbol	Welding Positions [a]
1	PA, PB, PD, PF, PG
2	PA, PB, PD, PF
3	PA, PB
4	PA
5	PA, PB, PG

[a] Positions are defined in ISO 6947
PA = Flat position
PB = Horizontal-vertical position
PD = Horizontal-overhead position
PF = Vertical-up position
PG = Vertical-down position

Table 5B Symbol for Welding Position (Classification according to alloy type)

Symbol	Welding Positions [a]
-1	PA, PB, PD, PF
-2	PA, PB
-4	PA, PB, PD, PF, PG

[a] Positions are defined in ISO 6947
PA = Flat position
PB = Horizontal-vertical position
PD = Horizontal-overhead position
PF = Vertical-up position
PG = Vertical-down position

Classifications of Solid Stainless Steel Wires

Wire electrodes and rods for arc welding are covered by EN ISO 14343 as set out below:

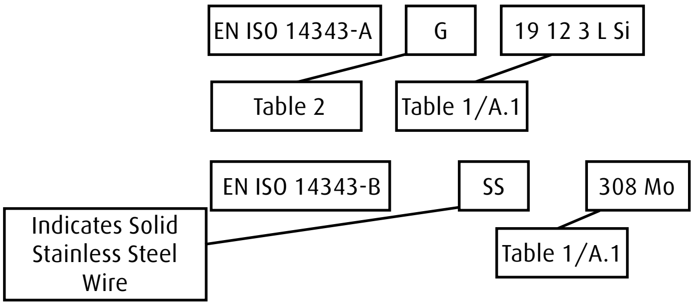


Table 2 Symbol for Type of Covering

Symbol	Type of Covering
G	GMAW
W	GTAW
P	PAW
S	SAW

Table A.1 Expected Minimum Tensile Properties of All Weld Metal

Alloy Symbol		Mechanical Property			
Classification According to Nominal Composition (EN ISO 14343-A)	Classification According to Alloy Type (EN ISO 14343-B)	Proof Strength ($R_{p0,2}$ N/mm²)	Tensile Strength (R_m N/mm²)	Elongation [a] (%)	Post Weld Heat Treatment
	409	180	380	14	none
	409Nb	250	450	15	[b]
13 [c]	410 [b]	250	450	15	[c] or [b]
13L		250	450	15	[c]
13 4	410NiMo	500	750	15	[d]
	420	250	450	15	[c]
17	430	300	450	15	[e]
	430Nb	250	450	15	[e]
18LNb	430LNb	220	410	15	none
	308	350	550	30	none
	308Si	350	550	30	
19 9 L	308L	320	510	30	
19 9 L Si	308LSi	320	510	30	
19 9 Nb	347	350	550	25	
19 9 Nb Si	347Si	350	550	25	
	347L	320	510	25	
	316	320	510	25	
	316Si	320	510	25	
19 12 3 L	316L	320	510	25	
19 12 3 L Si	316LSi	320	510	25	
	316LCu	320	510	25	
19 12 3 Nb	318	350	550	25	
	318L	320	510	25	
19 12 3 Nb Si		350	550	25	
	317	350	550	25	
18 15 3 L	317L	300	480	25	
	321	350	550	25	
22 9 3 N L	2209	450	550	20	none
25 7 2 L		500	700	15	
25 9 3 Cu N L		550	620	18	
25 9 4 N L		550	620	18	

Table A.1 (continued)

Alloy Symbol		Mechanical Property			
Classification According to Nominal Composition (EN ISO 14343-A)	**Classification According to Alloy Type (EN ISO 14343-B)**	**Proof Strength ($R_{p0,2}$ N/mm^2)**	**Tensile Strength (R_m N/mm^2)**	**Elongation [a] (%)**	**Post Weld Heat Treatment**
18 15 3 L		300	480	25	none
18 16 5 N L		300	480	25	
19 13 4 N L		350	550	25	
20 25 5 Cu L		350	550	25	
20 25 5 Cu N L	385	320	510	25	
20 16 3 Mn L		320	510	25	
20 16 3 Mn N L		320	510	25	
25 22 2 N L		320	510	25	
27 31 4 Cu L	383	320	510	25	
	320	240	500	25	
	320LR	320	550	25	
		300	520	25	
	307	350	590	25	none
18 8 Mn		350	500	25	
20 10 3	308Mo	400	620	20	
	308LMo	320	510	30	
23 12 L23 12 L Si	309L	320	510	25	
23 12 Nb	309LSi	320	510	25	
		350	550	25	
	309LNb	320	510	25	
23 12 2 L	309Mo	350	550	25	
29 9	309LMo	350	550	25	
	312	450	650	15	
16 8 2	16-8-2	320	510	25	none
19 9 H	19-10H	350	550	30	
	308H	350	550	30	
19 12 3 H	316H	350	550	25	
22 12 H	309	350	550	25	
	309Si	350	550	25	
25 4		450	650	15	
25 20	310	350	550	20	
	310S	350	550	20	
	310L	320	510	20	
25 20 Mn		350	550	20	
25 20 H		350	550	10[f]	
18 36 H	330	350	550	10[f]	
	630	725	930	5	[g]

NOTE: Weld metal may have elongation lower than that of the parent metal

[a] Gauge length is equal to five times the specimen diameter

[b] 730 - 760°C for 1 hr, furnace cooling down to 600°C, then air cooling

[c] 840 - 870°C for 2 hr, furnace cooling down to 600°C, then air cooling

[d] 580 - 620°C for 2 hr, air cooling

[e] 760 - 790°C for 2 hr, furnace cooling down to 600°C, then air cooling

[f] These wire electrodes deposit high carbon weld metal for service at high temperatures. Room temperature elongation has little relevance to such applications

[g] 1 025 - 1 050°C for 1 hr, air cool to ambient, then 610 - 630°C for 4 hr, air cool

Table 1 Chemical Composition Requirements

Alloy Designation [a] for Classification According to		Chemical Composition (%) (m/m) [b,c]											
Nominal Composition [d] (EN ISO 14343-A)	**Alloy Type (EN ISO 14343-B)**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**N**	**Cu**	**Nb [e]**	**Other**
Martensitic-Ferritic Types													
—	409	0,08	0,8	0,8	0,03	0,03	10,5 - 13,5	0,6	0,50	—	0,75	—	Ti 10 x C - 1,5
—	409Nb	0,12	0,5	0,6	0,03	0,03	10,5 - 13,5	0,6	0,75	0,10 - 0,20	0,75	8 x C - 1,0	—
13	(410)	0,15	1,0	1,0	0,03	0,02	12,0 - 15,0	0,3	0,3	—	0,3	—	—
(13)	410	0,12	0,5	0,6	0,03	0,03	11,5 - 13,5	0,6	0,75	—	0,75	—	—
13L	—	0,05	1,0	1,0	0,03	0,02	12,0 - 15,0	0,3	0,3	—	0,3	—	—
13 4	(410NiMo)	0,05	1,0	1,0	0,03	0,02	11,0 - 14,0	3,0 - 5,0	0,4 - 1,0	—	0,3	—	—
(13 4)	410NiMo	0,06	0,5	0,6	0,03	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,75	—	—
—	420	0,25 - 0,4	0,5	0,6	0,03	0,03	12,0 - 14,0	0,75	0,75	—	0,75	—	—
17	(430)	0,12	1,0	1,0	0,03	0,02	16,0 - 19,0	0,3	0,3	—	0,3	—	—
(17)	430	0,1	0,5	0,6	0,03	0,03	15,5 - 17,0	0,6	0,75	—	0,75	—	—
—	430Nb	0,1	0,5	0,6	0,03	0,03	15,5 - 17,0	0,6	0,75	—	0,75	8 x C - 1,2	—
18LNb	430LNb	0,02	0,5	0,8	0,03	0,02	17,8 - 18,8	0,3	0,3	0,02	0,3	0,05 + 7 (C+N) up to 0,5	—
Austenitic Types													
—	308	0,08	0,65	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,75	—	0,75	—	—
—	308Si	0,08	0,65 - 1,0	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,75	—	0,75	—	—
19 9 L	(308L)	0,03	0,65	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	—	—
(19 9 L)	308L	0,03	0,65	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,75	—	0,75	—	—
19 9 L Si	(308LSi)	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	—	—
(19 9 L Si)	308LSi	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 11,0	0,75	—	0,75	—	—
19 9 Nb	(347)	0,08	0,65	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	10 x C - 1,0	—
(19 9 Nb)	347	0,08	0,65	1,0 - 2,5	0,03	0,03	19,0 - 21,5	9,0 - 11,0	0,75	—	0,75	10 x C - 1,0	—
19 9 Nb Si	(347Si)	0,08	0,65 - 1,2	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	10 x C - 1,0	—
(19 9 Nb Si)	347Si	0,08	0,65 - 1,0	1,0 - 2,5	0,03	0,03	19,0 - 21,5	9,0 - 11,0	0,75	—	0,75	10 x C - 1,0	—

Table 1 (continued)

Alloy Designation [a] for Classification According to		Chemical Composition (%) (m/m) [b,c]											
Nominal Composition [d] (EN ISO 14343-A)	**Alloy Type (EN ISO 14343-B)**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**N**	**Cu**	**Nb [e]**	**Other**
—	347L	0,03	0,65	1,0 - 2,5	0,03	0,03	19,0 - 21,5	9,0 - 11,0	0,75	—	0,75	10 x C - 1,0	—
—	316	0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
—	316Si	0,08	0,65 - 1,0	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
19 12 3 L	(316L)	0,03	0,65	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	—	—
(19 12 3 L)	316L	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
19 12 3 L Si	(316LSi)	0,03	0,65 - 1,2	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	—	—
(19 12 3 L Si)	316LSi	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
—	316LCu	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	1,0 - 2,5	—	—
19 12 3 Nb	(318)	0,08	0,65	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	10 x C - 1,0	—
(19 12 3 Nb)	318	0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	8 x C - 1,0	—
—	318L	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	8 x C - 1,0	—
19 12 3 Nb Si	—	0,08	0,65 - 1,2	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	10 x C - 1,0	—
—	317	0,08	0,65	1,0 - 2,5	0,03	0,03	18,5 - 20,5	13,0 - 15,0	3,0 - 4,0	—	0,75	—	—
(18 15 3 L)	317L	0,03	0,65	1,0 - 2,5	0,03	0,03	18,5 - 20,5	13,0 - 15,0	3,0 - 4,0	—	0,75	—	—
—	321	0,08	0,65	1,0 - 2,5	0,03	0,03	18,5 - 20,5	9,0 - 10,5	0,75	—	0,75	—	Ti 9 x C - 1,0
Ferritic-Austenitic Types (Sometimes referred to as austenitic-ferritic types)													
22 9 3 N L	(2209)	0,03	1,0	2,5	0,03	0,02	21,0 - 24,0	7,0 - 10,0	2,5 - 4,0	0,1 - 0,2	0,3	—	—
(22 9 3 N L)	2209	0,03	0,9	0,5 - 2,0	0,03	0,03	21,5 - 23,5	7,5 - 9,5	2,5 - 3,5	0,08 - 0,2	0,75	—	—
25 7 2 L	—	0,03	1,0	2,5	0,03	0,02	24,0 - 27,0	6,0 - 8,0	1,5 - 2,5	—	0,3	—	—
25 9 3 Cu N L	—	0,03	1,0	2,5	0,03	0,02	24,0 - 27,0	8,0 - 10,5	2,5 - 4,5	0,2 - 0,3	1,5	—	W 1,0

Table 1 (continued)

Alloy Designation [a] for Classification According to		Chemical Composition (%) (m/m) [b,c]											
Nominal Composition [d] (EN ISO 14343-A)	**Alloy Type (EN ISO 14343-B)**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**N**	**Cu**	**Nb [e]**	**Other**
Fully Austenitic Types [f]													
18 15 3 L [f]	(317L) [f]	0,03	1,0	1,0 - 4,0	0,03	0,02	17,0 - 20,0	13,0 - 16,0	2,5 - 4,0	—	0,3	—	—
18 16 5 N L [f]	—	0,03	1,0	1,0 - 4,0	0,03	0,02	17,0 - 20,0	16,0 - 19,0	3,5 - 5,0	0,1 - 0,2	0,3	—	—
19 13 4 L [f]	(317L) [f]	0,03	1,0	1,0 - 5,0	0,03	0,02	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	—	0,3	—	—
19 13 4 N L [f]	—	0,03	1,0	1,0 5,0	0,03	0,02	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	0,1 - 0,2	0,3	—	—
20 25 5 Cu L [f]	(385) [f]	0,03	1,0	1,0 - 4,0	0,03	0,02	19,0 - 22,0	24,0 - 27,0	4,0 - 6,0	—	1,0 - 2,0	—	—
(20 25 5 Cu L) [f]	385 [f]	0,025	0,5	1,0 - 2,5	0,02	0,03	19,5 - 21,5	24,0 - 26,0	4,2 - 5,2	—	1,2 - 2,0	—	—
20 25 5 Cu N L [f]	—	0,03	1,0	1,0 - 4,0	0,03	0,02	19,0 - 22,0	24,0 - 27,0	4,0 - 6,0	0,1 - 0,2	1,0 - 2,0	—	—
20 16 3 Mn L [f]	—	0,03	1,0	5,0 - 9,0	0,03	0,02	19,0 - 22,0	15,0 - 18,0	2,5 - 4,5	—	0,3	—	—
20 16 3 Mn N L [f]	—	0,03	1,0	5,0 - 9,0	0,03	0,02	19,0 - 22,0	15,0 - 18,0	15,0 - 18,0	0,1 - 0,2	0,3	—	—
25 22 2 N L [f]	—	0,03	1,0	3,5 - 6,5	0,03	0,02	24,0 - 27,0	21,0 - 24,0	1,5 - 3,0	0,1 - 0,2	0,3	—	—
27 31 4 Cu L [f]	(383) [f]	0,03	1,0	1,0 - 3,0	0,03	0,02	26,0 - 29,0	30,0 - 33,0	3,0 - 4,5	—	0,7 - 1,5	—	—
(27 31 4 Cu L) [f]	383 [f]	0,025	0,5	1,0 - 2,5	0,02	0,03	26,5 - 28,5	30,0 - 33,0	3,2 - 4.2	—	0,7 - 1,5	—	—
—	320 [f]	0,07	0,6	2,5	0,03	0,03	19,0 - 21,0	32,0 - 36,0	2,0 - 3.0	—	3,0 - 4,0	8 x C - 1,0	—
—	320LR [f]	0,025	0,15	1,5 - 2,0	0,015	0,02	19,0 - 21,0	32,0 - 36,0	2,0 - 3,0	—	3,0 - 4,0	8 x C - 0,40	—
Special Types (Often used for dissimilar metal joining)													
—	307 [f]	0,04 - 0,14	0,65	3,3 - 4,8	0,03	0,03	19,5 - 22,0	8,0 - 10,7	0,5 - 1,5	—	0,75	—	—
18 8 Mn [f]	—	0,2	1,2	5,0 - 8,0	0,03	0,03	17,0 - 20,0	7,0 - 10,0	0,3	—	0,3	—	—
20 10 3	(308Mo)	0,12	1,0	1,0 - 2,5	0,03	0,02	18,0 - 21,0	8,0 - 21,0	—	1,5 - 3,5	—	0,3	—
(20 10 3)	308Mo	0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,75	—	—
—	308LMo	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,75	—	—

Table 1 (continued)

Alloy Designation[a] for Classification According to		Chemical Composition (%) (m/m)[b,c]											
Nominal Composition[d] (EN ISO 14343-A)	**Alloy Type (EN ISO 14343-B)**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**N**	**Cu**	**Nb[e]**	**Other**
23 12 L	(309L)	0,03	0,65	1,0 - 2,5	0,03	0,02	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	—	—
(23 12 L)	309L	0,03	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
23 12 L Si	(309LSi)	0,03	0,65 - 1,2	1,0 - 2,5	0,03	0,02	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	—	—
(23 12 l Si)	309LSi	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
23 12 Nb	—	0,08	1,0	1,0 - 2,5	0,03	0,02	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	10 x C - 1,0	—
—	309LNb	0,03	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	10 x C - 1,0	—
—	309Mo	0,12	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	2,0 - 3,0	—	0,75	—	—
23 12 2 L	(309LMo)	0,03	1,0	1,0 - 2,5	0,03	0,02	21,0 - 25,0	11,0 - 15,5	2,0 - 3,5	—	0,3	—	—
(23 12 2 L)	309LMo	0,03	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	2,0 - 3,0	—	0,75	—	—
29 9	312	0,15	1,0	1,0 - 2,5	0,03	0,02	28,0 - 32,0	8,0 - 12,0	0,3	—	0,3	—	—
(29 9)	312	0,15	0,65	1,0 - 2,5	0,03	0,03	28,0 - 32,0	8,0 - 10,5	0,75	—	0,75	—	—
Heat Resisting Types													
16 8 2	(16-8-2)	0,1	1,0	1,0 - 2,5	0,03	0,02	14,5 - 16,5	7,5 - 9,5	1,0 - 2,5	—	0,3	-	—
(16-8-2)	16 8 2	0,1	0,65	1,0 - 2,5	0,03	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	—	0,75	-	—
19 9 H	(19-10H)	0,04 - 0,08	1,0	1,0 - 2,5	0,03	0,02	18,0 - 21,0	9,0 - 11,0	0,3	—	0,3	-	—
(19 9 H)	19-10H	0,04 - 0,08	0,65	1,0 - 2,0	0,03	0,03	18,5 - 20,0	9,0 - 11,0	0,25	—	0,75	0,05	Ti 0,05
(19 9 H)	308H	0,04	0,65	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,50	—	0,75	—	—
19 12 3 H	(316H)	0,04 - 0,08	1,0	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,3	—	—
(19 12 3 H)	316H	0,04 - 0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
22 12 H	(309)	0,04 - 0,15	2,0	1,0 - 2,5	0,03	0,02	21,0 - 24,0	11,0 - 14,0	0,3	—	0,3	—	—

Table 1 (continued)

Alloy Designation [a] for Classification According to		Chemical Composition (%) (m/m) [b,c]											
Nominal Composition [d] (EN ISO 14343-A)	**Alloy Type (EN ISO 14343-B)**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**N**	**Cu**	**Nb [e]**	**Other**
(22 12 H)	309	0,12	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
—	309Si	0,12	0,65 - 1,0	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
25 4	—	0,15	2,0	1,0 - 2,5	0,03	0,02	24,0 - 27,0	4,0 - 6,0	0,3	—	0,3	—	—
25 20 [f]	(310) [f]	0,08 - 0,15	2,0	1,0 - 2,5	0,03	0,02	24,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—
(25 20) [f]	310 [f]	0,08 - 0,15	0,65	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	—	0,75	—	—
—	310S [f]	0,08	0,65	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	—	0,75	—	—
—	310L [f]	0,03	0,65	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	—	0,75	—	—
25 20 H [f]	—	0,35 - 0,45	2,0	1,0 - 2,5	0,03	0,02	24,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—
25 20 Mn [f]	—	0,08 - 0,15	2,0	2,5 - 5,0	0,03	0,02	24,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—
18 36 H [f]	(330)	0,18 - 0,25	0,4 - 2,0	1,0 - 2,5	0,03	0,02	15,0 - 19,0	33,0 - 37,0	0,3	—	0,3	—	—
(18 36 H) [f]	330	0,18 - 0,25	0,65	1,0 - 2,5	0,03	0,03	15,0 - 17,0	34,0 - 37,0	0,75	—	0,75	—	—
Precipitation Hardening Type													
—	630	0,05	0,75	0,25 - 0,75	0,03	0,03	16,0 - 16,75	4,5 - 5,0	0,75	—	3,25 - 4,0	0,15 - 0,3	—

a A designation in parentheses, e.g. (308L) or (19 9 L) indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one not in parentheses. A given product may, by having a more restricted chemical composition which fulfils both sets of designation requirements, be assigned both designations independently

b Single values shown in the table are maximum values. Two values shown indicate minimum and maximum limits for a range

c The results shall be rounded to the same number of significant figures as in the specified value using the rules in according with Annex B, Rule A of ISO 31-0:1992

d Wire electrodes not listed in the table shall be symbolised similarly and prefixed by the letter 'Z'

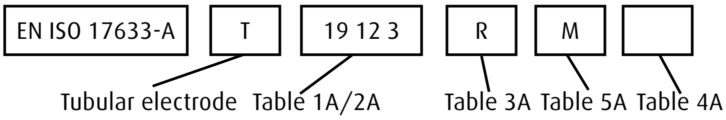
e Up to 20% of the amount of Nb can be replaced by Ta

f The all weld metal is in most cases fully austenitic and therefore can be susceptible to microfissuring or hot cracking. The occurrence of fissuring/cracking is reduced by increasing the weld metal manganese level and in recognition of this the manganese range is extended for a number of grades

Classifications of Tubular Stainless Steel Welding Consumables

Tubular electrodes for FCW welding are covered by EN ISO 17633 as set out below:

For classification by nominal composition



For classification by alloy type

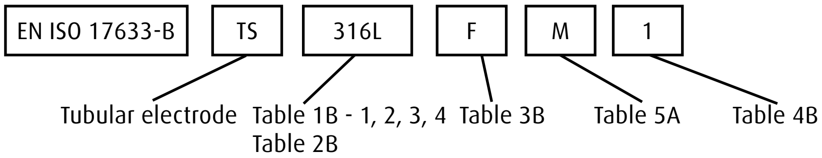


Table 1A Symbols for Chemical Composition Requirements for All Weld Metal (Classification according to nominal composition)

Alloy Designation According to Nominal Composition	Chemical Composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P e	S e	Cr	Ni	Mo	Nb + Ta f	Cu	N	Ti
13	M, C, N	0,12	1,5	1,0	0,03	0,025	11,0 - 14,0	0,3	0,3	—	0,3	—	—
13 Ti	M, C, N	0,10	0,8	1,0	0,03	0,030	10,5 - 13,0	0,3	0,3	—	0,3	—	10 x C - 1,5
13 4	M, C, N	0,06	1,5	1,0	0,03	0,025	11,0 - 14,5	3,0 - 5,0	0,4 - 1,0	—	0,3	—	—
17	M, C, N	0,12	1,5	1,0	0,03	0,025	16,0 - 18,0	0,3	0,3	—	0,3	—	—
19 9 L	M, C, N	0,04	2,0	1,2	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,3	—	0,3	—	—
19 9 Nb	M, C, N	0,08	2,0	1,2	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,3	8 x C - 1,1	0,3	—	—
19 12 3 L	M, C, N	0,04	2,0	1,2	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,5 - 3,0	—	0,3	—	—
19 12 3 Nb	M, C, N	0,08	2,0	1,2	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,5 - 3,0	8 x C - 1,1	0,3	—	—
19 13 4 N L	M, C, N	0,04	1,0 - 5,0	1,2	0,03	0,025	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	—	0,3	0,08 - 0,20	—
22 9 3 N L	M, C, N	0,04	2,5	1,2	0,03	0,025	21,0 - 24,0	7,5 -10,5	2,5 - 4,0	—	0,3	0,08 - 0,20	—
18 16 5 N L	M, C, N	0,04	1,0 - 4,0	1,2	0,035	0,025	17,0 - 20,0	15,5 - 19,0	3,5 - 5,0	—	0,3	0,08 - 0,20	—
18 8 Mn	M, C, N	0,20	4,5 - 7,5	1,2	0,035	0,025	17,0 - 20,0	7,0 - 10,0	0,3	—	0,3	—	—
20 10 3	M, C, N	0,08	2,5	1,2	0,035	0,025	19,5 - 22,0	9,0 - 11,0	2,0 - 4,0	—	0,3	—	—
23 12 L	M, C, N	0,04	2,5	1,2	0,03	0,025	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	—	—
23 12 2 L	M, C, N	0,04	2,5	1,2	0,03	0,025	22,0 - 25,0	11,0 - 14,0	2,0 - 3,0	—	0,3	—	—
29 9	M, C, N	0,15	2,5	1,2	0,035	0,025	27,0 - 31,0	8,0 - 12,0	0,3	—	0,3	—	—

Table 1A (continued)

Alloy Designation According to Nominal Composition	Chemical Composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P [e]	S [e]	Cr	Ni	Mo	Nb + Ta [f]	Cu	N	Ti
22 12 H	M, C, N	0,15	2,5	1,2	0,03	0,025	20,0 - 23,0	10,0 - 13,0	0,3	—	0,3	—	—
25 20	M, C, N	0,06 - 0,20	1,0 - 5,0	1,2	0,03	0,025	23,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—

[a] Single values shown in the table are maximum values
[b] Tubular cored electrodes not listed in the table shall be symbolised similarly and prefixed by the letter 'Z'
[c] The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992
[d] The symbol 'N' shall be used for tubular cored electrodes without a gas shield
[e] The sum of P and S shall not exceed 0,05%, except for 18 16 5 L, 18 8 Mn and 29 9
[f] Up to 20% of the amount of Nb can be replaced by Ta

Table 2A Tensile Properties of All Weld Metal (Classification according to nominal composition)

Alloy Designation According to Nominal Composition	Minimum Proof Strength (MPa)	Minimum Tensile Strength (MPa)	Minimum Elongation [a] (%)	Post Weld Heat Treatment
13	250	450	15	[b]
13 Ti	250	450	15	[b]
13 4	500	750	15	[c]
17	300	450	15	[d]
19 9 L	320	510	30	none
19 9 Nb	350	550	25	
19 12 3 L	320	510	25	
19 12 3 Nb	350	550	25	
19 13 4 N L	350	550	25	
22 9 3 N L	450	550	20	
18 16 5 N L	300	480	25	
18 8 Mn	350	500	25	
20 10 3	400	620	20	
23 12 L	320	510	25	
23 12 2 L	350	550	25	
29 9	450	650	15	
22 12 H	350	550	25	
25 20	350	550	20	

[a] Gauge length is equal to five times the test specimen diameter
[b] The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 840 - 870°C, held for 2 hr, furnace cooled to 600°C, then cooled in air
[c] The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 580 - 620°C, held for 2 hr, then cooled in air
[d] The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 760 - 790°C, held for 2 hr, furnace cooled to 600°C, then cooled in air

Table 3A Symbols for Type of Electrode Core (Classification according to nominal composition)

Symbol	Characteristics
R	Rutile, slow freezing slag
P	Rutile, fast freezing slag
M	Metal powder
U	Self-shielding
Z	Other types
(See Annex B)	

Table 5A Types of Shielding Gases

Symbol for Shielding Gas	
M	Ar + 20 - 25% CO_2
B	100% CO_2
A	Ar + 0 - 3% O_2
I	100% Ar
G	Unspecified

Table 4A Symbols for Welding Position (Classification according to nominal composition)

Symbol	Welding Positions [a]
1	PA, PB, PC,PD, PE, PF and PG
2	PA, PB, PC, PD, PE and PF
3	PA and PB
4	PA
5	PA, PB and PG
a	PA = Flat position PB = Horizontal-vertical position PC = Horizontal position PD = Horizontal-overhead position PE = Overhead position PF = Vertical-up position PG = Vertical-down position

Table 1B-1 Symbols for Chemical Composition Requirements for All Weld Metal of Gas Shielded Flux Cored Electrodes (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
307	M, B, C, G	0,13	3,30 - 4,75	1,0	0,04	0,03	18,0 - 20,5	9,0 - 10,5	0,5 - 1,5	—	0,5	—	—
308	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	—	0,5	—	—
308L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 12,0	0,5	—	0,5	—	—
308H	M, B, C, G	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	—	0,5	—	—
308Mo	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	2,0 - 3,0	—	0,5	—	—
308LMo	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,5	—	—
309	M, B, C, G	0,10	0,5 - 2,5	1,0	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	—	0,5	—	—
309L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	—	0,5	—	—
309Mo	M, B, C, G	0,12	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LMo	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LNb	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	0,7 - 1,0	0,5	—	—
310	M, B, C, G	0,20	1,0 - 2,5	1,0	0,035	0,03	25,0 - 28,0	20,0 - 22,5	0,5	—	0,5	—	—
312	M, B, C, G	0,15	0,5 - 2,5	1,0	0,04	0,03	28,0 - 32,0	8,0 - 10,5	0,5	—	0,5	—	—
316	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—

Table 1B-1 (continued)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction)[a, b, c]											
	Shielding Gas[d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
316L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316H	M, B, C, G	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316LCu	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 16,0	1,25 - 2,75	—	1,0 - 2,5	—	—
317	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	12,0 - 14,0	3,0 - 4,0	—	0,5	—	—
317L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	12,0 - 16,0	3,0 - 4,0	—	0,5	—	—
318	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	8 x C - 1,0	0,5	—	—
347	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
347L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
409	M, B, C, G	0,10	0,8	1,0	0,04	0,03	10,5 - 13,5	0,6	0,5	—	0,5	—	10 x C - 1,5
409Nb	M, B, C, G	0,12	1,2	1,0	0,04	0,03	10,5 - 14,0	0,6	0,5	8 x C - 1,5	0,5	—	—
410	M, B, C, G	0,12	1,2	1,0	0,04	0,03	11,0 - 13,5	0,6	0,5	—	0,5	—	—
410NiMo	M, B, C, G	0,06	1,0	1,0	0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,5	—	—
430	M, B, C, G	0,10	1,2	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	—	0,5	—	—
430Nb	M, B, C, G	0,10	1,2	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	0,5 - 1,5	0,5	—	—
16-8-2	M, B, C, G	0,10	0,5 - 2,5	0,75	0,04	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	—	0,5	—	—
2209	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	21,0 - 24,0	7,5 - 10,0	2,5 - 4,0	—	0,5	0,08 - 0,20	—
2553	M, B, C, G	0,04	0,5 - 2,5	0,75	0,04	0,03	24,0 - 27,0	8,5 - 10,5	2,9 - 3,9	—	1,0 - 2,5	0,10 - 0,20	—

[a] '–' signs in the table are used to indicate that these elements are not required to be analysed

[b] Single values shown in the table are maximum values

[c] The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 1B-2 Symbols for Chemical Composition Requirements for All Weld Metal of Self-Shielded Flux Cored Electrodes (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) [a, b, c]												
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
307	N	0,13	3,30 - 4,75	1,0	0,04	0,03	19,5 - 22,0	9,0 - 10,5	0,5 - 1,5	—	0,5	—	—
308	N	0,08	0,5 - 2,5	1,0	0,04	0,03	19,5 - 22,0	9,0 - 11,0	0,5	—	0,5	—	—
308L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	19,5 - 22,0	9,0 - 12,0	0,5	—	0,5	—	—
308H	N	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	19,5 - 22,0	9,0 - 11,0	0,5	—	0,5	—	—
308Mo	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	2,0 - 3,0	—	0,5	—	—
308LMo	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,5	—	—
308HMo	N	0,07 - 0,12	1,25 - 2,25	0,25 - 0,80	0,04	0,03	19,0 - 21,5	9,0 - 10,7	1,8 - 2,4	—	0,5	—	—
309	N	0,10	0,5 - 2,5	1,0	0,04	0,03	23,0 - 25,5	12,0 - 14,0	0,5	—	0,5	—	—
309L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	23,0 - 25,5	12,0 - 14,0	0,5	—	0,5	—	—
309Mo	N	0,12	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LMo	N	0,04	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LNb	N	0,03	0,5 - 2,5	1,0	0,04	0,03	23,0 - 25,5	12,0 - 14,0	0,5	0,7 - 1,0	0,5	—	—
310	N	0,20	0,5 - 2,5	1,0	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,5	—	0,5	—	—
312	N	0,15	0,5 - 2,5	1,0	0,04	0,03	28,0 - 32,0	8,0 - 10,5	0,5	—	0,5	—	—
316	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316H	N	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316LCu	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 16,0	1,25 - 2,75	—	1,0 - 2,5	—	—
317	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,5 - 21,0	13,0 - 15,0	3,0 - 4,0	—	0,5	—	—
317L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,5 - 21,0	13,0 - 15,0	3,0 - 4,0	—	0,5	—	—
318	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	8 x C - 1,0	0,5	—	—
347	N	0,08	0,5 - 2,5	1,0	0,04	0,03	19,0 - 21,5	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
347L	N	0,04	0,5 - 2,5	1,0	0,04	0,03	19,0 - 21,5	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
409	N	0,1	0,8	1,0	0,04	0,03	10,5 - 13,5	0,6	0,5	—	0,5	—	10 x C - 1,5

Table 1B-2 (continued)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
409Nb	N	0,12	1,0	1,0	0,04	0,03	10,5 - 14,0	0,6	0,5	8 x C - 1,5	0,5	—	—
410	N	0,12	1,0	1,0	0,04	0,03	11,0 - 13,5	0,6	0,5	—	0,5	—	—
410NiMo	N	0,06	1,0	1,0	0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,5	—	—
430	N	0,10	1,0	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	—	0,5	—	—
430Nb	N	0,10	1,0	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	0,5 - 1,5	0,5	—	—
16-8-2	N	0,10	0,5 - 2,5	0,75	0,04	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	—	0,5	—	—
2209	N	0,04	0,5 - 2,0	1,0	0,04	0,03	21,0 - 24,0	7,5 - 10,0	2,5 - 4,0	—	0,5	0,08 - 0,20	—
2553	N	0,04	0,5 - 1,5	0,75	0,04	0,03	24,0 - 27,0	8,5 - 10,5	2,9 - 3,9	—	1,5 - 2,5	0,10 - 0,20	—

[a] '–' signs in the table are used to indicate that these elements are not required to be analysed

[b] Single values shown in the table are maximum values

[c] The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 1B-3 Symbols for Chemical Composition Requirements for All Weld Metal of Gas Shielded Metal Cored Electrodes (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
308L	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	19,5 - 22,0 18,0 - 21,0	9,0 - 11,0 9,0 - 12,0	0,75	—	0,75	—	—
308Mo	A, M	0,08	1,0 - 2,5	0,30 - 0,65	0,03	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,75	—	—
309L	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	23,0 - 25,5 22,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
309LMo	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	23,0 - 25,5 21,0 - 25,0	12,0 - 14,0 12,0 - 16,0	2,0 - 3,0	—	0,75	—	—
316L	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	18,0 - 20,5 17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
347	A M	0,08	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,04	0,03	19,0 - 21,5 18,0 - 21,0	9,0 - 11,0	0,75	10 x C - 1,0 8 x C - 1,0	0,75	—	—
409	A	0,08	0,8	0,8	0,03	0,03	10,5 - 13,5	0,6	0,75	—	0,75	—	10 x C - 1,5
409Nb	A, M	0,12	1,2	1,0	0,04	0,03	10,5 - 14,0	0,6	0,75	8 x C - 1,5	0,75	—	—

Table 1B-3 (continued)

Alloy Designation According to Alloy Type	Chemical composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
410	A M	0,12	0,6 1,2	0,5 1,0	0,03 0,04	0,03	11,5 - 13,5 11,0 - 13,5	0,6	0,75	—	0,75	—	—
410NiMo	A M	0,06	0,6 1,0	0,5 1,0	0,03 0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,75	—	—
430	A M	0,10	0,6 1,2	0,5 1,0	0,03 0,04	0,03	15,0 - 17,0 15,0 - 18,0	0,6	0,75	—	0,75	—	—
430Nb	A, M	0,10	1,2	1,0	0,04	0,03	15,0 - 18,0	0,6	0,75	0,5 - 1,5	0,75	—	—

a '–' signs in the table are used to indicate that these elements are not required to be analysed
b Single values shown in the table are maximum values
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 1B-4 Symbols for Chemical Composition Requirements for All Weld Metal of Cored Rods for Gas Tungsten Arc Welding (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
308L	I	0,03	0,5 - 2,5	1,2	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	—	0,5	—	—
309L	I	0,03	0,5 - 2,5	1,2	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	—	0,5	—	—
316L	I	0,03	0,5 - 2,5	1,2	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
347	I	0,08	0,5 - 2,5	1,2	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—

a '–' signs in the table are used to indicate that these elements are not required to be analysed
b Single values shown in the table are maximum values
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 2B Tensile Properties of All Weld Metal (Classification according to alloy type)

Alloy Designation According to Alloy Type	Minimum Tensile Strength (MPa)	Minimum Elongation a (%)	Post Weld Heat Treatment
307	590	25	none
308	550	30	
308L	520	30	
308H	550	30	
308Mo	550	30	
308LMo	520	30	
308HMo	550	30	
309	550	25	
309L	520	25	
309Mo	550	15	
309LMo	520	15	
309LNb	520	25	
310	550	25	
312	660	15	
316	520	25	
316L	485	25	
316H	520	25	
316LCu	485	25	
317	550	20	
317L	520	20	
318	520	20	
347	520	25	
347L	520	25	
409	450	15	
409Nb	450	15	b
410	480	15	b
410NiMo	760	10	c
430	450	15	d
430Nb	450	13	d
16-8-2	520	25	none
2209	690	15	
2553	760	13	

a Gauge length is equal to five times the test specimen diameter

b The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 730 - 760°C, held for 1 hr, furnace cooled to 315°C, then cooled in air

c The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 590 - 620°C, held for 1 hr, then cooled in air

d The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 760 - 790°C, held for 2 hr, furnace cooled to 600°C, then cooled in air

Table 3B Symbol for Type of Tubular Cored Electrode and Rod (Classification according to alloy type)

Symbol	Characteristics
F	Flux cored electrodes
M	Metal cored electrodes
R	Cored rods for gas tungsten arc welding

Table 4B Symbol for Welding Position (Classification according to alloy type)

Symbol	Welding Positions a
0	PA and PB
1	PA, PB, PC, PD, PE, PF or PG, or PF + PG
a	PA = Flat position PB = Horizontal-vertical position PC = Horizontal position PD = Horizontal-overhead position PE = Overhead position PF = Vertical-up position PG = Vertical-down position

10204 Metallic Products Types Inspection Documents

This Euro-norm document covers the types of documentation required for material certification. It does not specify what tests must be done but does differentiate between actual test results and typical or statistical test results. Customers must specify on their purchase order the tests required and the test method required.

The relevant sections are Type 2.1, 2.2, 3.1 and 3.2 as shown in the table below.

Table 1 Inspection Document Content

Document Type	Document Content
2.1	Statement of compliance with order. Validated by the manufacturer
2.2	Statement of compliance with order, with indication of results of non-specific inspection. Validated by the manufacturer
3.1	Statement of compliance with order, with indication of results of specific inspection. Validated by the manufacturer's authorised inspection representative independent of the manufacturing department
3.2	Statement of compliance with order, with indication of results of specific inspection. Validated by the manufacturer's authorised inspection representative independent of the manufacturing department and either the purchaser's authorised inspection representative or the inspector designated by the official regulations

Stainless Steel Dissimilar Welding Chart

201	202	301	302	302B	303	304	304L	305	308	309	309S	310	310S	314	316	316L	317	317L	321	330	347	318	403	405	410	414	416	420	430	430F	431	440A	440E	440C	446	Base Metal
308	308	308	308	308	308 312	308	308	308	308	308	308	308	308	308 312	308	308	308	308	308	312 309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	201
	308	308	308	308	308 312	308	308	308	308	308	308	308	308	308 312	308	308	308	308	308	312 309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	202
		308	308	308	308 312	308	308	308	308	308	308	308	308	308 312	308	308	308	308	308	312 309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	301
			308	308	308 312	308	308	308	308	308	308	308	308	308 312	308	308	308	308	308	312 309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	302
				309	308 312	308	308	308	308	308	308	308	308	308 312	308	308	308	308	308	312 309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	302B
					308 312	308 312	308 312	308 312	308 312	308 312	308 312	312	312	312	308 312	308 312	308 312	308 312	308 312	312 309	308 312	308 312	309	309	309	309	309	309	309	309	309	309	309	309	312	303
						308	308	308	308	308	308	308	308	308 312	308	308	308	308	308	312 309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	304
							308L	308	308	308	308	308	308	308 312	308L	308L	308L	308L	308L	312 309	308L	308L	309	309	309	309	309	309	309	309	309	309	309	309	310	04L
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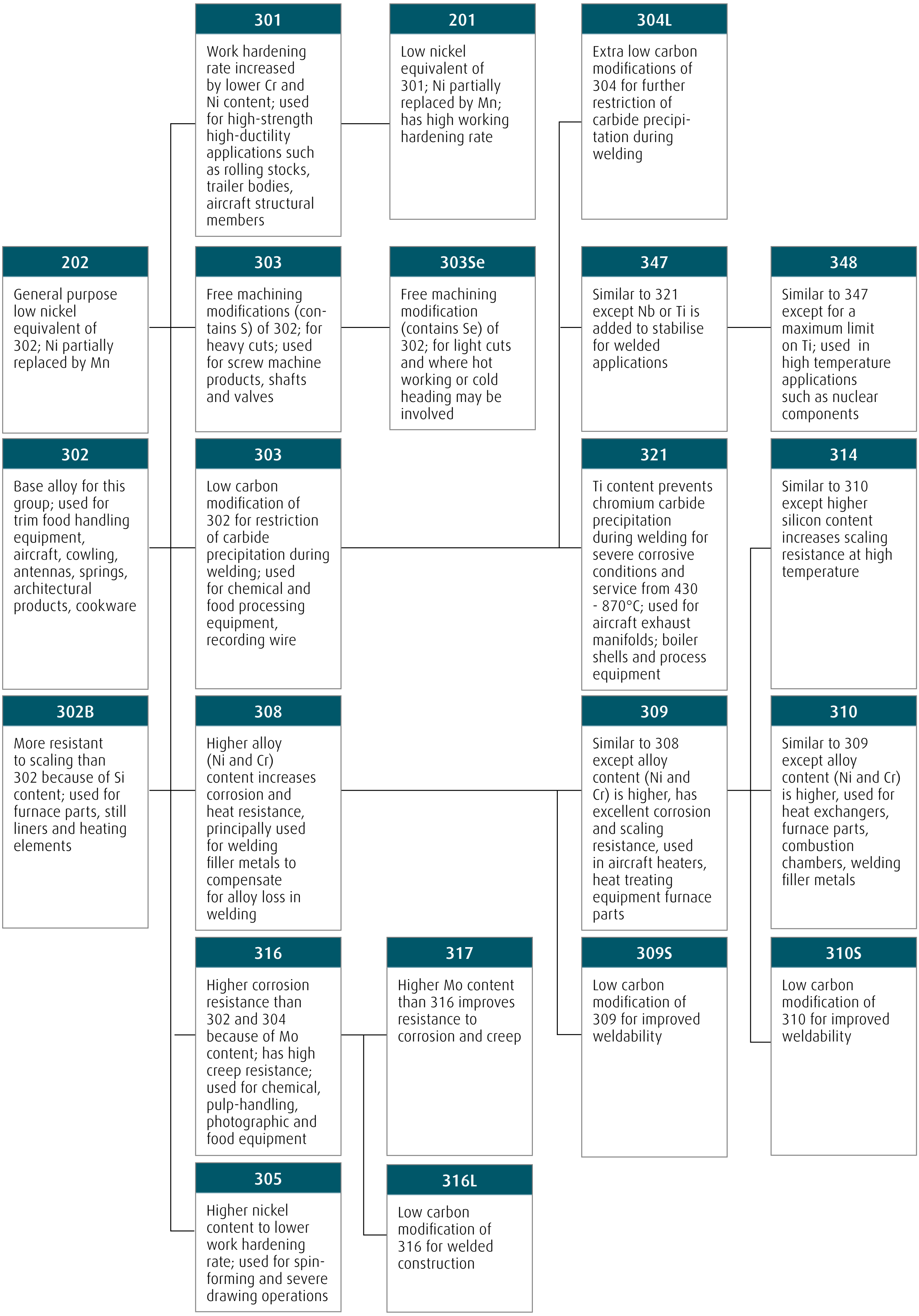
										309	309	309	309	309 312	309	309 316	309	309	308 347	312 309	308 347	308 347	309	309	309	309	309	309	309	309	309	309	309	309	310	309
											309	309	309	309 312	309 316	316	316	316	308 347	312 309	308 347	308 347	309	309	309	309	309	309	309	309	309	309	309	309	310	309S
												310	310	310 312	316	316	317	317	308	312 309	308 347	308 347	309	309	309	309	309	309	309	309	309	309	309	309	310	310
													310	310 312	316	316	317	317	308	312 309	308 347	308 347	309	309	309	309	309	309	309	309	309	309	309	309	309 310	310S
														310 312	316	316	317	317	308	312 309	308 347	308 347	309	309	309	309	309	309	309	309	309	309	309	309	309 310	314
															316 16.8.2	316	316	316	308	312 309	308 16.8.2	308 316	309	309	309	309	309	309	309	309	309	309	309	309	310	316
																316	316	316L	308L	312 309	316L	316L	309	309	309	309	309	309	309	309	309	309	309	309	310	316L
																	317	317	308	312 309	308L 16.8.2	308L 16.8.2	309	309	309	309	309	309	309	309	309	309	309	309	310	317
																		317L	308L 347	312 309	308L	308L	309	309	309	309	309	309	309	309	309	309	309	309	310	317L
																			347	312 309	347	347	309	309	309	309	309	309	309	309	309	309	309	309	310	321
																				330	312 309	312 309	312	312	312	312	312	312	312	312	312	312	312	312	312	330
																					347	347	309	309	309	309	309	309	309	309	309	309	309	309	310	347
																						347	309	309	309	309	309	309	309	309	309	309	309	309	310	348
																							410	410	410	410	312 309	410	430	309	410	410	410	410	410	403
																								410	410	410	312 309	410	430	309	410	410	410	410	410	405
																									410	410	312 309	410	430	309	410	410	410	410	410	410
																										309	312 309	410	430	309	410	410	410	410	410	414
																											410 309	309	410 309	309	410 309	309	309	309	309 310	416
																												420 410	410	309	410	420	420	420	430	420
																													430	309	430	430	430	430	430	430
																														309	309	309	309	309	309 310	430F
																															309	309	309	309	309 310	431
																																309	309	309	309 310	440A
																																	309	309	309 310	440B
																																		309	309 310	440C
																																			312 310	446

Note

- This chart is only a suggestion of which filler materials should be adequate for joining of stainless steels. This does not mean that other filler metal alloys are not recommended or are of a lesser quality. In all instances, the chart should be used as a reference only. Actual application should dictate the proper alloy choice.
- The shaded sections of the chart indicate 'free machining' alloys, which are considered not weldable. This is due to the high percentage of sulphur or other low melting point elements that cause hot cracking. If high quality joints are required, welding is not generally recommended.
- This chart does not indicate welding procedure. Some stainless steels require preheat while others should not have a preheat. Some welds require a buttering layer or rather more rigid procedures. Please contact Afrox regarding procedure recommendation.

Figure 1

The interrelationship and applications of the austenitic stainless steels.
Machine Design Reference Issue, The Penton Publishing Co., Cleveland, Ohio, 1967.



301
Work hardening rate increased by lower Cr and Ni content; used for high-strength high-ductility applications such as rolling stocks, trailer bodies, aircraft structural members

201
Low nickel equivalent of 301; Ni partially replaced by Mn; has high working hardening rate

304L
Extra low carbon modifications of 304 for further restriction of carbide precipitation during welding

202
General purpose low nickel equivalent of 302; Ni partially replaced by Mn

303
Free machining modifications (contains S) of 302; for heavy cuts; used for screw machine products, shafts and valves

303Se
Free machining modification (contains Se) of 302; for light cuts and where hot working or cold heading may be involved

347
Similar to 321 except Nb or Ti is added to stabilise for welded applications

348
Similar to 347 except for a maximum limit on Ti; used in high temperature applications such as nuclear components

302
Base alloy for this group; used for trim food handling equipment, aircraft, cowling, antennas, springs, architectural products, cookware

303
Low carbon modification of 302 for restriction of carbide precipitation during welding; used for chemical and food processing equipment, recording wire

321
Ti content prevents chromium carbide precipitation during welding for severe corrosive conditions and service from 430 - 870°C; used for aircraft exhaust manifolds; boiler shells and process equipment

314
Similar to 310 except higher silicon content increases scaling resistance at high temperature

302B
More resistant to scaling than 302 because of Si content; used for furnace parts, still liners and heating elements

308
Higher alloy (Ni and Cr) content increases corrosion and heat resistance, principally used for welding filler metals to compensate for alloy loss in welding

309
Similar to 308 except alloy content (Ni and Cr) is higher, has excellent corrosion and scaling resistance, used in aircraft heaters, heat treating equipment furnace parts

310
Similar to 309 except alloy content (Ni and Cr) is higher, used for heat exchangers, furnace parts, combustion chambers, welding filler metals

316
Higher corrosion resistance than 302 and 304 because of Mo content; has high creep resistance; used for chemical, pulp-handling, photographic and food equipment

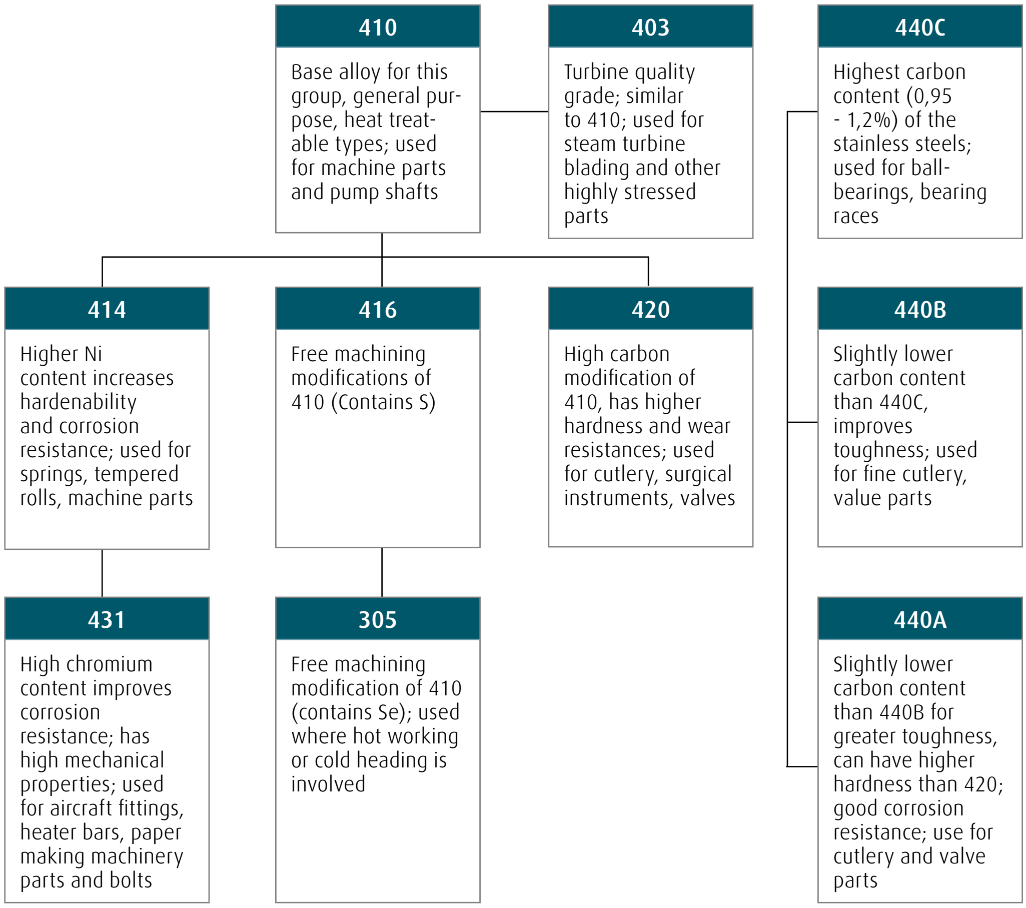
317
Higher Mo content than 316 improves resistance to corrosion and creep

309S
Low carbon modification of 309 for improved weldability

310S
Low carbon modification of 310 for improved weldability

305
Higher nickel content to lower work hardening rate; used for spin-forming and severe drawing operations

316L
Low carbon modification of 316 for welded construction



410
Base alloy for this group, general purpose, heat treatable types; used for machine parts and pump shafts

403
Turbine quality grade; similar to 410; used for steam turbine blading and other highly stressed parts

440C
Highest carbon content (0,95 - 1,2%) of the stainless steels; used for ball-bearings, bearing races

414
Higher Ni content increases hardenability and corrosion resistance; used for springs, tempered rolls, machine parts

416
Free machining modifications of 410 (Contains S)

420
High carbon modification of 410, has higher hardness and wear resistances; used for cutlery, surgical instruments, valves

440B
Slightly lower carbon content than 440C, improves toughness; used for fine cutlery, value parts

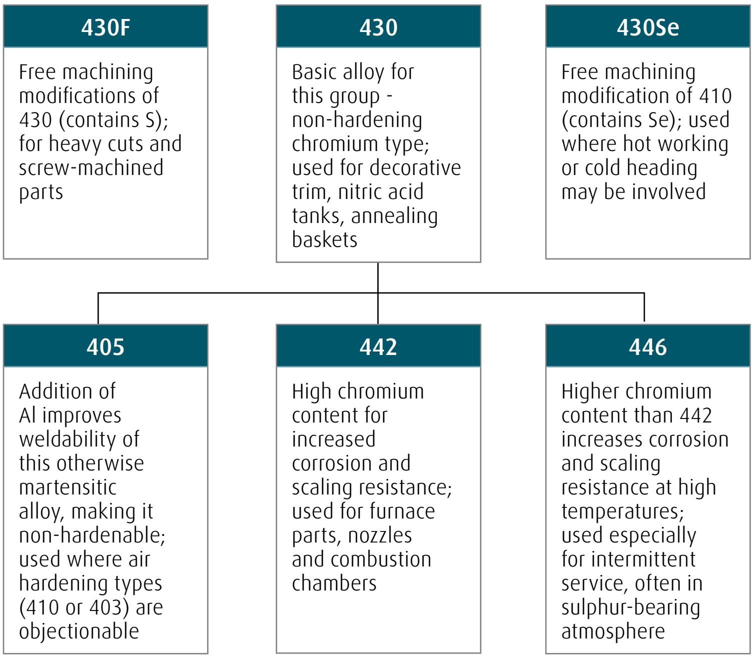
431
High chromium content improves corrosion resistance; has high mechanical properties; used for aircraft fittings, heater bars, paper making machinery parts and bolts

305
Free machining modification of 410 (contains Se); used where hot working or cold heading is involved

440A
Slightly lower carbon content than 440B for greater toughness, can have higher hardness than 420; good corrosion resistance; use for cutlery and valve parts

Figure 2

The interrelationship and applications of the martenistic stainless steels.
Machine Design Reference Issue, The Penton Publishing Co., Cleveland, Ohio, 1967.



430F
Free machining modifications of 430 (contains S); for heavy cuts and screw-machined parts

430
Basic alloy for this group - non-hardening chromium type; used for decorative trim, nitric acid tanks, annealing baskets

430Se
Free machining modification of 410 (contains Se); used where hot working or cold heading may be involved

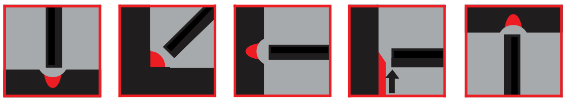
405
Addition of Al improves weldability of this otherwise martensitic alloy, making it non-hardenable; used where air hardening types (410 or 403) are objectionable

442
High chromium content for increased corrosion and scaling resistance; used for furnace parts, nozzles and combustion chambers

446
Higher chromium content than 442 increases corrosion and scaling resistance at high temperatures; used especially for intermittent service, often in sulphur-bearing atmosphere

Stainless Steel Electrodes

Afrox 308L



Afrox 308L is a rutile basic coated low carbon electrode for the high quality welding of stainless steel of the 19% chromium and 9% nickel type. It is recommended for welding AISI 302, 304, 304L, 321 and 347 stainless steels, which may be used in the following applications: brewing equipment, steam piping, vacuum pump parts, dairy equipment, textile drying equipment, chemical handling equipment, pharmaceutical and food processing.

Re-baking

Dry electrodes at 300°C for 2 hours.

Approvals
TÜV, EN 13479, CE (C880-CPD-0035), BV

Classifications		
AWS	A5.4	E308L-17
EN ISO	3581-A	E 19 9 L R 12

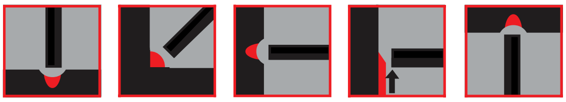
Typical Chemical Analysis			
% Carbon	0,03 max	**% Nickel**	9,0 - 11,0
% Manganese	0,5 - 2,5	**% Sulphur**	0,025 max
% Silicon	0,9 max	**% Phosphorous**	0,025 max
% Chromium	18,0 - 21,0		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	400 MPa min
Tensile Strength	520 - 630 MPa
% Elongation on 4d	35 min
Charpy V-Notch at +20°C	50 J min
Charpy V-Notch at -70°C	40 J min
Hardness VPN	180 - 220

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	45 - 80	3 x 5,0	W075702
3,25	350	70 - 120	3 x 5,0	W075703
4,0	350	100 - 150	3 x 5,0	W075704

Afrox 309L



Afrox 309L is a rutile basic coated low carbon grade electrode of the 23% chromium and 12% nickel type. It is recommended for welding corrosion resistant and heat resistant steels of the AISI 309 type, which is often used for furnace parts, aircraft components, heat exchangers and chemical processing equipment.

Afrox 309L can also be used for welding dissimilar carbon manganese steels and low alloy steels, welding stainless steels to mild steels and as a buffer for hardfacing applications.

Re-baking

Dry electrodes at 300°C for 2 hours.

Approvals
TÜV

Classifications		
AWS	A5.4	E309L-17
EN ISO	3581-A	E 23 12 L R 12

Typical Chemical Analysis			
% Carbon	0,03 max	**% Nickel**	12,0 - 14,0
% Manganese	0,5 - 2,5	**% Sulphur**	0,025 max
% Silicon	0,9 max	**% Phosphorous**	0,025 max
% Chromium	22,0 - 25,0		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	400 MPa min
Tensile Strength	550 - 650 MPa
% Elongation on 5d	30 min
Charpy V-Notch at +20°C	>60 J min
Charpy V-Notch at -70°C	40 J min
Hardness VPN	170 - 200
Ferrite Number WRC (1992)	20FN

Packing Data
(DC+ AC 70 OCV min)

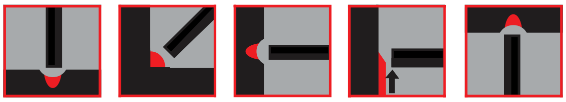
Diameter (mm)	**Electrode Length (mm)**	**Current (A)**	**Item Number (1 kg electrode pack)**	**Pack Mass (kg)**	**Item Number (multi-kg pack)**
2,5	300	40 - 80	W072772	3 x 4,0	W075772
3,25	350	70 - 105	W072773	3 x 4,0	W075773
4,0	350	90 - 145	-	3 x 4,0	W075774
5,0	350	140 - 190	-	3 x 4,0	W075775

DriPac Range

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	**Electrode Length (mm)**	**Current (A)**	**Pack Mass (kg)**	**Item Number (multi-kg pack)**
2,5	300	40 - 80	2 x 6,0	W075776
3,25	350	70 - 105	2 x 6,0	W075777

Afrox 310



Afrox 310 is an all-position rutile basic coated electrode of the 25% chromium and 20% nickel type. It is suitable for welding AISI 310 grade materials and resists scaling in oxidising atmospheres at temperatures up to 1 100°C while maintaining adequate joint strength.

Re-baking

Dry electrodes at 300°C for 2 hours.

Classifications		
AWS	A5.4	E310-16
EN ISO	3581-A	E 25 20 R 26

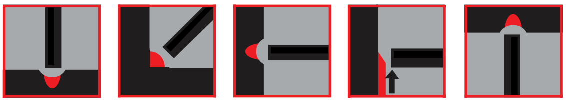
Typical Chemical Analysis			
% Carbon	0,08 - 0,15	**% Nickel**	20,0 - 22,5
% Manganese	1,5 - 2,5	**% Molybdenum**	0,20 max
% Silicon	0,75 max	**% Sulphur**	0,025 max
% Chromium	25,0 - 28,0	**% Phosphorous**	0,025 max

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	370 MPa min
Tensile Strength	550 - 650 MPa
% Elongation on 4d	30 min
Charpy V-Notch at +20°C	65 J min
Charpy V-Notch at -70°C	45 J min
Charpy V-Notch at -196°C	35 J min

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	50 - 70	3 x 4,0	W075732
3,25	350	80 - 95	3 x 4,0	W075733
4,0	350	95 - 130	3 x 4,0	W075734

Afrox 316L



Afrox 316L is a low carbon 19% chromium, 12% nickel and 3% molybdenum rutile basic coated electrode. It is recommended for welding of low carbon molybdenum bearing steels of the AISI 316L type which may be used for applications such as pulp handling equipment, high temperature equipment, heat exchangers, chemical storage and transportation tanks, oil refining equipment and pharmaceutical equipment.

Re-baking

Dry electrodes at 300°C for 2 hours.

Approvals

TÜV, EN 13479, CE (C880-CPD-0035), BV

Classifications

AWS	A5.4	E316L-17
EN ISO	3581-A	E 19 12 3 L 12

Typical Chemical Analysis

% Carbon	0,03 max	**% Nickel**	11,0 - 14,0
% Manganese	0,5 - 2,5	**% Molybdenum**	2,5 - 3,0
% Silicon	0,90 max	**% Sulphur**	0,02 max
% Chromium	17,0 - 20,0	**% Phosphorous**	0,025 max

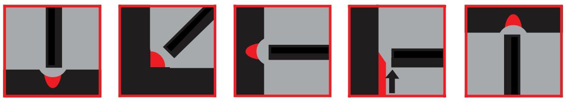
Typical Mechanical Properties (All weld metal)

0,2% Proof Stress	430 MPa min
Tensile Strength	520 - 650 MPa
% Elongation on 4d	35 min
Charpy V-Notch at +20°C	50 J min
Charpy V-Notch at -70°C	35 J min

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Item Number (4 electrode sleeve)	Item Number (1 kg electrode pack)	Pack Mass (kg)	Item Number (multi-kg pack)
2,0	300	30 - 60	-	-	3 x 3,0	W075751
2,5	300	40 - 80	W072752	W072782	3 x 4,0	W075752
3,25	350	70 - 105	W072753	W072783	3 x 4,0	W075753
4,0	350	90 - 145	-	-	3 x 4,0	W075754
5,0	350	140 - 190	-	-	3 x 4,0	W075755
2,5 (DriPac)	300	40 - 80	-	-	3 x 2,0	W075756
3,25 (DriPac)	350	70 - 105	-	-	3 x 2,0	W075757

Afrox E3CR12



Afrox E3CR12 is a heavily coated 13% chromium alloyed electrode suitable for all-position welding of 13% chromium ferritic steels. The deposited weld metal is sound with a low inclusion content and exhibits good toughness at temperatures down to -20°C. The electrode features a smooth, stable, low spatter arc on DC+. Weld bead appearance is good with a smooth uniform ripple. The slag is readily removed from the weld surface in all positions. Afrox E3CR12 has been especially developed for the welding of 3CR12 material. The weld metal has similar corrosion properties to that of 3CR12 without over alloying, i.e. in contrast to the 300 series electrodes.

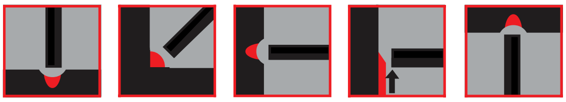
Classifications		
AWS	A5.4	E410NiMo
EN ISO	3581-A	E13 4 R 26
EN ISO	3581-B	ES 410 NiMo-26

Typical Chemical Analysis			
% Carbon	0,03	**% Nickel**	4,8
% Manganese	0,16	**% Molybdenum**	0,48
% Silicon	0,4	**% Sulphur**	0,01
% Chromium	12,0	**% Phosphorous**	0,03

Typical Mechanical Properties (All weld metal)	
PWHT 605°C x 1 hr	
Yield Strength	850 MPa
Tensile Strength	920 MPa
% Elongation on 5d	18
Charpy V-Notch at +20°C	40 - 55 J
Charpy V-Notch at -20°C	25 - 35 J

Packing Data (DC+ AC 70 OCV min)			
Diameter (mm)	**Current (A)**	**Pack Mass (kg)**	**Item Number**
3,2	70 - 130	3 x 5,0	W075843
4,0	100 - 170	3 x 5,0	W075844

Afrox 904L



Afrox 904L gives a fully austenitic low carbon weld metal with molybdenum and copper, with good resistance to corrosion in sulphuric, phosphoric and other inorganic and organic acids. It is not normally chosen for resistance to corrosion in concentrated nitric acid. For service in severe chloride pitting media, overmatching nickel-based weld metal is recommended. It is the preferred weld metal for some lower alloy austenitics such as Creusot UHB 34L and UHB 734L for wet process phosphoric acid service. Applications include tanks and process vessels, piping systems, agitators, rotors, cast pumps and valves for use in the fertiliser, phosphoric and sulphuric environments. It is also used in some offshore applications, including overlays on mild and low alloy steels.

Re-baking

Re-dry electrodes at 300 - 350°C for 2 hours.

Classifications

AWS	A5.4	E385-16

Typical Chemical Analysis

% Carbon	0,03 max	**% Nickel**	24,0
% Manganese	1,0	**% Molybdenum**	4,0
% Silicon	0,8	**% Copper**	1,3
% Sulphur	0,005	**% Niobium**	0,1
% Phosphorous	0,02	**% Nitrogen**	0,08
% Chromium	21,0		

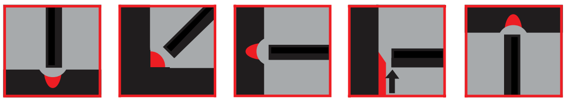
Typical Mechanical Properties (All weld metal)

Tensile Strength	580 MPa min
0,2% Proof Stress	375 MPa min
% Elongation on 5d	32 min
Impact Energy at -196°C	35 J min
Microstructure	In the as welded condition the weld metal microstructure is fully austenitic

Packing Data
(DC+ AC OCV 70 V min)

Diameter (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	50 - 75	5,0	W078104
3,2	65 - 105	5,0	W078106
4,0	85 - 150	5,0	W078108

Afrox 2209



Inox 2209 is a rutile coated electrode designed for the welding of austenitic-ferritic duplex steels. The weld deposit has a ferrite content of 25 - 30% providing resistance to stress corrosion cracking and pitting in chloride and hydrogen sulphide environments at service temperatures up to 300°C. The electrode has good re-strike characteristics with excellent bead profile and overall ease of operation. Suitable for use on AC and DC and welding transformers with low OCV. Suitable for welding SAF 2205 and LDX 2101.

Re-baking

Re-dry electrodes at 300°C for 2 hours.

Classifications

AWS	A5.4	E2209-17
EN ISO	3581-A	E 2293 N L R
EN ISO	3581-B	ES 2209-17

Typical Chemical Analysis

% Carbon	<0,04	**% Nickel**	9,0
% Silicon	0,8	**% Molybdenum**	3,0
% Manganese	0,9	**% Nitrogen**	0,1
% Chromium	22,0		

Typical Mechanical Properties (All weld metal)

Tensile Strength	>760 MPa
0,2% Proof Stress	>620 MPa
% Elongation on 4d	>25
Impact Energy at +20°C	>55 J

Packing Data (DC+ AC OCV 42 V min)

Diameter (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	50 - 80	3 x 5,0	W075742
3,2	70 - 120	3 x 5,0	W075743
4,0	90 - 150	3 x 5,0	W075744

Stainless Steel Wires for MIG & TIG Welding

Afrox MIG 307Si

Afrox MIG 307Si is a bright drawn, stainless steel welding wire suitable for the joining of armour plate, austenitic manganese steels, ferritic chromium stainless steels and dissimilar steels. The wire is also suitable for buffer layering prior to hardfacing. The weld deposit is work hardenable and heat resistant up to 850°C.

Classifications

EN ISO	14343-A	G 18 8 Mn
EN ISO	14343-B	SS 307 Si (nearest)

Typical Chemical Analysis

% Carbon	0,2 max	**% Manganese**	5,0 - 8,0
% Silicon	1,5 max	**% Chromium**	17,0 - 20,0
% Nickel	7,0 - 10,0	**% Sulphur**	0,025 max
% Phosphorous	0,035 max		

Typical Mechanical Properties (All weld metal)

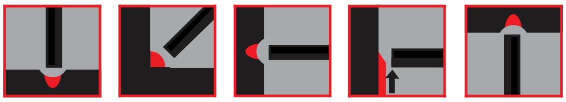
0,2% Proof Stress	390 MPa
Tensile Strength	590 - 740 MPa
% Elongation on 4d	30 min
Charpy V-Notch at +20°C	60 J min
Microstructure	Fully austenitic

Packing Data

Diameter (mm)	Pack Mass (kg)	Item Number
1,0	15,0 (spool)	W033244
1,2	15,0 (spool)	W033242
1,0	15,0 (spool)	W033003
1,0	120,0 (drum)	W033457
1,0	220,0 (drum)	W033467

Suggested shielding gas: Stainshield®, Stainshield® Plus

Afrox TIG 307Si



TIG 307Si is for use on dissimilar combinations of CMn, stainless, hardenable, wear resistant and armour steels. Also suitable for 13% Mn manganese (Hadfield) steel and mixed welding applications. Can be used as buffer layers and a surfacing consumable.

Classifications		
AWS	A5.9	Similar to ER307
EN ISO	14343	W 18 8 Mn
EN ISO	14343	SS 307 nearest

Typical Chemical Analysis			
% Carbon	0,08	**% Chromium**	19,0
% Manganese	6,0	**% Nickel**	8,5
% Silicon	0,8	**% Molybdenum**	0,2
% Sulphur	0,01	**% Copper**	0,1
% Phosphorous	0,015		

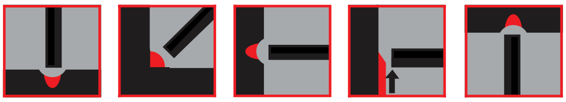
Typical Mechanical Properties (All weld metal)	
Tensile Strength	605 MPa
0,2% Proof Stress	414 MPa
% Elongation on 4d	42
Charpy V-Notch at +20°C	105 J
Charpy V-Notch at -50°C	65 J
Microstructure	In the as welded condition the weld metal microstructure is fully austenitic

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030405
2,4	100	12	5,0	W030407

Suggested shielding gas: Argon

Afrox Exhaust F1 1,00 mm



Exhaust F1 (MIG/GMAW) is a ferritic stainless steel wire developed and customised for the automotive industry and exhaust manufacturers. Welds of ferritic stainless steel sheets obtained with Exhaust F1 wire exhibit far better thermal fatigue cycles due to unique chemical composition.

Classifications	
ISO	14343.2: 18LNb
AISI	430Cb
DIN	85561.4511

Typical Chemical Analysis			
% Carbon	0,05	**% Chromium**	17,5 - 19,0
% Manganese	0,3 - 0,8	**% Nickel**	0,56
% Silicon	0,3 - 1,0	**% Molybdenum**	0,50
% Sulphur	0,030	**% Copper**	0,50
% Phosphorous	0,030	**Nb**	10xC - 0,7

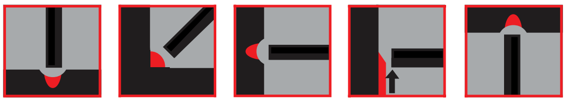
Typical Mechanical Properties (All weld metal)	
Tensile Strength	520 MPa
0,2% Proof Stress	360 MPa
% Elongation on 5d	23

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,0	200	26	220,0	W033466

Suggested shielding gas: Stainshield®

Afrox MIG/TIG 308LSi



MIG/TIG 308LSi is used to weld 18/8 stainless steels including 301, 302, 303, nitrogen bearing 304LN and similar. Service temperatures are typically -100°C to about 400°C. Applications can be found in the brewery, food, architectural and general fabrication industries.

Classifications

AWS	A5.9	ER308LSi
EN ISO	14343-A	G/W 19 9 LSi
EN ISO	14343-B	SS 308 LSi

Typical Chemical Analysis

% Carbon	0,01	**% Chromium**	20,0
% Manganese	1,7	**% Nickel**	10,0
% Silicon	0,8	**% Molybdenum**	0,1
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	10,0

Typical Mechanical Properties (All weld metal)

	MIG	TIG
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
Impact Energy at -20°C	30 - 60 J	80 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN	

Packing Data

MIG (DC+)

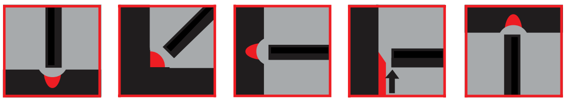
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,9	160	23	15,0	W033014
1,0	200	26	15,0	W033224
1,2	260	26	15,0	W033222

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030413

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 308L



MIG/TIG 308L is used to weld 18/8 stainless steels including 301, 302, 303, nitrogen bearing 304LN and similar. Service temperatures are typically -100°C to about 400°C. Applications can be found in the brewery, food, architectural and general fabrication industries.

Classifications		
AWS	A5.9	ER308L
EN ISO	14343-A	G/W 19 9 L
EN ISO	14343-B	SS 308L

Typical Chemical Analysis			
% Carbon	0,03 max	**% Phosphorous**	0,03 max
% Manganese	1,0 - 2,5	**% Chromium**	19,5 - 22,0
% Silicon	0,3 - 0,65	**% Nickel**	9,0 - 11,0
% Sulphur	0,03 max	**Ferrite Number**	10,0

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
Impact Energy at -196°C	30 - 60 J	80 J
Hardness	200/220 HV	200/220 HV
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN	

Packing Data
MIG (DC+)

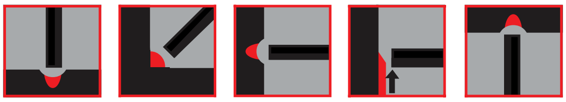
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,2	260	26	15,0	W033010
1,0	260	26	220,0	W033447
1,2	260	26	220,0	W033448

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	100	12	5,0	W030560
2,0	100	12	5,0	W030562
2,4	100	12	5,0	W030561

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 308H



MIG/TIG 308H consumables are designed to match unstabilised 18% Cr, 10% Ni austenitic stainless steels for elevated temperature strength and oxidation resistance. These steels and the weld metal have carbon content controlled to 0,04 - 0,08%. The 308H consumables should also be considered for welding thick (>12 mm) stabilised grades 321H or 347H to avoid in-service HAZ cracking and low creep rupture ductility associated with 347 weld metal.

Materials to be Welded	
ASTM / UNS	304 H, S30409, CF 10, CF 8
DIN	1.4948
BS	304S51, 302C25, 304C15

Classifications		
AWS	A5.9	ER308H
EN ISO	14343 - A	G/W 19 9 H
EN ISO	14343 - B	SS 308H

Typical Chemical Analysis			
% Carbon	0,05	**% Chromium**	19,9
% Manganese	1,8	**% Nickel**	9,5
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,002	**% Copper**	0,1
% Phosphorous	0,015		

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	550 MPa min	630 MPa
0,2% Proof Stress	350 MPa min	450 MPa
% Elongation on 4d	30	43
Impact Energy -20°C	-	100 J
Microstructure	Austenite with delta ferrite controlled 3 - 8FN	

Packing Data
MIG (DC+)

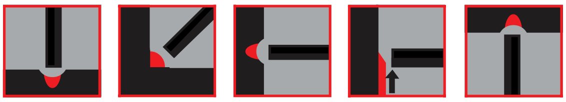
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	260	28	15,0	W033026

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030417
2,0	100	12	5,0	W030418
2,4	100	12	5,0	W030419

Suggested gas for welding: Stainshield®, Stainshield Plus® (MIG), Argon (TIG)

Afrox MIG 309LSi



MIG 309LSi is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are three main areas of application: buffer layers and clad steels, dissimilar joints and similar metal joints.

Classifications		
AWS	A5.9	ER309L Si
EN ISO	14343 - A	23 12 L Si
EN ISO	14343 - B	309L Si

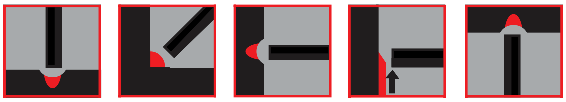
Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	23,5
% Manganese	1,7	**% Nickel**	13,0
% Silicon	0,8	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	1,15
% Phosphorous	0,015	**Ferrite Number**	12,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	560 MPa
0,2% Proof Stress	430 MPa
% Elongation on 4d	42
% Elongation on 5d	39
Impact Energy at -20°C	80 J
Impact Energy at +20°C	100 J
Microstructure	Austenite with ferrite in the range 8 - 20FN

Packing Data
MIG (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,8	120	19	15,0	W033035
0,9	160	23	15,0	W033036
1,0	200	26	15,0	W033228
1,2	260	26	15,0	W033227
1,6	280	28	15,0	W033039

Afrox MIG/TIG 309L



MIG/TIG 309L is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are three main areas of application: buffer layers and clad steels, dissimilar joints and similar metal joints.

Classifications		
AWS	A5.9	ER309L
EN ISO	14343-A	G/W 23 12 L
EN ISO	14343-B	SS 309L

Typical Chemical Analysis			
% Carbon	0,03 max	**% Phosphorous**	0,02 max
% Manganese	1,0 - 2,5	**% Nickel**	12,0 - 14,0
% Silicon	0,3 - 0,65	**% Chromium**	23,0 - 25,0
% Sulphur	0,02 max	**Ferrite Number**	6,0 - 12,0

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	560 MPa	590 MPa
0,2% Proof Stress	430 MPa	450 MPa
% Elongation on 4d	42	43
% Elongation on 5d	39	41
Impact Energy at +20°C	100 J	>200 J
Hardness	175 - 215 HV	205 - 2 250 HV
Microstructure	Austenite with ferrite in the range 6 - 12FN	

Packing Data
MIG (DC+)

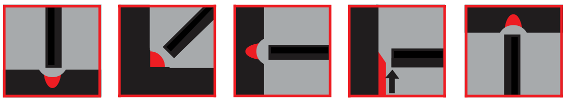
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,0	220	25	15,0	W033455
1,2	260	26	15,0	W033127
1,2	260	26	120,0	W033108

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	100	12	5,0	W030570
2,0	100	12	5,0	W030572
2,4	100	12	5,0	W030571

Suggested gas for welding: Argon (TIG)

Afrox MIG/TIG 310



MIG/TIG 310 consumables are used primarily for welding similar wrought or cast 25% Cr, 20% Ni (310) parent alloys with up to 0,25% carbon. Parent metal and weld metal are fully austenitic. The high alloy content of type 310 gives useful oxidation resistance up to peak temperatures of about 1 200°C for heat shields, furnace parts and ducting. Can be used for mixed welding, dissimilar joints, buffer layers and surfacing, as well as specialised applications requiring low magnetic permeability and for cryogenic installations.

Classifications

AWS	A5.9	ER310
EN ISO	14343-A	G/W 25 20
EN ISO	14343-B	SS 310

Typical Chemical Analysis

% Carbon	0,11	**% Chromium**	26,0
% Manganese	1,8	**% Nickel**	21,0
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	1,1
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal)

	MIG	**TIG**
Tensile Strength	540 MPa	560 MPa
0,2% Proof Stress	355 MPa	370 MPa
% Elongation on 4d	27	25
Impact Energy at -196°C	70 J	-
Hardness cap/mid	185 HV	185 HV
Microstructure	Fully austenitic	

Packing Data
MIG (DC+)

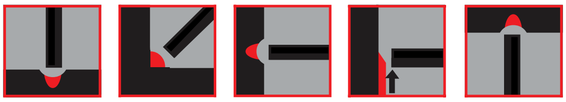
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	220	29	15,0	W033054

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030433
2,0	100	12	5,0	W030434
2,4	100	12	5,0	W030435

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 316LSi



MIG/TIG 316LSi consumables are used for Mo bearing austenitic stainless steels with 1,5 - 3% Mo. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

Classifications		
AWS	A5.9	ER316LSi
EN ISO	14343-A	G/W 19 12 3 L Si
EN ISO	14343-B	SS 316L Si

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	18,5
% Manganese	1,4	**% Nickel**	12,8
% Silicon	0,8	**% Molybdenum**	2,6
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	6,0

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
% Elongation on 4d	40	33
Impact Energy at -130°C	<70 J	>100 J
Impact Energy -196°C	30 - 60 J	>60 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN depending on the application	

Packing Data
MIG (DC+ or pulsed)

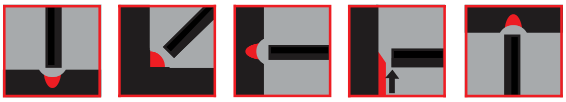
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,8	120	26	15,0	W033069
0,9	160	26	15,0	W033070
1,0	200	26	15,0	W033234
1,2	260	26	15,0	W033232
1,6	280	26	15,0	W033073

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030445
3,2	100	12	5,0	W030448

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 316L



MIG/TIG 316L consumables are used for Mo bearing austenitic stainless steels with 1,5 - 3% Mo. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

Classifications		
AWS	A5.9	ER316L
EN ISO	14343-A	G/W 19 12 3 L
EN ISO	14343-B	SS 316L

Typical Chemical Analysis			
% Carbon	0,03 max	**% Chromium**	18,0 - 20,0
% Manganese	1,0 - 2,5	**% Nickel**	11,0 - 14,0
% Silicon	0,3 - 0,65	**% Molybdenum**	2,0 - 3,0
% Sulphur	0,03 max	**Ferrite Number**	3,0 - 10,0
% Phosphorous	0,03 max		

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
Impact Energy at -130°C	>70 J	>100 J
Impact Energy at -196°C	30 - 60 J	>60 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 3 - 10FN depending on the application	

Packing Data

MIG (DC+)

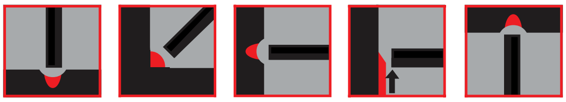
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	260	26	15,0	W033066

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030550
2,0	100	12	5,0	W030553
2,4	100	12	5,0	W030551
3,2	130	12	5,0	W030552

Suggested gas for welding: Stainshield® (MIG), Argon (TIG)

Afrox TIG 317L



TIG 317L is used to weld 317/317L stainless steels in which the raised Mo level provides improved resistance to pitting in high chloride environments and to some acids (not nitric acid). These steels are used in marine, chemical process, papermaking, and food processing applications. Also suitable for 316/316L and their stabilised versions when the benefits of higher molybdenum weld metal are required to maximise weld area pitting resistance. Not suitable for structural service above about 400°C or for cryogenic applications.

Classifications

AWS	A5.9	ER317L
EN ISO	14343-A	W 19 13 4 L
EN ISO	14343-B	SS 317L

Typical Chemical Analysis

% Carbon	0,015	**% Chromium**	19,0
% Manganese	1,5	**% Nickel**	14,0
% Silicon	0,4	**% Molybdenum**	3,5
% Sulphur	0,01	**Ferrite Number**	5,0
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal)

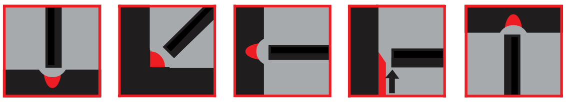
Tensile Strength	630 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	35
Impact Energy at +20°C	75 J
Microstructure	Austenite with 2 - 10FN (3 - 9% ferrite), typically 5FN

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030453

Suggested shielding gas: Argon

Afrox TIG 318Si



TIG 318Si is used to weld titanium or niobium-stabilised grades of molybdenum-bearing austenite stainless steels, or as an alternative electrode for unstabilised grades such as 316/316L. It is not recommended for structural service above 400°C. It is also used for depositing corrosion resistance overlays and valve seat inlays on medium carbon alloy steels.

Classifications		
AWS	A5.9	ER318
EN ISO	14343-A	W 19 12 3 Nb (nearest)
EN ISO	14343-B	SS 318 Si (nearest)

Typical Chemical Analysis			
% Carbon	0,045	**% Chromium**	19,0
% Manganese	1,3	**% Nickel**	9,5
% Silicon	0,8	**% Molybdenum**	2,5
% Sulphur	0,01	**% Copper**	0,2
% Phosphorous	0,02	**Ferrite Number**	10,0
% Niobium	0,6		

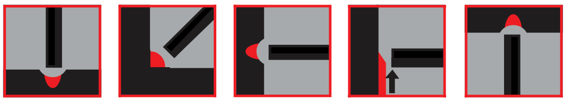
Typical Mechanical Properties (All weld metal)	
Tensile Strength	655 MPa
0,2% Proof Stress	440 MPa
% Elongation on 4d	42
Impact Energy at +20°C	90 J
Microstructure	Austenite with 3 - 14FN (3 - 12% ferrite), typically 10FN

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	100	12	5,0	W030459

Suggested shielding gas: Argon

Afrox MIG/TIG 347



MIG/TIG 347 is used to weld titanium and niobium stabilised 18/8 stainless steel types 321 and 347. Also suitable for unstabilised grades such as 304/304L. Service temperatures are typically -100°C to approximately 400°C. Applications are similar to 308L and include food, brewery, pharmaceutical equipment, architectural, general fabrication and nuclear engineering. The 347 consumables covered here are generally not suitable for service in elevated temperature structural applications where 0,04 - 0,08% carbon is specified for creep resistance.

Classifications		
AWS	A5.9	ER347
EN ISO	14343-A	G/W 19 9 Nb
EN ISO	14343-B	SS 347

Typical Chemical Analysis			
% Carbon	<0,04	**% Chromium**	19,5
% Manganese	1,5	**% Nickel**	9,7
% Silicon	0,4	**% Molybdenum**	0,2
% Sulphur	0,005	**% Copper**	0,1
% Phosphorous	0,02	**% Niobium**	0,6
Ferrite Number	8,0		

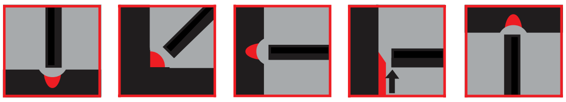
Typical Mechanical Properties (All weld metal)	
Tensile Strength	660 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	42
Impact Energy at -20°C	100 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 3 - 12FN

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	100	12	5,0	W030461
2,0	100	12	5,0	W030462
2,4	100	12	5,0	W030463

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 904L



MIG/TIG 904L consumables give a fully austenitic, low carbon weld metal with molybdenum and copper, with good resistance to corrosion in sulphuric, phosphoric and other inorganic and organic acids. They are not normally chosen for resistance to corrosion in concentrated nitric acid. For service in severe chloride pitting media, overmatching nickel-based weld metal is recommended. It is the preferred weld metal for some lower alloy austenitics such as Creusot UHB 34L and UHB 734L for wet process phosphoric acid service. Applications include tanks and process vessels, piping systems, agitators, rotors, cast pumps and valves for use in the fertiliser, phosphoric, sulphuric and acetic acid plants, and in salt and seawater environments. It is also used in some offshore applications, including overlays on mild and low alloy steels.

Classifications		
AWS	A5.9	ER385
EN ISO	14343-A	G/W 20 25 5 Cu L
EN ISO	14343-B	SS 385

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	20,0
% Manganese	1,7	**% Nickel**	25,0
% Silicon	0,3	**% Molybdenum**	4,5
% Sulphur	0,001	**% Copper**	1,5
% Phosphorous	0,01	**Ferrite Number**	10,0
% Niobium	0,6		

Typical Mechanical Properties (All weld metal)	
Tensile Strength	650 MPa
0,2% Proof Stress	490 MPa
% Elongation on 4d	35
Impact Energy at +20°C	210 J
Microstructure	In the as welded condition the weld metal microstructure is fully austenitic

Packing Data
MIG (DC+)

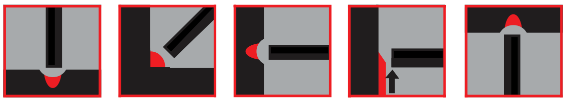
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,0	200	26	220,0	W033104
1,0	200	26	15,0	W033105
1,2	230	30	15,0	W033106

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030465
2,0	100	12	5,0	W030466
2,4	100	12	5,0	W030467

Suggested shielding gas: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 2209



MIG/TIG 2209 is used to weld duplex stainless steel pipe, plate, fittings and forgings having an approximate 50:50 microstructure of austenite with a ferrite matrix. This, coupled with general alloying level, confers:

- High strength compared with standard austenitic steels, e.g. type 316L
- Good general corrosion resistance in a range of environments
- High resistance to chloride induced stress corrosion cracking (CSCC)
- High resistance to pitting attack in chloride environments, e.g. sea water.

These alloys are finding widening application in the offshore oil/gas, chemical and petrochemical process industries, e.g. pipework systems, flow-lines, risers, manifolds, etc.

Materials to be Welded

Standard duplex '2205' types of ferritic – austenitic stainless steels. Proprietary alloys include:	SAF 2205, A 903, SAF 2304, UR 35N, LD X 2101

Classifications

AWS	A5.9	ER2209
EN ISO	14343-A	G/W 22 9 3 N L
EN ISO	14343-B	SS 2209

Typical Chemical Analysis

% Carbon	<0,015	**% Chromium**	23,0
% Manganese	1,6	**% Nickel**	8,2
% Silicon	0,5	**% Molybdenum**	3,2
% Sulphur	0,001	**% Copper**	0,1
% Phosphorous	0,015	**% Nitrogen**	0,17
Pitting Resistance Equivalent	PRE_n = Cr + 3,3 Mo + 16N	**PRE_n**	>35

Typical Mechanical Properties (All weld metal)

	TIG	**MIG**
Tensile Strength	820 MPa	800 - 835 MPa
0,2% Proof Stress	660 MPa	560 - 620 MPa
% Elongation on 4d	32	28 - 35
Impact Energy at -30°C	>140 J	>70 J
Impact Energy at -50°C	>120 J	>60 J
Impact Energy at -75°C	>70 J	-
Hardness	270 HV	270 HV
Microstructure	Multi-pass welds in the as welded condition contain about 25 - 50% ferrite depending on dilution and heat input/cooling rate conditions	

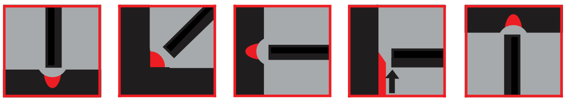
Packing Data

MIG (DC+)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,2	180	28	15,0	W033445
TIG (DC-)				
1,6	100	12	5,0	W030489
2,0	100	12	5,0	W030490
2,4	100	12	5,0	W030491

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Ar/He/CO$_2$ (Pulse), Argon (TIG)

Afrox TIG 2594



TIG 2594 is a solid electrode for welding Zeron® 100 and other super duplex alloys for service in the as welded condition. This electrode is overmatching with respect to nickel content to achieve the correct austenite-ferrite microstructural phase balance.

Classifications

AWS	A5.9	ER2594
EN ISO	14343-A	25 9 4 NL

Typical Chemical Analysis

% Carbon	0,015	**% Nickel**	9,3
% Manganese	0,7	**% Molybdenum**	3,7
% Silicon	0,4	**% Tungsten**	0,6
% Sulphur	0,002	**% Copper**	0,7
% Phosphorous	0,02	**% Nitrogen**	0,23
% Chromium	25,0	**PRE$_n$** 41	**PRE$_W$** 42
Pitting Resistance Equivalent		PRE$_W$ = Cr + 3,3Mo + 1,65W + 16N	
		PRE$_n$ = Cr + 3,3 Mo + 16N	

Typical Mechanical Properties (All weld metal)

	MIG	**TIG**
Tensile Strength	645 MPa	695 MPa
0,2% Proof Stress	860 MPa	870 MPa
% Elongation on 5d	23	32
Charpy V-Notch at -50°C	60 J	130 J
Hardness	290 HV	290 HV

TIG (DC-)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	100	12	2,5	W078100
2,4	100	12	2,5	W078102

Recommended shielding gas: Argon (TIG), Ar/He/CO_2 (MIG)

Stainless Steel Consumables for Submerged Arc Welding

Afrox Subarc 308L

Subarc 308L is used to weld 18/8 stainless steels including 301, 302, 303 nitrogen bearing 304LN and titanium stabilised 321. Service temperatures are typically -100°C to about 400°C. Applications include food, brewery, pharmaceutical equipment, architectural, general fabrication and nuclear engineering.

Classifications		
AWS	A5.9	ER308L
EN ISO	14343-A	S 19 9 L
EN ISO	14343-B	SS 308L

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	20,0
% Manganese	0,7	**% Nickel**	10,0
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	10,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	570 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	41
Impact Energy at -130°C	50 J
Impact Energy at -196°C	30 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN depending on the application

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	350	28	25,0	W078142
3,2	380	30	25,0	W078144

Suggested flux: Afrox Flux MK-SS or Oerlikon OP33

Afrox Subarc 309L

Subarc 309L is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are three main areas of application: buffer layers and clad steels, dissimilar joints and similar metal joints.

Classifications		
AWS	A5.9	ER309L
EN ISO	14343-A	S 23 12 L
EN ISO	14343-B	SS 309L

Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	23,0
% Manganese	1,7	**% Nickel**	13,0
% Silicon	0,5	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	12,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	600 MPa
0,2% Proof Stress	400 MPa
% Elongation on 4d	40
Impact Energy at -130°C	100 J

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	350	28	25,0	W078152
3,2	400	32	25,0	W078154

Suggested flux: Afrox Flux MK-SS or Oerlikon Flux OP33

Afrox Subarc 310

Afrox Subarc 310 consumables are used primarily for welding similar wrought or cast 25% Cr, 20% Ni (310) parent alloys with up to 0,25% carbon. Parent metal and weld metal are fully austenitic. The high alloy content of type 310 gives useful oxidation resistance up to peak temperatures of about 1 200°C for heat shields, furnace parts and ducting.

Classifications		
AWS	A5.9	ER310
EN ISO	14343-A	S 25 20
EN ISO	14343-B	SS 310

Typical Chemical Analysis			
% Carbon	0,11	**% Chromium**	26,0
% Manganese	1,8	**% Nickel**	21,0
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	0,1
% Phosphorous	0,015	**% Ferrite**	10,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	540 MPa
0,2% Proof Stress	355 MPa
% Elongation on 4d	27
Impact Energy at -130°C	70 J
Microstructure	Fully austenitic. Typical magnetic permeability <1,01

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	320	30	25,0	W078157

Suggested flux: Afrox Flux MK-SS Oerlikon Flux OP33

Afrox Subarc 316L

Subarc 316L consumables are used for Mo bearing austenitic stainless steels with 1,5 - 3% Mo. They are also suitable for Ti or Nb stabilised and nitrogen-bearing or free machining versions of the above alloys. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

Classifications

AWS	A5.9	ER316L
EN ISO	14343-A	S 19 12 3 L
EN ISO	14343-B	SS 316L

Typical Chemical Analysis

% Carbon	0,01	**% Chromium**	18,5
% Manganese	1,4	**% Nickel**	12,8
% Silicon	0,5	**% Molybdenum**	2,6
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	6,0

Typical Mechanical Properties (All weld metal)

Tensile Strength	570 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	41
Impact Energy at -196°C	30 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 3 - 10FN depending on the application

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
3,2	400	32	25,0	W078164

Suggested flux: Afrox Flux MK-SS or Oerlikon Flux OP33

Afrox Subarc 2209

Subarc 2209 is used on duplex stainless steel pipe, plate, fittings and forgings having an approximate 50:50 microstructure of austenite with a ferrite matrix. This, coupled with general alloying level, confers:

- High strength compared with standard austenitic steels, e.g. type 316L
- Good general corrosion resistance in a range of environments
- High resistance to chloride induced stress corrosion cracking (CSCC)
- High resistance to pitting attack in chloride environments, e.g. sea water.

These alloys are finding widening application in the offshore oil/gas, chemical and petrochemical process industries, e.g. pipework systems, flow-lines, risers, manifolds, etc.

Classifications

AWS	A5.9	ER2209
EN ISO	14343-A	S 22 9 3 NL
EN ISO	14343-B	SS 2209

Typical Chemical Analysis

% Carbon	0,015	**% Nickel**	8,2
% Manganese	1,6	**% Molybdenum**	3,2
% Silicon	0,5	**% Chromium**	23,0
% Sulphur	0,001	**% Copper**	0,1
% Phosphorous	0,015	**% Nitrogen**	0,17

Typical Mechanical Properties (All weld metal)

Tensile Strength	800 - 835 MPa
0,2% Proof Stress	560 - 602 MPa
% Elongation on 4d	28 - 35
Impact Energy at -30°C	85 J
Impact Energy at -50°C	70 J
Microstructure	Multi-pass welds in the as welded condition contain about 25 - 50% ferrite depending on dilution and heat input/cooling rate conditions

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
3,2	400	32	25,0	W078178

Suggested flux: Afrox Flux MK-SS or Oerlikon Flux OP33 or Metrode Flux SSB

Hobart SWX220

Hobart SWX220 flux is an agglomerated flux containing chromium for the welding of AISI 300 and 400 series stainless steels. The addition of chromium helps to reduce the losses caused by oxidation in the arc. The weld has good mechanical properties and impacts and the weld bead appearance is clean and well shaped. Hobart SWX220 can also be used to join dissimilar steels such as 300 series stainless to low carbon steel using an ER309L type wire. When welding stainless steels, it is recommended to keep the heat input to below 25 kJ/cm to avoid cracks during the solidification stage.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300°C at a flux depth of about 25 mm.

Classifications		
AWS	A5.17/ASME SFA 5.17	ER-308, ER-308L, ER-309, ER-309L, ER-316, ER-316L ER-410, ER-420, ER-410NiMo, ER-430, ER-347

Flux Characteristics	
Maximum Welding Current	800 A
Polarity	DC or AC

Packing Data	
Pack Mass (kg)	**Item Number**
25,0	W071404

Oerlikon OP33 Submerged Arc Flux

Oerlikon OP33 is a basic submerged arc welding flux suitable for welding austenitic stainless steels. Its behaviour as to carbon content of the weld metal is neutral, which means that using the appropriate electrode, OP33 can be used for welding extra low carbon steels. It does not possess chromium compensating elements. Nevertheless, chromium burn-out is very low. Its behaviour to silicon and manganese is also neutral, that is, there is neither pick-up nor burn-out of these elements. Burn-out of manganese will only occur when using wire electrodes having high manganese content (ER307). Weld seams are smooth and finely rippled and without undercuts into the base metal. They are free of slag reminders, even when using stabilised materials. Good slag removal makes OP33 ideally suited for fillet welding. It is suitable to be used on DC positive up to 800 A.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300 - 350°C at a flux depth of about 25 mm.

Classifications

AWS	A5.17	ER-308, ER-308L, ER-309, ER-309L, ER-316, ER-316L ER-410, ER-420, ER-410NiMo, ER-430, ER-347
EN ISO	760	SA AFG 2 54 DC

Approvals

Qualification Tests	TÜV, UDT
Approvals	DB, Controlas

Packing Data

Pack Mass (kg)	**Item Number**
35,0	W124501

Main Constituents

SiO_2 + TiO_2	**Al_2O_3 + MnO**	**CaF_2**
10%	35%	50%
Basicity (Boniszewski)		1,8
Maximum Welding Current		800 A
Polarity		DC

Typical Chemical Analysis

	S19 9 L (308L)	**S19 9 Nb (347)**	**S19 12 3 L (316L)**	**S19 12 3 Nb (318)**	**S23 12 (309L)**
% Carbon	>0,04	>0,07	>0,04	>0,07	>0,04
% Chromium	>18,0	>18,0	>18,0	>18,0	>23,0
% Nickel	>9,0	>9,0	>10,0	>10,0	>12,0
% Molybdenum	-	-	>2,5	>2,5	-
% Niobium	-	>8 x C	-	>8 x C	-

Typical Mechanical Properties (All weld metal in the as welded condition)

	S19 9 L (308L)	**S19 9 Nb (347)**	**S19 12 3 L (316L)**	**S19 12 3 Nb (318)**	**S23 12 (309L)**
Tensile Strength	>510 MPa	>550 MPa	>510 MPa	>550 MPa	>510 MPa
0,2% Proof Stress	>320 MPa	>350 MPa	>320 MPa	>350 MPa	>320 MPa
% Elongation	>30	>25	>25	>25	>25
Impact Energy at +20°C	>75 J	>65 J	>75 J	>65 J	>65 J

Stainless Steel Wires for Flux Cored Welding

Afrox Coremax 308LP

Coremax 308LP is an all-position flux cored wire for welding 304, 304L and 321 type austenitic stainless steels. It has excellent weldability and slag detachment and provides good resistance to intergranular corrosion. Coremax 308LP can also be used as a buffer layer prior to hardfacing.

Classifications		
AWS	A5.22	E308LT1-4
EN ISO	17633-A	T 19 9 L P M 2
EN ISO	17633-B	TS 308L F M I

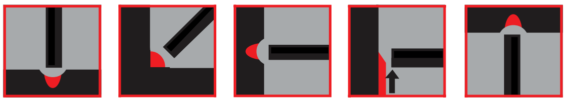
Typical Chemical Analysis			
% Carbon	0,029	**% Phosphorous**	0,025
% Manganese	1,63	**% Nickel**	9,93
% Silicon	0,56	**% Chromium**	19,5
% Sulphur	0,008	**% Molybdenum**	0,06

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	400 MPa
Tensile Strength	573 MPa
% Elongation on 5d	43
Charpy V-Notch at -196°C	31 J
Hardness	200 HV

Packing Data (DC+)					
Position	**Diameter (mm)**	**Current**		**Pack Mass (kg)**	**Item Number**
		Amps (A)	**Volts (V)**		
F, HV	1,2	140 - 220	23 - 33	15,0	W081141
UV, OH	1,2	120 - 200	24 - 30	15,0	

Recommended gas: Fluxshield®, but can be used with 100% CO$_2$

Afrox Coremax 309LP



Coremax 309LP is an all-position flux cored wire for welding 24% Cr, 13% Ni type austenitic stainless steels in the cast and wrought forms. It has excellent weldability and slag detachment and provides good resistance to intergranular corrosion. Coremax 309LP can also be used as a buffer layer prior to hardfacing and for joining 300 grade stainless steel to mild steels.

Classifications		
AWS	A5.22	E309LT1-4
EN ISO	17633-A	T 23 12 L P M 2
EN ISO	17633-B	TS 309L F M I

Typical Chemical Analysis			
% Carbon	0,026	**% Phosphorous**	0,024
% Manganese	1,51	**% Nickel**	12,78
% Silicon	0,55	**% Chromium**	24,07
% Sulphur	0,009	**% Molybdenum**	0,06

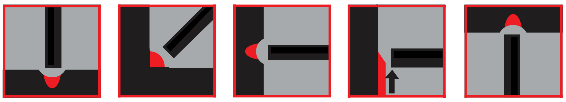
Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	450 MPa
Tensile Strength	568 MPa
% Elongation on 5d	40
Charpy V-Notch at -40°C	32 J
Hardness	205 HV

Packing Data (DC+)

Position	Diameter (mm)	Current		Pack Mass (kg)	Item Number
		Amps (A)	Volts (V)		
F, HV	1,2	130 - 220	23 - 33	15,0	W081142
VU, OH	1,2	130 - 180	24 - 30	15,0	

Recommended gas: Fluxshield®, but can be used with 100% CO$_2$

TIG Superoot 316L



TIG Superoot 316L is designed specifically for situations where it is impractical to apply back-purge for TIG root runs, or to gain the economic benefit of eliminating back-purge. The use of a 316L root bead is considered compatible with subsequent filling with 308L, 347 or 316L as appropriate.

Classifications		
AWS	A5.22	E316T1-5
EN ISO	17633-A	T 19 12 3 L R I 1 (nearest)
EN ISO	17633-B	TS 316L R I 1

Typical Chemical Analysis			
% Carbon	0,01	**% Nickel**	12,5
% Manganese	1,6	**% Molybdenum**	2,2
% Silicon	0,8	**% Chromium**	19,2
% Sulphur	0,005	**% Copper**	0,05
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	450 MPa
Tensile Strength	605 MPa
% Elongation on 4d	38

Packing Data (DC+)				
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
2,2	90	12	3,0	W078065

Suggested shielding gas: Argon

PROBLEM STEELS

Section 12 - Welding Consumables

Problem Steels 574

Welding of Problem Steels 575

Problem Steels Electrodes 576

Problem Steels MIG & TIG Wires 579

Problem Steels Flux Cored Wires 581

Welding of Problem Steels

Steels containing carbon in excess of 0,25%, chromium and molybdenum over 1,5% and manganese over 1,5% exhibit increased strength and hardenability and decreased weldability.

Additional elements such as vanadium, silicon, nickel, boron, niobium and titanium also influence hardenability and weldability. Steels of increased hardenability tend to form brittle microstructures in the heat affected zone, which may result in cracking. Steels featuring reduced weldability are commonly referred to as ‘problem steels’ as a result of the problem areas that are directly caused by shrinkage stresses, rapid cooling rates and the presence of hydrogen.

Electrodes for welding problem steels are chromium nickel austenitic types containing delta ferrite in the range of 10–80%. The weld metal is insensitive to hot cracking above 1 200°C. At ambient temperatures, the weld metal is strong and tough and is capable of withstanding heavy impact and shock loading in service.

Problem steels fall into two categories, i.e. ferritic types which require preheat and austenitic steels such as 11–14% manganese steels, which require minimum heat input.

When hardenable ferritic steel types are to be welded, reference should be made to the section on mild and medium tensile steels for the calculation of the carbon equivalent and preheat temperatures.

Problem steel electrodes are suitable for welding combinations of dissimilar steels such as chromium, molybdenum, creep resistant steels and stainless steels to mild and low alloy steels. Care should be taken when welding such combinations to ensure that excessive dilution between the base and weld metal does not occur.

The Welding of Dissimilar Steels

When welding dissimilar steels, a number of factors must be taken into account. For example:

- The weld metal must be capable of accepting dilution from both dissimilar base materials without forming crack-sensitive microstructures. These structures must remain stable at the desired operating temperatures.
- The mechanical properties of the weld metal should be superior to the weaker of the two base materials.
- The coefficients of expansion should preferably be between those of the base materials in order to reduce possible stress concentrations.
- The corrosion resistance of the weld metal should be superior to at least one of the base materials to avoid preferential attack of the weld metal.

In many instances, it is not possible to satisfy all of the foregoing points and a compromise has to be made. Afrox 309 and 312 problem steel electrodes have been specially designed to weld a large number of dissimilar materials such as stainless steels to carbon manganese steels and low alloy steels, and low alloy steels to 11–14% manganese steels, high carbon and tool steels, etc.

Calculation of Final Weld Metal Structures

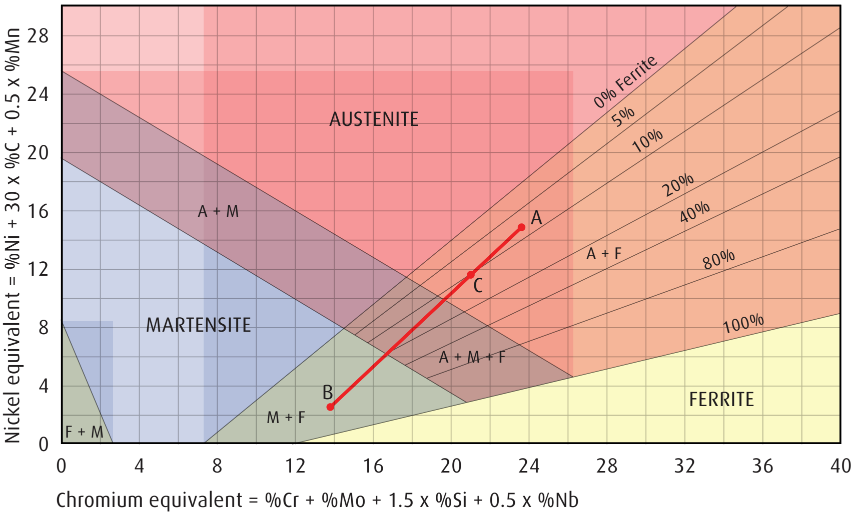
The final weld metal chemistry, and therefore properties, depend on the amount of dilution that occurs during welding.

Weld metal dilution is normally expressed as a percentage of the final weld metal composition, the effect depending on a number of factors such as the joint configuration, the welding technique and the welding process. With the manual metal arc process, dilution in the vicinity of ±25% can occur. This will obviously be greatest in the root pass and least in fill-in passes where two or more runs per layer are used.

The Schaeffler diagram is a useful tool, in that it allows us to determine, theoretically, the microstructures after dilution. This is illustrated by means of the following example:

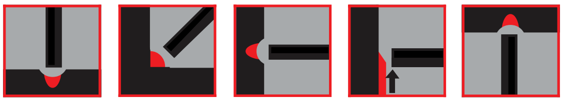
Suppose we want to weld 410 steel (13 Cr; 0,8 Mn; 0,5 Si and 0,08 C) with Afrox 309Mo (23 Cr; 12 Ni; 1,0 Mn; 0,5 Si and 0,03 C), and we assume 30% dilution (the base metal contributes 30% of the union and the electrode the other 70%).What is the composition of the resultant weld metal?

The 410 plate is represented by point B (Cr equivalent 13,75%; Ni equivalent 2,8%) and the Afrox 309 MoL electrode by point A (Cr equivalent 23,75%; Ni equivalent 14,5%). Any resultant weld metal from this mixture of A and B will be on the line that joins them. As we have assumed 30% dilution, point C will give the resultant microstructure (i.e. austenite with 10% ferrite). This weld is therefore possible without any danger of hot cracking.



Problem Steels Electrodes

Afrox 312



Afrox 312 is a rutile basic coated low carbon electrode of the 29% chromium, 9% nickel type. The structure is highly resistant to hot cracking and extremely tolerant of dilution from medium and high carbon steels, etc. Afrox 312 is a universal electrode specifically designed for welding steels of low weldability. The electrode is suitable for welding austenitic manganese steel, medium and high carbon hardenable steels, tools, dies, springs, etc. which may be of unknown composition.

Classifications		
AWS	A5.4	E312-16
EN ISO	3581-A	E29 9 R26
SANS	3581	E29 9 R26

Typical Chemical Analysis			
% Carbon	0,12 max	**% Nickel**	8,0 - 10,5
% Manganese	0,5 - 2,5 max	**% Molybdenum**	0,2 max
% Silicon	1,0 max	**% Sulphur**	0,025 max
% Chromium	28,0 - 32,0	**% Phosphorous**	0,025 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	600 MPa min
Tensile Strength	700 MPa
% Elongation on 4d	22 min
Charpy V-Notch at +20°C	30 J min

Packing Data

Diameter (mm)	Pack Mass (kg)	Item Number
2,5	1,0	W072682
3,25	1,0	W072683
2,5	sleeve	W072692
3,25	sleeve	W072693
2,5	4,0	W075692
3,25	4,0	W075693
4,0	4,0	W075694

Inox DW

Inox DW is an austenitic-ferritic electrode with approximately 50% ferrite content and is non-scaling to 1 100°C. The weld metal of Inox DW is highly crack resistant and is therefore suitable for difficult to weld steels and joining dissimilar materials, e.g. high alloy and unalloyed steels. It is also suitable as a stress compensating buffer layer on parent metals susceptible to cracking. Good all positional weldability. Unalloyed steels with C >0,25% should be preheated to 150-300°C depending on the carbon content and plate thickness. Note: Do not use for dissimilar joints in creep resisting applications.

Open Circuit Voltage

70 V min

Re-drying

Only dry electrodes should be used. Re-drying should be carried out at 300°C for 2 hours.

Classifications		
AWS	A5.4	E312-16
EN ISO	3581-A	E29 9 R12
EN ISO	3581-B	ES 312-16

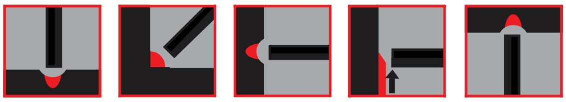
Typical Chemical Analysis			
% Carbon	0,12 max	**% Chromium**	29,0
% Manganese	1,0	**% Nickel**	9,0
% Silicon	0,9		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	>500 MPa
Tensile Strength	740 - 840 MPa
% Elongation on 5d	>22
Microstructure	Austenitic with approximately 50% delta ferrite

Packing Data

Diameter (mm)	Pack Mass (kg)	Item Number
2,5	5,0	W113082
4,0	5,0	W113084

Afrox 309Mo



Afrox 309Mo is a rutile basic coated low carbon electrode of the 23% chromium, 12% nickel and 2,5% molybdenum type. It is recommended for welding corrosion resistant CrNiMo steels to themselves and to mild and low alloy steels. The electrode is suitable for welding armour plate, austenitic manganese steel, medium and high carbon hardenable steels, tools, dies, springs, etc. which may be of unknown composition. Afrox 309Mo is also recommended for welding dissimilar steels such as stainless steels to carbon manganese or low alloy steels, and for welding austenitic manganese steel to carbon manganese and low alloy steels.

Classifications		
AWS	A5.4	E309Mo-16
EN ISO	3581-A	E23 12 2 L R26
EN ISO	3581-B	ES 309 Mo-16

Typical Chemical Analysis			
% Carbon	0,04 max	**% Nickel**	13,2
% Manganese	1,0	**% Molybdenum**	2,5
% Silicon	0,75	**% Sulphur**	0,015
% Chromium	22,5	**% Phosphorous**	0,03

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	560 MPa min
% Elongation on 4d	30 min
Charpy V-Notch at +20°C	50 J min
Charpy V-Notch at -70°C	30 J min

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (4 electrode sleeve)
2,5	300	50 - 90	3 x 4,0	W075792
3,25	350	70 - 130	3 x 4,0	W075793
4,0	350	100 - 170	3 x 4,0	W075794

Problem Steels MIG & TIG Wires

MIG 312

MIG 312 is used for welding medium and high carbon hardenable steels, of known or unknown specifications. Combination of high alloy and high ferrite content gives extreme tolerance to dilution on a wide range of hardenable and alloy steels with minimum or no preheat. Weld deposit work hardens and gives good wear and friction resistance. Not recommended for applications operating above 300°C or for welds to be post weld heat treated.

Materials to be Welded

Medium and high carbon hardenable steels, tool steels and free cutting steels.

Classifications		
AWS	A5.9	ER 312
EN ISO	14343-A	E29 9
EN ISO	14343-B	SS 312

Typical Chemical Analysis			
% Carbon	0,1	**% Chromium**	30,0
% Manganese	1,8	**% Nickel**	9,3
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	0,1
% Phosphorous	0,02		

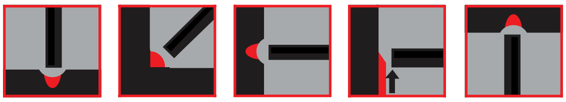
Typical Mechanical Properties (All weld metal)

	Argoshield® 5	**Stainshield® Plus**
Tensile Strength	813 MPa	789 MPa
0,2% Proof Stress	628 MPa	638 MPa
% Elongation on 4d	25	10
% Reduction of Area	31	10
Impact Energy +20°C	-	27 J
Hardness	270 HV	300 HV
Microstructure	Duplex austenite-ferrite microstructure with approximately 40% ferrite	

Packing Data
MIG (DC+)

Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,2	220	26	15,0	W033060

MIG/TIG 309LMo



MIG/TIG 309LMo is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are no comparable base materials.

Materials to be Welded

There are three main areas of application: buffer layers and clad steels, dissimilar joints and hardenable steels.

Classifications		
AWS	A5.9	ER309LMo (nearest)
EN ISO	14343-A	E23 12 2 L
EN ISO	14343-B	SS 309LMo

Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	22,0
% Manganese	1,7	**% Nickel**	14,5
% Silicon	0,5	**% Molybdenum**	2,7
% Sulphur	0,005	**% Copper**	0,2
% Phosphorous	0,015	**% Ferrite**	10,0

Typical Mechanical Properties (All weld metal) TIG	
0,2% Proof Stress	350 MPa min
Tensile Strength	550 MPa min
% Elongation on 5d	25 min
Charpy V-Notch at +20°C	>90 J min

Packing Data
MIG (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	220	26	15,0	W033048

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,0	100	12	5,0	W030430
2,4	100	12	5,0	W030431

Suggested gas for welding: Stainshield® (MIG), Argon (TIG)

Problem Steels Flux Cored Wires

Coremax 309LMo

Coremax 309LMo is a flux cored wire for welding under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are no comparable base metals. There are three main areas of application.

Buffer layer and clad steel: Overlays on CMn, mild steel or low alloy steels and for joining 316L clad plate. Subsequent layers are deposited with an electrode chosen to not match the cladding, e.g. 316L, 318. Also as a buffer layer prior to hard surfacing with chromium carbide type consumables.

Dissimilar joints: Tolerance to dilution is exploited in joining stainless types 410, 304L, 321 and 316L to mild and low alloy steels such as stiffeners, brackets and other attachments. Service temperatures above 300°C are normally avoided. For some of these applications, a more economic alternative may be suitable, e.g. 309L, 307.

Hardenable steels: The high level of alloying and ferrite level tolerates dilution from a wide range of alloyed and hardenable steels to give crack-free welds.

Classifications		
WS	A5.22	E309LMo T0-1
EN ISO	17633-A	T23 12 2 L P C 1
EN ISO	17633-B	TS309LMO-FMO

Typical Chemical Analysis			
% Carbon	0,025	**% Phosphorous**	0,023
% Manganese	1,5	**% Chromium**	22,93
% Silicon	0,57	**% Nickel**	12,7
% Sulphur	0,01	**% Molybdenum**	2,35

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	550 MPa
Tensile Strength	683 MPa
% Elongation on 5d	33
Charpy V-Notch at 0°C	39 J
Hardness HV	245
Microstructure	Austenite with ferrite in the range 10-30FN

Packing Data
MIG (DC+)

Position	Diameter (mm)	Current		Pack Mass (kg)	Item Number
		Amps (A)	Volts (V)		
F, HF	1,2	180	26	15,0	W081112

Suggested gas for welding: 100% CO_2. For CO_2

HARDFACING

Section 12 - Welding Consumables

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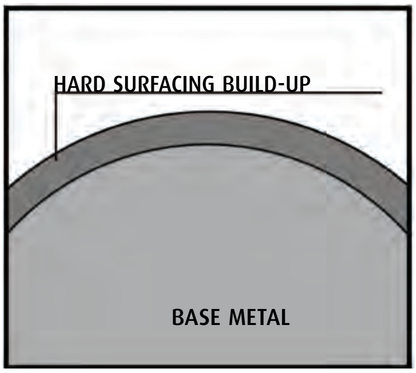
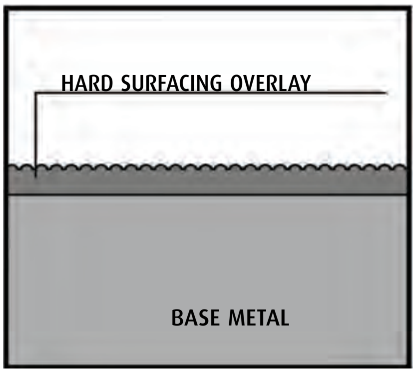
Hard Surfacing Definition

Hard surfacing is the deposition of a special alloy material on a metallic part, by various welding processes, to obtain more desirable wear properties and/or dimensions. The properties usually sought are greater resistance to wear from abrasion, impact, adhesion (metal-to-metal), heat, corrosion or any combination of these factors.

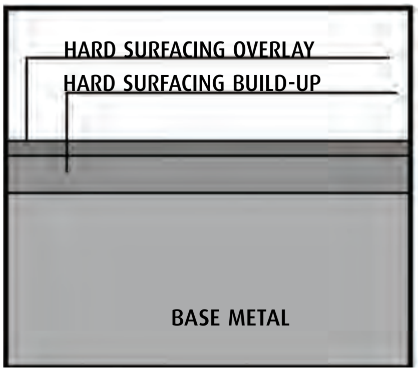
A wide range of surfacing alloys is available to fit the need of practically any metal part. Some alloys are very hard, others are softer with hard abrasion resistant particles dispersed throughout. Certain alloys are designed to build a part up to a required dimension, while others are designed to be a final overlay that protects the work surface.



Hard surfacing build-up can be used to return parts to their original dimensions



Hard surfacing overlay can be used by itself to give parts additional resistance to wear

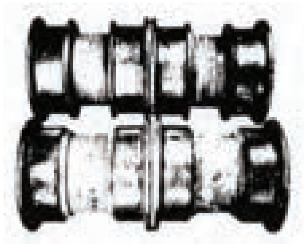


Hard surfacing build-up and overlay can be used together to rebuild parts to size and give them additional resistance to wear

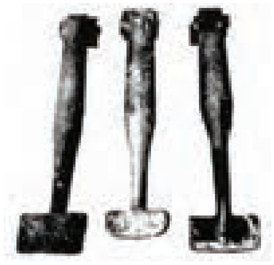
Reasons for Hardsurfacing

Companies use hard surfacing products to:

1. Reduce costs - Hard surfacing a worn metal part to like new condition is usually 25 - 75% of the cost of a replacement part.
2. Prolong equipment life - Surfacing extends life 30 - 300 times, depending upon application, as compared to that of a non-surfaced part.
3. Reduce downtime - Because parts last longer, fewer shutdowns are required to replace them.
4. Reduce inventory of spare parts - There is no need to keep numerous spare parts when worn parts can be rebuilt.



Worn track rollers rebuilt by submerged arc hardfacing



Work railway tampers can be rebuilt by using manual or open arc processes

Now, on the side of reclaiming the part!

Reclaiming by hardfacing can often be done at a fraction of the cost of a new part.

It gives independence from shortages of spare parts thus reducing inventory and administration costs as well as eliminating waiting time for replacement components - greater efficiency.

Parts reclaimed by hardfacing are often better than new ones, just as a hardfaced component lasts from between two to twenty times longer than one that is not.

An added bonus of reclaiming by hardfacing is that in many cases the part can be rebuilt on site without the need for completely or even partly dismantling the machine.

Hardfacing worn components can save thousands of rands in maintenance costs.

Uses for Hardsurfacing

There are basically two main areas where hard surfacing is used:

1. To reclaim worn parts:

There is no known total solution to metal wear. Hence the stage must be reached when all components subject to wear will reach the limit of their useful life.

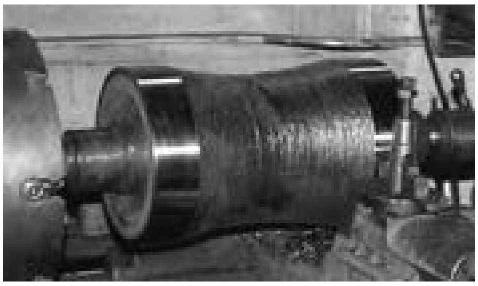
There are two avenues open to the plant engineer. Does he replace the part or does he reclaim it? To replace the part he must have it in stock or try to obtain a new one. The part may be expensive and if it requires frequent replacement a number must be kept on hand. This adds to the inventory costs and administration expenses of the business, aside from the actual cost of the replacement part.

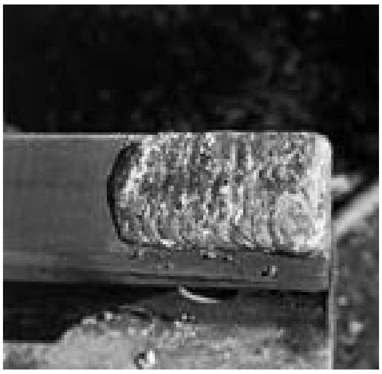
In many cases, the part may be imported or not held in stock by the appropriate agents. Long delays can be involved - this means downtime of equipment and lost production.

Then what of the quality of the replacement part? Will it last as well as is desired? Will it fit directly into the machine or will it require machining? Will adaptors have to be made or purchased so that it can be fitted to existing equipment?

2. The protection of new metal parts against the loss of metal.

Hard surfacing overlay is used on both new and/or original equipment where the part is most susceptible to wear. The higher alloy overlay offers much better wear resistance than that of the original base material. This usually increases the work life of the component up to two or more times that of a part which is not surfaced. Although the added hard surfacing material may add to the price of the equipment, usually a less expensive base material may be used.


Build-up. Steel mill roll rebuilt to original dimensions - it is being machined prior to service


Build-up. Worn rail end rebuilt past original dimensions - it will be ground prior to service


Overlay. Bucket lip hard surfaced as preventive maintenance


Overlay. Replacement dragline bucket tooth hard surfaced as new equipment

Choosing the Hardfacing Process

Nature of Work to be Hardfaced
Hardfacing can be applied by a number of welding processes. In most cases, the equipment is identical or similar to that used for structural welding.

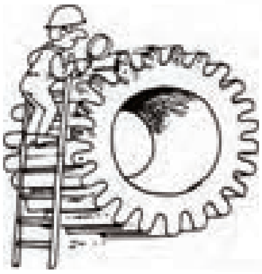
Selection of the most suitable welding process for a given job will depend on a number of factors including:

Function of the component:
i.e. What type of hardfacing alloy is required; some processes are limited to certain alloy types.

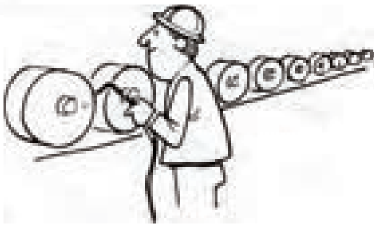
Base metal composition:
Different processes may have different heat inputs which render them unsuitable for certain base metal types, e.g. manganese steels require low heat input and so gas hardfacing would not be suitable.

Size and shape:
Surfacing large areas with gas or manual arc may often prove uneconomical. Parts of irregular shape may not be suitable for automatic applications.

Accessibility:
It may not always be possible to manipulate heavy automatic equipment into areas where work must be done. Also, out-of-position welding will limit the choice of processes.



State of repair:
Large badly worn components requiring heavy rebuilding would be best suited to processes with high deposition rates.



Number:
If a large number of the same or similar items are to be hardfaced, an automatic process would be most suited.

Processes Used in Hardfacing

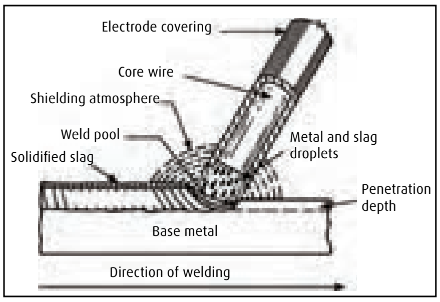
Shielded Metal Arc Welding (Covered Electrode)

Advantages

- Alloy availability - most hard surfacing alloys are available as covered electrodes
- Material thickness - within certain practical and economic limitations, most parts can be welded with the SMAW process
- Welding position - hard surfacing covered electrodes are available for out-of-position work
- Versatility - covered electrodes are capable of being used outdoors and in remote locations.

Disadvantages

- Dilution - two or three layers are needed to obtain maximum wear properties
- Low efficiency/deposition - stub loss and deposition of 0,5 - 3 kg/hr.



Shielded Metal Arc Welding (SMAW)

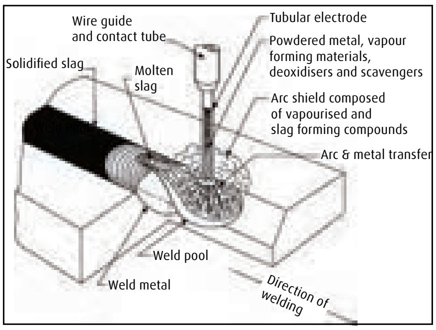
Flux Cored Arc Welding

Advantages

- Alloy availability - almost as many alloys available as SMAW, with the ability to customise alloys easily if the demand requires
- High deposition - rates ranging from 1,8 - 11,3 kg/hr
- Deposit integrity - good recovery of elements across the arc
- Easy to operate - minimal time is required to train an operator
- Versatility - not as versatile as covered electrodes, but capable of being used outdoors and in remote locations due to open arc operation.

Disadvantages

- Dilution - two or three layers are needed to obtain maximum wear properties
- Welding position - although some wires have out-of-position capabilities, most are designed for flat and horizontal applications.



Open Arc Flux Cored Arc Welding (FCAW)

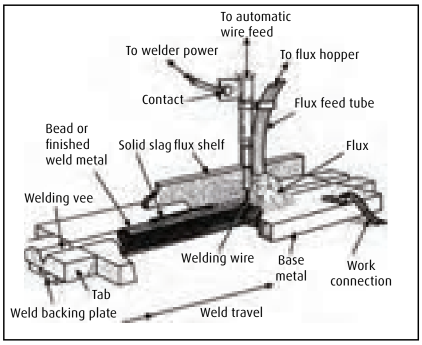
Submerged Arc Welding

Advantages

- Easily automated - process lends itself to automatic application
- High deposition - more economical to rebuild large worn parts
- Operator skill - little skill is needed and training is minimal
- Weld deposit - produces smooth, clean and sound weld deposits
- Shop environment - no flashes since flux surrounds the arc.

Disadvantages

- Alloy availability - limited to certain alloys that are commonly used for submerged arc rebuilding
- Welding position - limited to flat position because of the flux shielding - usually limited to cylindrical parts
- Material thickness - sub arc hard surfacing limited to larger parts that lend themselves to automatic application
- Extremely high dilution - multiple layers are needed for maximum wear properties
- High heat input - can distort parts
- Versatility - limited to shop applications due to automatic equipment required
- Flux required - additional expense and special welding equipment required.



Submerged Arc Welding (SAW)

Welding Process Dilution Factors

Oxy-Acetylene	0 - 5	% Dilution
TIG Welding	5 - 15	% Dilution
Covered Electrode	20 - 45	% Dilution
Flux Cored Wire	20 - 45	% Dilution
Submerged Arc	25 - 50	% Dilution

For further information regarding dilution and its effect on wear resistance of hard surfacing deposits, see page 591.

Gas Hardfacing

Rod Deposition

This process uses alloyed hardfacing rods which may be cast, wrought or powder filled tubes. Standard gas welding equipment is used.

Advantages

- Low dilution of deposit
- Good control of deposit shape
- Low thermal shock due to slow heating and cooling.

Disadvantages

- Low deposition rates
- High heat input
- Not suited to large components.

Powder Spraying

Flame Spraying

This process involves spraying alloys in powder form onto the base component. The sprayed powder may then be fused to produce a strong bond and a dense, porous-free deposit.

Equipment used can be either hand held spraying torches or sophisticated metallising guns for more specialised applications.

Advantages

- Precise control over deposit thickness and shape
- Negligible dilution of deposit
- Easy to use
- Suitable for automation
- Wide choice of coating materials available.

Disadvantages

- High heat input with fused coatings.

High Velocity Oxy-Fuel Process (HVOF)

This process is similar to flame spraying except that the pressures used for the gas stream are much higher thus increasing the velocity of the gas leaving the nozzle. This allows for higher deposition rates than flame spraying.

Advantages

- Precise control over deposit thickness and shape
- Negligible dilution of deposit
- Suitable for automation
- Wide choice of coating materials available.

Disadvantages

- Relatively high cost of equipment
- Limited mobility.

Electric Arc Spraying

In arc spraying, a DC electric current is struck between two continuously fed consumable wires that make up the coating material.

A compressed gas is then injected through a nozzle atomising the molten wire and projecting it onto the workpieces.

Advantages

- High deposition rates
- Negligible dilution of deposit
- Suitable for automation
- Precise control over deposit thickness and shape.

Disadvantages

- Limited mobility
- Relatively high cost of equipment
- Limited to consumables which will conduct current
- Exposed electric arc.

Plasma Transferred Arc (PTA)

In plasma spraying, a DC electric current is used to generate a stream of ionised gas at high temperature. This ionised gas or plasma is the heat source, which then conducts the coating material, which is introduced into the plasma stream in the form of a powder onto the workpiece.

Advantages

- Negligible dilution of deposit
- Suitable for automation
- Precise control over deposit thickness and shape
- High melting point materials can be used.

Disadvantages

- Limited mobility
- Relatively high cost of equipment
- Oxidation of the spray material may occur.

General Hardfacing Data

Weldability of Steels and Irons

Hardfacing can be applied successfully to a wide variety of base metal types. As with structural or repair welding, different types of base metals may require some adjustments to be made to standard welding practice. The following section discusses the various requirements of the different types of base metals. If in doubt about what type of metal a particular item is made from, refer to page 604. 'Identification of Metals' will prove helpful.

Mild Steel and Low Alloy Steels

This group of materials include plain carbon steels containing up to 0,3 carbon as well as the low alloy types which may include small amounts of elements such as manganese and chromium. Most of these alloys can be found in either wrought (rolled, forged, etc.) or cast form. In general, these steels can be welded without any special precautions, but for large sections or thicknesses over about 20 mm, a preheat of about 100°C will help to reduce any risk of stress cracking.

Hardenable Carbon and Alloy Steels

This group includes carbon steels with over 0,3 carbon as well as the alloy steels used for items such as cutting knives, dozer blades, certain bucket teeth, etc. It is always advisable to give steels in this group a preheat of 150 - 200°C before welding and then to allow the part to cool slowly under some form of insulation such as lime when the hardfacing is completed. Whenever possible, the preheat temperature should be maintained during the hardfacing operation. Under such circumstances, it is advantageous to perform all the welding required on an individual component in a short space of time without undue interruptions. Buffer layers may also be required on these steels for certain service conditions.

Tool Steels

Tool and die steels are often very susceptible to hot zone cracking due to the formation of untempered martensite during the hardfacing operation. To offset this, it is necessary to use a high preheat temperature, in the order of 500°C, and to maintain this temperature throughout the welding operation. Immediately after hardfacing, the part should be cooled very slowly by covering well with a good insulator such as dry powdered lime or vermiculite, or alternatively the part can be slowly cooled in a furnace.

Austenitic Stainless Steels

These materials can be hardfaced without any preheat but it is desirable to limit hardfacing to the weldable grades of stainless steels especially if the component is for use in corrosive environments. These grades either contain stabilisers such as titanium or are made with very low carbon contents. Austenitic stainless steels are more likely to suffer from distortion than are other types of steel and as such, it is desirable to keep heat input as low as practical during hardfacing.

Plain Chromium Stainless Steels

These can be either the hardenable martensitic types or the soft ferritic grades. Both can be hardfaced successfully. For the hard types, a preheat of about 400°C should be used followed by slow cooling under insulation after hardfacing. The soft ferritic types require no preheat and heat input should be kept to a minimum during hardfacing to avoid excessive grain growth and consequent strength reductions.

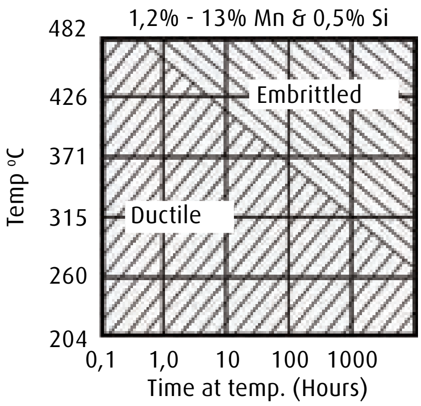
Austenitic Manganese Steels

These steels, which contain 11 to 14% manganese, are very tough and strong with excellent resistance to impact. In fact, they have the ability to work harder under load which makes them very suitable for use in crushing equipment. They are almost inevitably encountered in the form of castings which will be non-magnetic or very feebly magnetic even after prolonged use.

Austenitic manganese steels should not be preheated except in very cold climates, when a warming to about 50°C may be used.

To avoid the possibility of forming brittle phases in the weld zone, heat input must be kept to an absolute minimum. Components made from 11-14% manganese steel should be kept cool during hardfacing either by immersing all but the working area in water or by welding intermittently. Frequent hosing with water is advisable where there is a danger of the weld zone exceeding a temperature of 300°C for any appreciable amount of time. Also, low amperages should always be used. The embrittlement of manganese steels is a time/temperature reaction (see overleaf). Higher carbon and lower manganese accelerates this reaction.

Manganese steels should never be hardfaced by gas flame processes due to the high heat input.



Grey Cast Iron

There are two techniques used for hardfacing cast iron. The first involves preheating to about 500°C under which circumstances large areas can be rebuilt or hardfaced with little risk of cracking. Cooling after welding should be slow and some form of insulation cover is generally used. Rebuilding or crack repair is best performed using a pure or high nickel electrode such as Ferroloid 4 and Ferroloid 3 or a low hydrogen mild steel electrode such as Afrox 7018-1. Similarly, gas processes may be used such as powder spraying.

The second technique is often used on large items which are not practical to preheat. It involves using the high alloy hardfacing electrodes which produce a high incidence of relief checks. High travel speeds and low currents are normally used to promote as much relief checking as is practical. The relief checks so produced reduce stresses in the weld area and ensure a sound overall job.

Note that for repair welding without preheat, Ferroloid 4 is recommended as the most appropriate electrode.

Ni-Hard Cast Irons

These are among the most difficult of materials to hardface, but a good degree of success has been achieved using the following procedure.

Firstly, the entire casting must be preheated to a dull red and this temperature must be maintained throughout the entire welding operation.

The area to be hardfaced must then be completely overlayed with pure nickel electrodes or nickel wire for gas shielded or sub arc welding.

Hardfacing is then applied over the top of the nickel using any hardfacing electrode suitable for the service conditions of the component.

After welding, the casting must be cooled very slowly from red heat under a cover of insulating material or in a furnace.

White Cast Iron

Hardfacing of white cast iron is not recommended.

Preparation for Hardfacing

Surface Condition

The first requirement is that the workpiece be clean and free of rust or heat scale. Wire brushing, grinding and/or solvent washing may be required to remove dirt, grease, rust, etc. The degree of cleanliness required is greater when gas hardfacing is to be used and for this process the job should always be dressed back to clean, shiny base metal.

A sound base is required and this may necessitate removing fatigued or rolled-over metal, high ridges, or other major surface irregularities. This may be done by grinding, machining or arc gouging.

Cracks in the base metal should be arc gouged or ground out and repaired using compatible electrodes.

When building up edges of cutting tools, dies, etc., a recess is required to provide adequate support for the hardfacing material.

Job Positioning

Wherever possible, the job should be positioned so that hardfacing can be performed in the downhand position (workpiece horizontal). An uphill inclination of about 10° can sometimes be of assistance in laying down heavier weld passes.

If work must be done out of position, detailed attention will have to be given to selecting suitable consumables and welding processes.

Preheating

The effect of preheating reduces the tendency to:

1. Develop cracks. Moisture may be brought into the molten weld metal by electrode coatings or fluxes. The hydrogen that is created from the moisture increases the chance of weld or heat affected zone cracking. Preheating slows down the cooling rate which allows the hydrogen to escape.
2. Develop shrinkage stresses. Molten weld metal contracts while it cools, which causes stress to build up between the contracting weld metal and the cooler base metal. This can cause cracking during or after welding. By preheating the base metal, the temperature differential between the base metal and the weld metal is reduced. This will diminish the susceptibility to cracking.
3. Develop porosity. Again, hydrogen is the culprit. Moisture can be present on a non-preheated surface. During welding, hydrogen can be trapped in the weld metal and can cause porosity as it solidifies. Preheating will eliminate moisture on a base material.
4. Develop hard zone adjacent to welds. Some alloy steels have a tendency to become hard and crack in the heat affected zone due to the fast cooling rates during welding. Preheating slows the cooling rate and provides a more ductile microstructure.
5. Develop distortion. As weld metal cools, it contracts and develops stresses between the weld metal and the cooler base metal. The base metal then can become permanently distorted. Preheating can help minimise distortion by reducing the temperature differential between the base metal and the weld metal.

How are preheat temperatures determined?

Base material chemistry must be known before an accurate preheat temperature can be selected. The carbon content and alloy content of the base metal are two major factors that affect preheat temperatures.

Normally, the higher the carbon content and/or the higher the alloy content, the higher the preheating temperature. During welding, the interpass temperature should be the same as the preheat temperature.

Another major factor in determining preheat temperatures is the base metal thickness. As the base metal increases in thickness, a higher preheat temperature is needed.

When preheating, a soaking preheat is required to bring the entire component to the given preheat temperature. Usually all components that are preheated should be slow cooled.

The Use of Buffer Layers

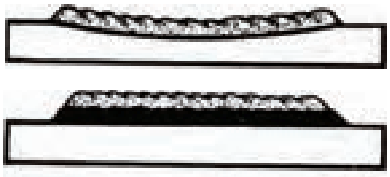
The term buffer is used to describe the presence of an intermediate deposit laid between the base metal and the actual hardfacing weld material.

There are a number of cases where this practice is necessary.

1. Hardfacing on soft material for high load service.

When the ‘harder’ hardfacing materials are used on a soft base material, e.g. mild steel, there will be a tendency for the hardfacing layer to sink in under high load condition. This may result in spalling off of the hardfacing material under extreme conditions.

To overcome this, a layer of strong, tough material is deposited on the workpiece prior to hardfacing. Suitable buffering materials for such work would be Afrox 300 or Afrox 312, Tube Alloy AP-O, Tube Alloy Build-Up-O and Corewear 31-S.

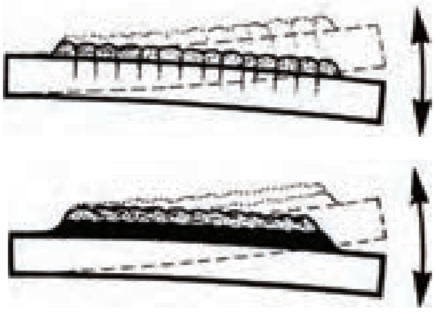


2. Hardfacing on components subject to heavy impact or flexing.

Many hardfacing deposits contain ‘relief checks’.

When a component is subject to heavy impact or flexing, there is the risk that even deposits which do not relief check during welding will develop fine transverse cracks. These are not detrimental to the hardfacing but there is a danger that under such service conditions, the cracks will act as stress concentrators and progress through into the base metal. This tendency is most pronounced where the base metal is a high strength steel.

The use of a suitable buffer layer between the base and hardfacing deposit will prevent this crack propagation from occurring. Suitable materials for this work are Afrox 312, or for use on alloy steel base metals, a low hydrogen electrode such as Afrox 7018-1 will prove reliable.



3. Hardfacing over partly worn hardfacing.

It frequently happens that components which have previously been hardfaced have worn through in certain areas and some of the original hardfacing material is still remaining.

In many cases, it is possible to re-apply hardfacing deposits directly over this existing material, especially types suitable for multi-layering and if it has not been fractured by heavy impact. If this is not so, it is necessary to take some action to prevent subsequently applied hardfacing material from ‘spalling off’.

The best technique is to gouge out the remaining doubtful hardfacing material. If however, it is impractical to do this, a buffer layer of Afrox 312 or Afrox 7018-1 between the two deposits will secure the existing hardfacing and produce a very tough base metal for the final hardfacing layers.

Controlling Distortion

Distortion is present to some degree in all welding and in many cases it is not severe enough to be of any consequence. There are, however, a number of instances where it can cause problems in hardfacing, especially on thin base metal sections.

Distortion is caused by two prime factors:

1. Contraction of the weld metal during cooling from the molten state to ambient temperature.

Molten metal contracts or shrinks approximately 11% in volume on cooling to room temperature. In hardfacing, the molten weld metal bonds to the parent metal and during its shrinkage tends to pull it in an arc along the direction of the weld run.

2. Different rates of expansion and contraction between the metal adjacent to and at a distance from the weld.

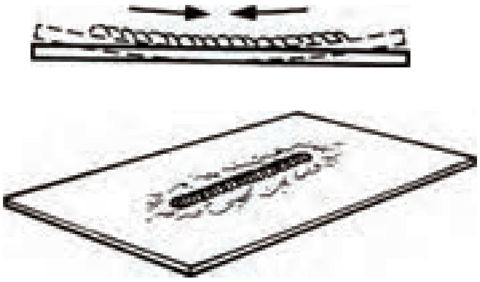
This problem is most accentuated in very thin base metal thicknesses. The metal close to the weld zone becomes very hot and starts to expand. Being restrained by the cold hard metal further out from the weld zone, it could only move by pushing out or buckling the plastic area around the weld. Once sufficient movement has taken place, it cannot be fully reversed during the cooling cycle and the job may remain permanently distorted.

There are a number of ways distortion can be controlled or at least kept to a minimum during hardfacing.

1. Using hardfacing alloys that relief check.

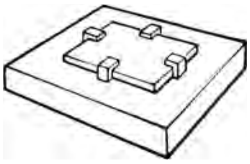
Many of the high alloy hardfacing materials relief check on cooling. This means that small cracks are formed across the weld bead so as to break up and reduce the amount of stress or pull that the cooling weld metal exerts on the base material.

These relief checks are in the vast majority of cases not detrimental to the performance of the hardfacing deposit and do not cause spalling and flaking. Relief checking tendency is increased by low welding currents and high travel speeds.



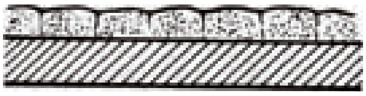
2. By restraining of parts.

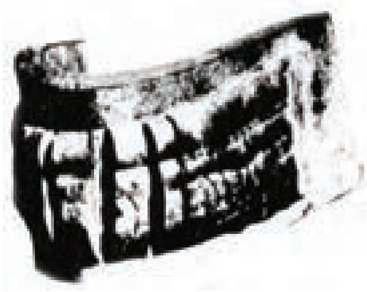
In many cases distortion, especially of the first type discussed, can be overcome by restraining the part so that it is not free to move. This can be done by clamping or tack welding the part to a firm support. For flat items such as crusher jaws, etc. two parts can be clamped or tack welded back to back and hardfacing applied to each alternately.



3. By presetting.

By presetting or prebending the part in the opposite direction to that which it would distort, the welding will tend to pull it back to its original form. The amount and actual nature of the presetting required for a given job will be best established by experience.



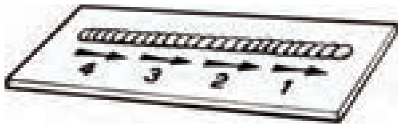


4. By preheating.

By slowing down the cooling rate and thus the rate at which hot metal contracts, preheating can sometimes be used to reduce distortion. This is because it allows more time for stresses to become equalised in areas immediately adjacent to the weld rather than distorting the overall job.

5. By correct welding sequence.

The use of intermittent welding techniques such as back stepping can help greatly in reducing distortion on flat items such as bulldozer and grader blades.



Also as mentioned earlier, if two items are fixed back to back and the hardfacing performed alternately on each, the distortion is minimised. This technique is often used on crusher jaws and other large flat items.

NOTE: When hardfacing long thin components such as guillotine blades, there is a strong likelihood that there will be some shrinkage of the base metal which will result in the blade becoming shorter. This can be largely overcome by restraining the blade but even so, it is advisable to make some allowance for shrinkage when cutting material for new blades.

Controlling Deposit Dilution

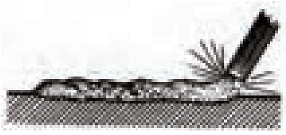
Deposit dilution occurs when base metal, melted by the electric arc, or gas flame mixes with the molten weld metal during hardfacing.

Dilution is defined as the change in chemical composition of a welding filler metal caused by the admixture of the base metal or previous weld metal in the weld bead. It is measured as the ratio between the base metal to the filler metal in the weld deposit (Fig. 1). That means the dilution percentage is the amount of base metal (or previous weld metal) that ends up in weld deposit.

Its prime effect is to reduce the alloy content of the hardfacing deposit and so adversely affect its wear or corrosion resistance. The amount of influence a given percentage of dilution will have on the properties of a hardfacing deposit depends largely on the chemistry of the base material.

The degree of deposit dilution experienced is a function of the welding process and conditions. In general, it can be stated that for arc welding higher currents and higher arc volts lead to higher dilution rates.

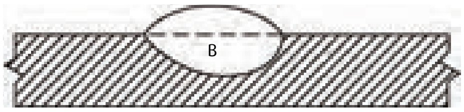
When joining two metals, the strength of the joint is determined by the amount of penetration or dilution. In hard surfacing, there is no need for high penetration, as only a bond between the weld deposit and base metal is required. Since the chemical composition and properties of hard surfacing overlays are usually quite different from the base metal, too much dilution can be detrimental. Hard surfacing overlay alloys are carefully formulated to furnish specific wear characteristics in the minimum amount of welding passes so, as dilution increases, the wear characteristics decrease.



Factors other than the welding process that influence dilution:

- Welding speed. The slower the welding speed, the higher the dilution rate.
- Preheat temperatures. Higher preheats give higher deposit dilution. Keep preheat temperatures within recommended ranges
- Welding current. The higher the current, the higher the dilution
- Welding position. In order of decreasing dilution: vertical-up (highest dilution), horizontal, uphill, flat, downhill (lowest)
- Welding technique. Greater width of electrode oscillation increases dilution. Stringer beads give minimum dilution. Greater overlap of previous bead also reduces dilution
- Number of layers. As more layers are deposited, the dilution decreases
- Electrode extension. Longer electrode extension decreases dilution (for wire processes).

Fig. 1

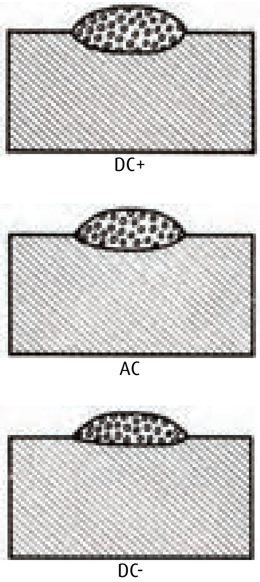


$$\% \text{ DILUTION} = \frac{B}{A + B} \text{ X } 100$$

The type of welding current and polarity used will also affect dilution. Greatest dilution is encountered using DC positive (DC+); AC has an intermediate effect and DC negative (DC-) gives lowest dilution.

Gas rod hardfacing and powder spray processes have by far the lowest dilution rates due to only very limited melting of the base metal during deposition.

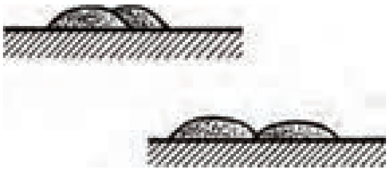
Fig. 2



Schematic representation of dilution effects resulting from different welding polarities

Hardfacing Deposit Patterns

Hardfacing deposits will generally be applied in one of three patterns. These are continuous cover, stringer beads or individual dots. The selection of which type of deposit is best suited will depend on a number of factors including function of the component, service conditions and state of repair.



Continuous Coverage

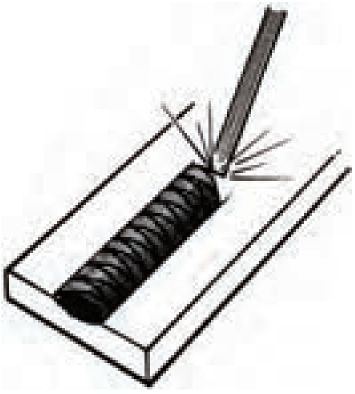
This will generally be used for rebuilding and hardfacing parts that have critical size or shape, such as rolls, shafts, tracks, crusher jaws and cones.

Continuous cover is often required on parts subject to high degrees of fine abrasion or erosion. Typical examples would be pump and fan impellers, sand chutes, valve seats, dredge bucket lips and pug mill augers.

Care should be taken that sufficient overlapping of weld runs is allowed to ensure adequate coverage of the surface being treated. For protection against fine abrasion or erosion, it is desirable to have the weld runs at right angles to the direction of travel of the abrasive material.

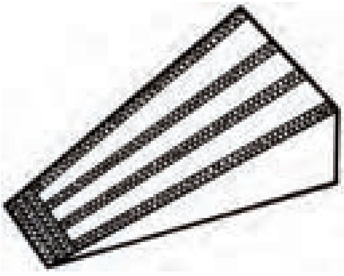
Stringer Beads

Stringer beads are often used when it is not necessary to completely cover the base material. Typical examples would be dragline buckets and teeth, ripper teeth, rock chutes, etc. When depositing stringer beads, a weave technique is often used depending on requirements and base metal type.

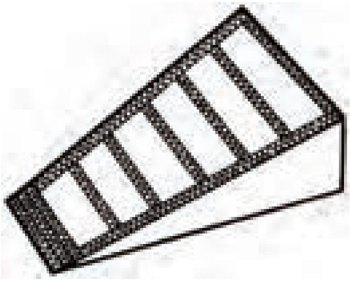


There are a number of ways that stringer bead hardfacing can be applied depending on the working conditions of the component. This is best illustrated by considering the three following patterns as applied to ripper teeth.

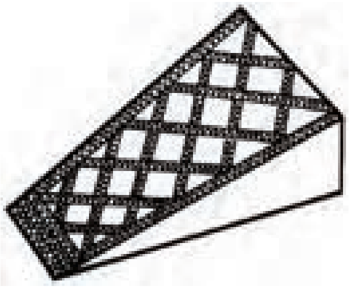
For teeth working in coarse rocky conditions, it is desirable to deposit the stringer beads so that they run parallel to the path of the material being handled. This causes the large lumps of rock, etc. to ride along the top of the hardfacing beads without coming in contact with the base metal.



For teeth working in fine sandy conditions, the stringer beads will be placed at right angles to the direction of travel. This permits the fine material to compact in the intermediate spaces and provide protection to the base material.



Most earth-moving equipment is required to operate under conditions where there will be a mixture of coarse and fine abrasive material contacting the surface. For this type of service, a combination pattern known as a 'checker' or 'waffle' pattern is generally used.



Dot Pattern

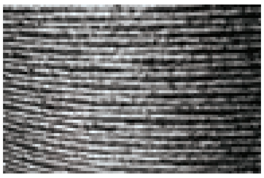
For less critical wear areas such as along the rear of buckets and shovels, etc. a dot pattern is often used. This is done by depositing the hardfacing alloy in small dots (15 - 20 mm dia. x 10 mm high) at about 50 mm centres over the surface. Also useful on large manganese castings to keep down heat input. Whilst not as effective as a 'waffle' pattern, it does allow fine material to compact between the dots whilst the high spots offer protection against large lumps or rocks.

Surface Finish

Will the deposit be machined? Ground? Flame cut? Must the component be heat treated? Are relief checks acceptable? These questions should be answered before an alloy is selected.

Hard surfacing usually produces the finished surface of a component. If a smooth surface is required for the intended service, the possibility and economics of grinding or machining must be taken into account. Some alloys can be heat treated to soften them enough for machining and then heat treated back to a hardness suitable for maximum service life. Some applications, like rock crushing, may intentionally lack smoothness to aid in gripping incoming material.

In the carbide family of hard surfacing alloys, some alloys are by design crack sensitive and will develop stress relieving checks or cracks in the weld deposit as it cools (see photo below). These cracks are necessary to prevent spalling and do not weaken or affect the wear characteristics of the alloy. Usually, the lower the percentage of carbides in an alloy, the less likely relief cracks will occur. But the lower the carbide percentage in the alloy, the lower the abrasion resistance.



Stress relief cracks in a high chrome carbide overlay

Since hard surfacing alloys range from easily machinable to difficult to grind, the required finish must be determined prior to choosing an alloy. Often some sacrifice in wear resistance must be made to be able to achieve the required surface finish. Check specific product specifications to make sure the required finish is achievable.

Applying Hardfacing Materials

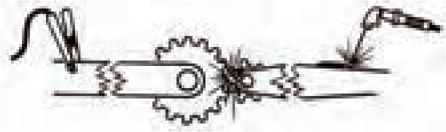
Electric Arc Hardfacing

As discussed earlier, there are a number of electric arc welding processes applicable to hardfacing. These are manual arc, semi-automatic and fully automatic open arc and submerged arc.

One important fact to remember when arc hardfacing by any of the above processes is the positioning of the work return lead. Arc welding requires a complete electrical circuit whereby the welding current can flow from the power source, across the arc and back to the power source again.

When hardfacing is to be performed on any machinery, the work return lead must be contacted as directly as possible onto the actual area being welded. If this is not done, there is a grave risk of arcing or electrical interference in other parts of the machinery which can cause extensive damage.

Take for example a bulldozer blade which is being hardfaced while still on the tractor. If the work return lead were clamped to the track instead of directly on the blade, the welding current may travel through bearings, rolls, transmission and other parts of the machine including generators and control equipment. By secondary arcing in these areas, a great deal of damage can be done to the machinery.



Manual Arc Hardfacing

The lowest welding current that will give good arc stability should be used for depositing hardfacing electrodes. Excessively high amperages result in deep penetration and undue dilution of the deposit. For higher deposition rates or heavier deposit thickness, it is always advisable to go to a larger size electrode rather than just increase welding current.

Recommended amperage usages for each electrode are printed on the electrode packets.

It is acceptable practice to apply hardfacing electrodes using a weave of three to four times the diameter of the electrode for downhand welding. For vertical welding, this may be increased to even double these limits but it should be noted that only a limited number of hardfacing electrodes are suitable for out of position welding.

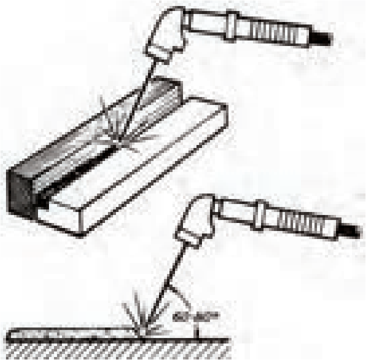
Reducing the rate of forward travel between weaves increases the deposit thickness. The width of the weave should be reduced to one or two times the diameter of the electrode and travel speed increased when heat input is to be kept to a minimum or when a high degree of relief checking is required. Typical examples would be hardfacing the 11-14% manganese steels or hardfacing grey cast iron without the use of preheating.

Some electrodes are not recommended for multi-layer applications due to a tendency of such deposits to spall or flake.

For building up the edge of a component such as a shear or guillotine blade, a strip of copper or carbon block may be placed along the working edge. This chills the slag and weld metal giving a good contour to the weld deposit.

For most hardfacing, the electrode should be held at an angle of between 60 - 80° to the workpiece. This will give good deposit shape and allow adequate control of the molten metal.

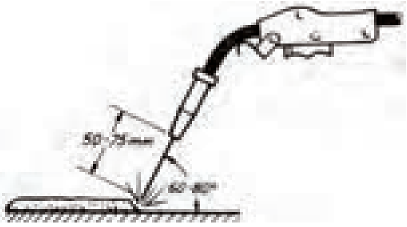
It should be remembered that most hardfacing electrodes run in a somewhat different manner to structural welding types. All tubular hardfacing electrodes have a globular type transfer which helps minimise deposit dilution. Also, most of the higher alloy types do not give a complete slag cover over the weld. In many such cases, it is possible to do multi-layer work without removing slag residues from previous runs.



Semi-Automatic Open Arc Hardfacing

Most of the details regarding welding currents, weave techniques, etc. as discussed for manual arc welding apply to this process.

In general, comparatively high amperages are used for open arc welding and accordingly heat input rate is higher than for manual arc welding. For this reason it is necessary to use high travel speeds with very little or no weave when heat input is to be kept low. For work on small 11 - 14% manganese steel components, where there is not sufficient base metal section to give rapid heat dissipation, frequent water spraying is recommended.



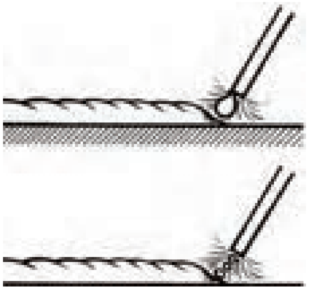
12-60 mm

For most work, a 12 - 60 mm wire stick out depending on wire size should be used. The wire should be kept at an angle of 60 - 80° from the workpieces and the shortest arc length consistent with stable arc conditions used. Open arc welding is not considered to be very suitable for out of position welding and for this reason, all work should be done downhand where possible.

Care should be taken that wire drive rolls are set to the correct tension so as to provide positive drive but not so tight that they may deform the wire. All conduits from the drive rolls to the gun should be kept as straight as possible with no twists, coils or kinks which would interfere with the wire feed. Contact tips, etc. should be kept clean and free from excessive build-up.

Many open arc hardfacing wires give a distinctly globular type transfer when used within the specified welding conditions. This is normal and desirable. Increasing current or voltage to try to achieve a spray type transfer similar to that of MIG welding is not advisable as excessive dilution of the deposit will occur and result in reduced wear resistance.

Most of the higher alloy tubular wires give incomplete slag cover of the weld. This is normal and it is often possible to do multi-layer work without removing residue from previous passes.



Automatic Open Arc Hardfacing

This process is almost identical to the semi-automatic open arc type except that the welding torch is mounted on a fixture to allow mechanical control.

The welding gun, which may be somewhat different in construction to those used for the semi-automatic process, may be either fixed, with the work mechanically driven under it, controlled to move over a stationary workpiece, or a combination of both of these.

In most cases, the unit will be set up so as to give an angle of about 75° between the wire and the job.

Automatic Submerged Arc Hardfacing

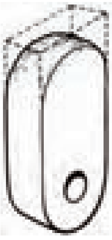
In submerged arc hardfacing the electric arc travels across the gap between the wire and the job under a cover of granulated flux.

The alloy additions necessary for a hard deposit may come either from the welding wire in which case a neutral shielding flux would be used or alternatively a mild steel filler wire is used and the alloys are introduced by way of a specially formulated flux. When using alloyed wire and a neutral flux, the deposit characteristics in terms of hardness and wear resistance are not greatly influenced by minor variations in welding conditions.

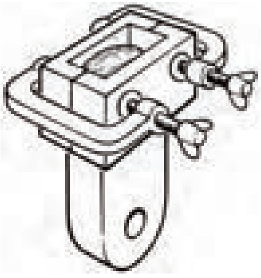
Weld Casting

Manual arc or semi-automatic open arc welding can be very successfully used to apply heavy deposits of hardfacing materials by the weld casting technique.

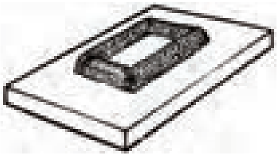
This is often used to rebuild items such as mill hammers or to deposit heavy wear pads on large components.



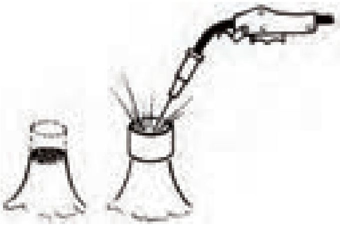
For most work, a heavy split copper mould is made which fits around the area to be built up. This can be stripped off after welding. For wear pads, a mould may be produced by welding a series of stringer beads one over the top of the other to produce a dam of the required height. Alternatively, a short length of round or square pipe may be tack welded onto the job to act as a mould.



The hardfacing material is then cast directly into the mould using a normal manual arc electrode or continuous wire under high amperage conditions. The resulting deposit will have a sound homogeneous structure free from relief checks and with no tendency to spall or flake.



Semi-automatic open arc welding is the more satisfactory process for weld casting due to the continuous wire feed giving uninterrupted welding and the low volume of slag that is produced. Larger diameter manual arc electrodes, e.g. 5 mm and above will give good results provided changes of electrodes are fairly quick.



Weld casting can be used to produce deposits of up to 150 cubic cm without any difficulty by stick electrodes or wire techniques, e.g. 100 mm x 70 mm pads 20 mm thick or 70 mm diameter x 40 mm thick.

Having positioned the mould in the required place, the arc is struck onto the base metal and weaved as quickly as possible over most of the area to be covered. The electrode or wire is then oscillated quickly over the top of the weld metal as it builds up taking care to keep the heat as uniform as possible. When the mould is filled, the entire surface should be at bright red to white heat.

With proper technique and some puddling of the electrode, all slag should be floated above the weld metal leaving a sound dense deposit.

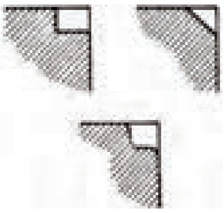
Due to the high heat input, weld casting is not recommended for use on 11-14% manganese steels. Also, on light sections there is a risk of excessive distortion around the weld pad.

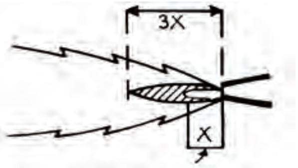
Gas Hardfacing

Rod Deposition

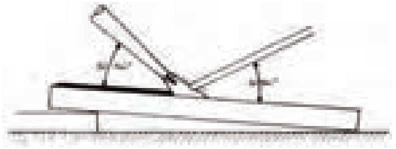
The practice of hardfacing by rod deposition can be likened in many ways to braze welding. The following is a step-by-step guide to the sequence of operations necessary to perform a successful hardfacing operation. This procedure can be used for all gas hardfacing rods except composite rod.

- Surfaces should be cleaned of all dirt, rust, etc. For deposits along edges, prepare a recess as shown opposite.
- Where necessary, preheat the job to the required level - refer page 589.
- Using a tip one or two sizes larger than would normally be applied for welding a similar sized item; adjust gas flow to produce a soft 2 - 3X carburising flame.
- Set the job up with a slight downhill slope for thin deposits or a slight uphill slope for thick deposits.
- With the inner cone of the flame held about 3 mm from the surface of the job, heat a small area at the start of the run until the surface begins to sweat, i.e. takes on a wet appearance. The rod should be held in the flame envelope to preheat the end.





- When the surface sweat is achieved over an area of about 10 to 15 mm in diameter, touch the end of the rod on to the sweating area, and melt off a small portion with the flame. Then raise the rod slightly away from the inner cone and heat the deposited globule of hardfacing material until it flows evenly over the surface to the required thickness.
- Taking care that the surface ahead of the deposited metal is sweating, lower the rod into the leading edge of the deposited puddle and make further additions as the surfacing operation progresses. When a run has been completed, withdraw the flame slowly from the surface, using a slight circular movement. This tends to lessen any cratering that may form at the end of a run.
- When the deposit is complete, edges, corners, etc. may be re-melted to facilitate smoothing of the surface.
- Slowly cool the completed job.



Note for Hardfacing Cast Iron

Since cast iron does not sweat on heating, as does steel, a slight surface melt is necessary. Care must be taken not to overheat the casting as this would result in excessive dilution of the hardfacing alloy. Any surface crust that forms should be broken with the end of the rod. Deposition of a thin preliminary run followed by a second heavier one is desirable. Use of cast iron welding flux may also be advantageous.

Powder Spraying

Hand Torch Procedure

By following the simple step-by-step procedure outlined below, even inexperienced operators can achieve good results with a little practice.

1. Make sure that the surface to be treated is completely clean and de-greased. Grinding or sandblasting helps produce better bonding.
2. Lightly preheat the job with the torch to about 250 - 300°C (just light blue colour).
3. Spray the first layer of powder lightly and rapidly over the surface to produce a very thin coating of alloy. This is to prevent the low alloy base material from oxidising when the work is brought to red heat.
4. Do the facing run in small sections: heat a small area of the work with the torch until the surface begins to show signs of sweating, then spray a small amount of powder on to the surface and hold the flame there until the material melts. Repeat this procedure as you travel along the work. For large surfaces, a weaving action is recommended, with a travel of between 25 and 35 mm. Introduce the powder on the outward weaving motion, then apply heat alone on the inward motion. Do not try to heat too large an area at once, as this tends to overheat the job and cause the hardfacing deposit to boil and bubble.

The depth of deposit is governed by the quantity of powder delivered to the flame. The amount of depression of the lever determines the powder flow:

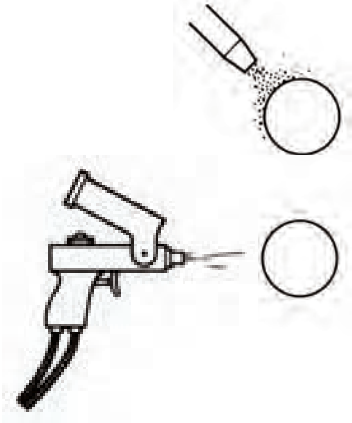
Slight depression gives a small flow, full depression gives maximum flow. Use a neutral flame.

Gun Spraying

The procedure for gun spraying varies considerably, depending on the type of equipment being used. The following is a brief guide only and should be used in conjunction with the gun manufacturer's recommendations.

1. Prepare the surface by rough threading or grit blasting. It is most important that the surface be free of oil, dirt, etc. Consequently, machining lubricants should not be used and blasting grit must be clean and uncontaminated.

2. Preheat the job to about 100 - 150°C. This is generally done with the job in position, e.g. spinning in a lathe. The flame of the spraying gun is often used for preheating.

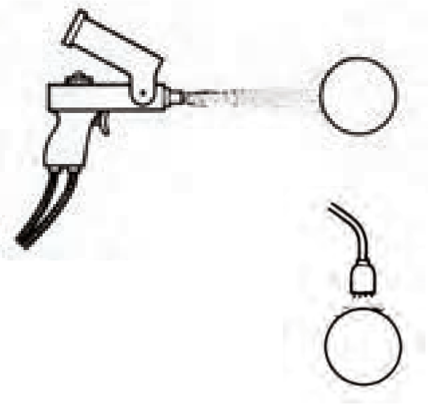


3. With gas flows, surface speed of work, and powder metering valves set to the equipment manufacturer's recommendations, open the powder control valve and commence spraying. Continue spraying until the required thickness of build-up is achieved, plus allowance for machining and about 15% shrinkage on fusing.

   As it is necessary to limit surface temperature during coating, intermittent spraying may be necessary.

4. Remove the spraying gun and fuse the deposit using a multi-hole heating torch adjusted to give a soft, neutral to slightly reducing flame. Normal practice is to preheat the job to 400 - 500°C, then bring the heating torch to within 25 to 50 mm of the surface. When the deposit is properly fused, it takes on a wet, glossy appearance.

5. Allow the job to cool slowly.



Wear Factors

The wearing of metal parts might be defined as a gradual decay or breakdown of the metal. When a part becomes so deformed that it cannot perform adequately, it must be replaced or rebuilt. While the end results of wear are similar, the causes of wear are different. It is essential to understand the wear factors involved before making a hard surfacing product selection.

It would be easy to select a surfacing alloy if all metal components were subjected to only one type of wear. However, a metal part is usually worn by combinations of two or more types of wear. This makes an alloy selection considerably more complicated.

A hard surfacing alloy should be chosen as a compromise between each wear factor. The initial focus should centre on the primary wear factor and then the secondary wear factor(s) should be examined. For example: upon examining a worn metal part, it is determined the primary wear factor is abrasion and the secondary wear factor is light impact. The surfacing alloy chosen should have very good abrasion resistance but also have a fair amount of impact resistance.

There are five major types of wear:

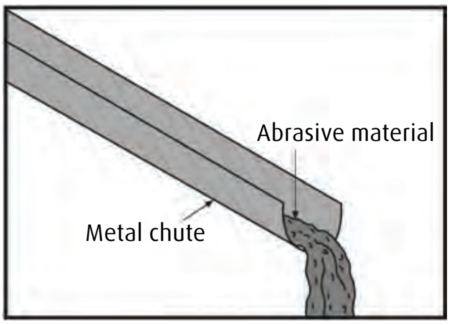
- Abrasive (3 categories)
- Impact
- Adhesive
- High temperature
- Corrosive.

1. **Abrasive wear** - Abrasive wear is caused by foreign materials rubbing against a metal part. It accounts for 50 - 60% of all wear on industrial metal components.

   Abrasive wear is really a group of wear problems. It can be broken down into three main categories:

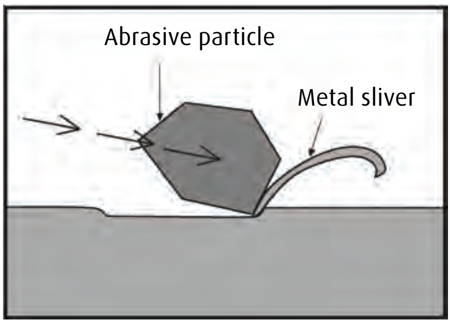
   a. **Low-stress scratching abrasion** - Normally the least severe type of abrasion, metal parts are worn away through the repeated scouring action of hard, sharp particles moving across a metal surface at varying velocities (Fig. 3). The velocity, hardness, edge sharpness, angle of introduction and size of the abrasive particles all combine to affect the amount of abrasion.

Fig. 3 Wear by Low Stress Scratching Abrasion



Sliding abrasive material gently scratches the metal surface, gradually wearing it down

Fig. 3 Cont.



Microschematic cross section shows how a moving abrasive grain scratches out a tiny sliver of metal

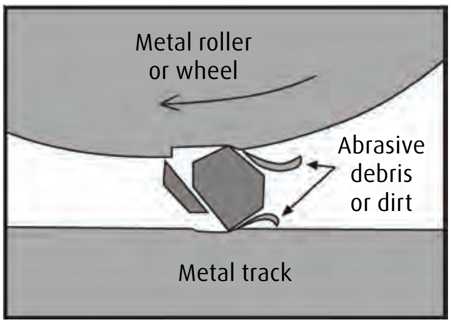
Carbide containing alloys (particularly chrome-carbide) are used successfully to resist low-stress abrasive wear. Due to the absence of impact, the relatively brittle high carbon chromium steel alloys are well suited for low-stress abrasive applications.

Typical components subjected to low-stress scratching abrasion include: agricultural implements, classifiers, screens, slurry pumps nozzles, sand slingers, and chutes.

   b. **High-stress grinding abrasion** - More intense than simple scratching, it results when small hard abrasive particles are forced against a metal surface with enough force that the particle is crushed, in a grinding mode. Most often the compressive force is supplied by two metal components with the abrasive sandwiched between the two - sometimes referred to as three-body abrasion (Fig.4). The surface becomes scored and surface cracking can occur.

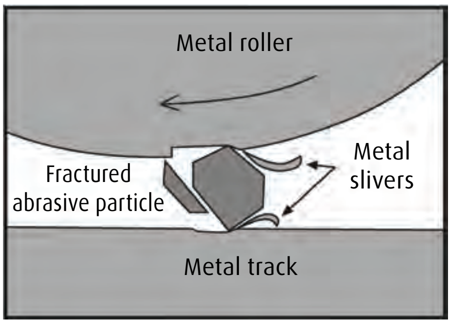
There are examples of softer, tough alloys outperforming harder alloys in grinding abrasion applications. The range of alloys used successfully includes austenitic manganese, martensitic irons, and some carbide containing alloys (usually smaller carbides, like titanium carbide) in a tough matrix.

Fig. 4 Wear by High Stress Grinding Abrasion



Two metal components squeeze abrasive material between them, breaking down the original particle size

Fig. 4 Cont.

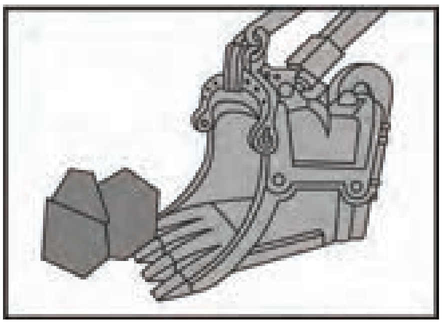


Microschematic cross section shows the fracturing of an abrasive particle into smaller, sharp cornered pieces which cut small furrows into both metal surfaces

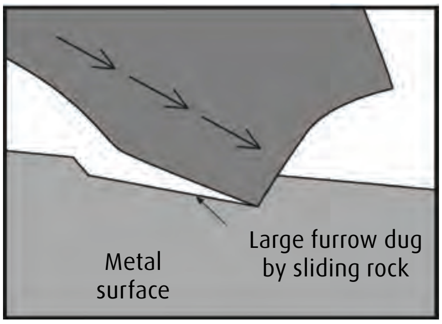
Typical components subjected to high-stress grinding abrasion include: augers, scraper blades, pulverisers, ball and rod mills, muller tires, brake drums, roll crushers, rollers, sprockets and mixing paddles.

c. **Gouging abrasion** - When high-stress or low-stress abrasion is accompanied by some degree of impact and weight, the resulting wear can be extreme. The metal surface receives prominent gouges and grooves when massive objects (often rock) are forced with pressure against it (Fig. 5). A low velocity example of this is a dragline bucket digging into the earth; a high velocity example would be rock crushing. In both instances, the action of the material on metal is similar to that of a cutting tool.

Fig. 5 Wear by Gouging



The rock's weight impacts on metal with a low velocity force and cuts into the metal surface

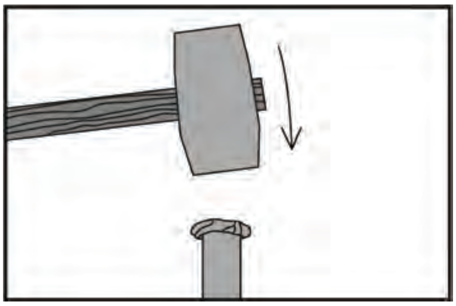


Microschematic cross section shows how heavy rock gouges or depresses the metal surface. The furrow is the result of gross plastic flow in the metal

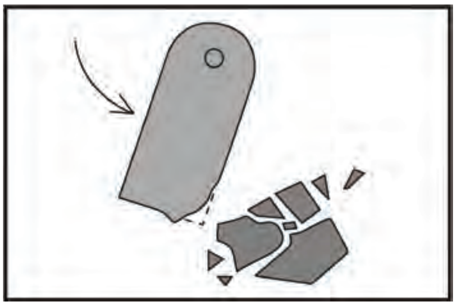
Gouging abrasion also places a premium on toughness, sometimes at the expense of harder, more abrasion resistant alloys. Carbide containing alloys are used successfully when supported by a tough alloy - preferably austenitic manganese. Typical components subjected to gouging abrasion include: dragline buckets, power shovel buckets, clam shell buckets, gyratory rock crushers, roll crushers and jaw crushers.

2. **Impact wear** - Impact, which is defined as the rapid application of a compressive load, produces momentary, extremely high mechanical stress on a metal component. When the stress exceeds the elastic limits of the metal, the metal deforms both beneath point and laterally across the surface away from the impact point.

Fig. 6 Wear by Impact



Wear by impact is readily observed on a chisel, where repeated hammer blows gradually deform the chisel top, finely cracking the edges and spreading the top like the head of a mushroom



Similar 'mushrooming' occurs on equipment such as rock crushing hammers, except the projecting edge can actually by knocked off by impacting rock

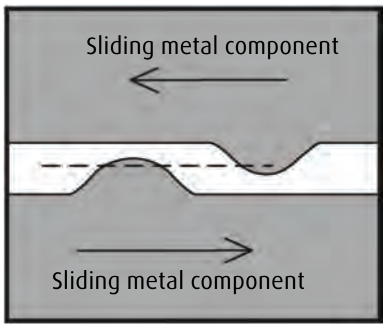
Very brittle metal cannot withstand much deformation so it may crack from either a severe blow or repeated lighter blows. Even if the metal is ductile enough to avoid cracking, repeated impact often compresses the surface, sometimes causing the metal to 'mushroom' at the edges and eventually chip off (Fig. 6).

Austenitic manganese steels (11 - 20% Mn) are the best choice for resisting heavy impact due to their work hardening characteristics. Although not as good as austenitic manganese, the martensitic alloys also offer moderate impact resistance.

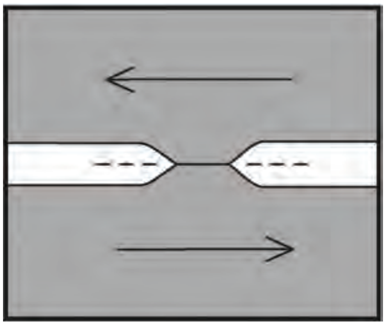
Typical components subjected to impact include: coupling boxes, crusher rolls, impact hammers, impactor bars, and railroad frogs and crossings.

3. **Adhesive wear (metal-to-metal)** - Metal-to-metal wear, accounting for as much as 15% of all wear, results from non-lubricated friction of metal parts. Metal surfaces, regardless of their finish, are composed of microscopic high and low areas. As metal surfaces slide against each other, the high areas are broken and tiny fragments of metal are torn away (Fig. 7). The continual removal of metal roughens the working surface and contributes to even more rapid wear.

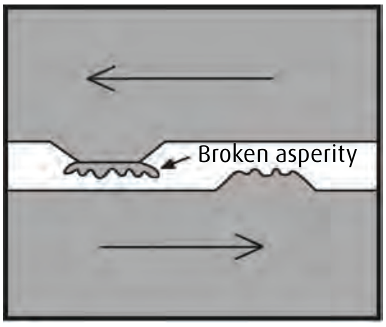
Fig. 7 Wear by Adhesion (Microschematic Cross Section)



Sliding metal components have tiny raised or roughened areas, called asperities, which collide



Contact under heat and pressure causes the metal to flow and bond momentarily in 'cold welding'



When machine force fractures cold welded asperities, jagged metal from one surface remains bonded to the opposite surface, accelerating wear

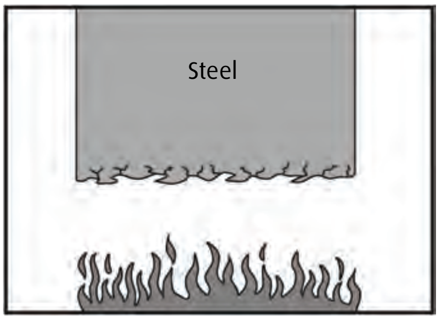
The martensitic hard surfacing alloys are a good choice for metal-to-metal wear resistance. Other alloys, including austenitic manganese and cobalt based alloys, are also used successfully. Since softer alloys matched with a harder surface will wear rapidly, it is important not to overmatch a component when hard surfacing for adhesive wear resistance.

Typical components subjected to adhesion include: steel mill rolls, undercarriage components, shear blades, shafts, trunnions and non-lubricated bearing surfaces.

4. **High temperature wear** - Steel surfaces exposed to high temperatures for long periods of time can steadily deteriorate. Heat affects the metal's microstructure and generally reduces its durability (Fig. 8). The wear resistance of most alloys is diminished when exposed to high heat in service due to softening through inadvertent tempering.

A major cause of metal failure from high temperature service is the thermal fatigue ('fire cracking') that results from repetitive intense heating followed by quick cooling. The repeated cycling eventually exceeds the ability of the metal.

Fig. 8 Wear by High Temperature Oxidation (Microschematic Cross Section)



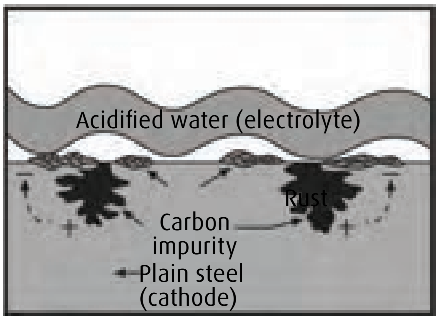
High temperatures encountered in certain applications can cause surface cracking and spalling

Martensitic steels containing 5 - 12% chromium are used extensively to combat thermal fatigue. Many chromium-carbide alloys retain their wear resistance up to temperatures of 650°C - service conditions over that temperature generally require a non-ferrous alloy.

5. **Corrosive wear** - Ferrous metals are subjected to many forms of corrosion, each of which can cause wear damage. The most common type of corrosion is rust. Rust transforms the surface of the metal into oxide which eventually flakes off, thus reducing the original thickness of the metal.

Corrosion as related to surfacing is usually a secondary wear factor. Although many hard surfacing alloys offer a certain amount of protection against corrosion, the selection of a surfacing alloy for a specific corrosive service should be handled as a separate issue.

Fig. 9 Wear by Liquid Corrosion (Microschematic Cross Section)



When water contacts steel, small electric cells are set up. The acidified moisture (electrolyte) attacks the steel surface, gradually changing it to oxide

Hard Surfacing Alloy Classifications

Afrox supplies products for hard surfacing in both the iron-base and non-ferrous categories. The iron-base alloys represent by far the largest usage of the hard surfacing alloys and will be discussed in more detail. Iron-base hard surfacing alloys can be subdivided according to their metallurgical phase or microstructure, each type resisting certain forms of wear better and/or more economically than others. For simplification, Afrox groups the different classifications into three main alloy families:

a. Austenitic alloys

b. Martensitic alloys

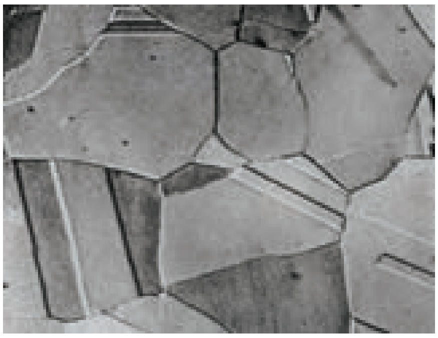
c. Carbide alloys

Included in each family are products which combine properties of the main alloy family with properties common to another alloy family. These products were developed either to resist two kinds of wear simultaneously or incorporate certain desirable characteristics.

Austenitic hard surfacing alloys:

- Excellent impact resistance
- Fair abrasion resistance
- Good build-up alloy.

Alloys which retain an austenitic microstructure at room temperature are referred to as austenitic. With compositions of 0,5 to over 1% carbon and from about 13 - 20% alloy (mainly manganese, with a few percent of nickel and/or chromium) they are commonly referred to as 'austenitic manganese' or 'Hadfield manganese' steels, similar to their base metal counterparts. These alloys are designed to match (or exceed) the properties of Hadfield manganese base metals. They are used extensively for rebuilding as a finished surface and prior to overlay of carbide alloys on austenitic manganese steel base metals.



Photomicrograph of austenite

Austenitic alloys with up to about 0,7% carbon and 20 - 30% alloy (usually about equal parts of manganese and chrome with some nickel) provide stable austenite even in high dilution situations on carbon and low alloy steels. This makes them a much better choice than the austenitic manganese alloys for overlay on carbon and low alloy steels or for dissimilar joining of manganese to carbon or low alloy steels.

Well designed austenitic surfacing alloys are extremely tough, ductile and work-hardenable. They offer excellent impact resistance, fair abrasion resistance (which improves as it work hardens) and have no relief checks. These alloys will normally work harden to a surface hardness up to 50 HRc and although this improves their abrasion resistance, they still retain their good impact resistance. The austenitic surfacing deposits, like the austenitic manganese base metals (see Base Materials), should not be exposed for extended periods to temperatures over 260°C to minimise embrittlement.

Martensitic hard surfacing alloys:

- Good impact resistance
- Fair abrasion resistance
- Good metal-to-metal wear resistance
- Used both for build-up and overlay.

Martensite is a hard microstructural phase which is formed in steels by rapid cooling. Since martensitic alloys are air-hardenable, the cooling rate plays an important part in the final hardness; faster cooling usually results in harder surfacing deposits. Preheats of 121 - 316°C are generally required when working with martensitic alloys to avoid cracking in the weld deposit (base metal must also be taken into account).

Low carbon, low alloy (less than 5%) martensitic alloys are used primarily for build-up on carbon and low alloy steels. Their relatively high compressive strength, toughness and good metal-to-metal sliding wear resistance make them suitable for not only rebuilding components to their original dimensions, but as a substrate for harder surfacing materials.

Photomicrograph of martensite

Slightly higher carbon and higher alloy (6 - 12%) martensitic alloys exhibit significantly higher as-welded hardnesses. This hardness gives them better metal-to-metal and abrasive wear resistance than the build-up alloys, but lower toughness. Even though their toughness can be improved by tempering, they are primarily used as overlay alloys.

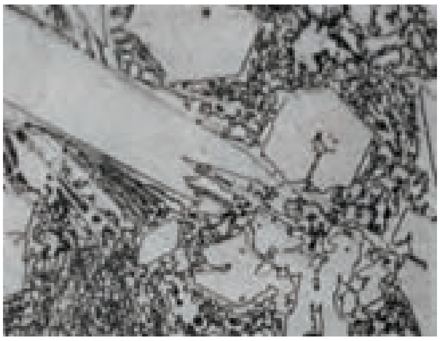
Another group of martensitic alloys common to hard surfacing are the martensitic stainless steels. Containing up to about 0,25% carbon and 18% alloy (mainly chromium), this group of alloys exhibits excellent thermal shock resistance. They also offer good metal-to-metal wear resistance and moderate corrosion resistance. They require rigid welding procedures for successful application and are used extensively for steel mill roll (including continuous caster) overlay.

Martensitic hard surfacing alloys provide a good balance of impact and abrasion resistance. By choosing the proper carbon-chromium content, it's possible to choose the best compromise of abrasion, adhesion and impact resistance. The ability of martensitic alloys to respond to heat treatment also makes it possible to change their hardness/toughness after welding to better suit the service conditions. This alloy family should not be used for joining applications and should not be applied to austenitic base metals.

- Carbide hard surfacing alloys
- Excellent abrasion resistance
- Good heat resistance
- Fair corrosion resistance
- Fair to low impact resistance.

By alloying several percent of carbon with a minimum 12% alloy (primarily chromium), hard carbides are formed and dispersed throughout the surfacing deposit (see Fig. 10). These dispersed carbides are much harder than the surrounding matrix and provide excellent abrasion resistance. They are used when the primary wear factor is abrasion.

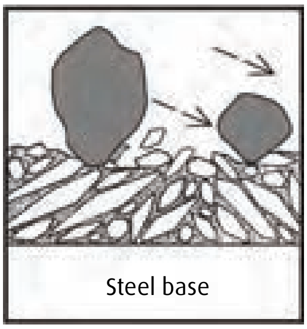
At the lower end of the carbon range (less than 3%), the quantity of carbides is small compared to the matrix in which they're dispersed and these alloys exhibit good abrasive wear resistance while retaining good toughness. These carbide surfacing alloys are used to resist a combination of abrasion and impact.



Photomicrograph of large carbides in a carbide eutectic matrix

As the carbon content increases (to as much as 7%) in the carbide containing alloys, the abrasion resistance increases and the toughness decreases (due to the higher percentage of carbides). All carbide surfacing develops transverse stress-relieving 'check cracks'. The higher carbon alloys develop these cracks more readily and closer together than the lower carbon versions.

Fig. 10



As carbides are undermined and knocked out by moving abrasive particles, additional carbides are uncovered to further resist abrasives and delay wear

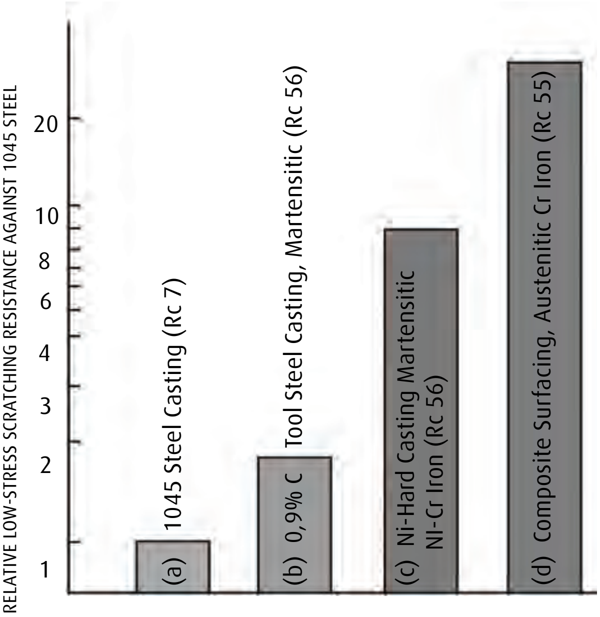
These alloys should not be used for joining but can be applied to carbon steel, low alloy steel, austenitic manganese steel and cast iron (with special welding procedures). A sound, tough base material is preferred as a base for carbide surfacing alloys and the thickness of deposit is usually limited to 2 - 4 layers to prevent spalling. Care should be taken in applying carbide alloys to thin base metals since the stress relief cracks can propagate through thin sections. These alloys exhibit good abrasion resistance at high temperatures (some up to 650°C) and should be considered non-machinable.

Hard Surfacing Misconception

Greater hardness does not always mean greater abrasion resistance or longer wear life. Several alloys may have the same hardness rating but vary greatly in their ability to withstand abrasive wear.

Hardness Compared to Wear Resistance

Fig. 11



These test results show the last three metals sharing a Rockwell hardness value that is almost identical, yet their resistance to scratching abrasion differs greatly:

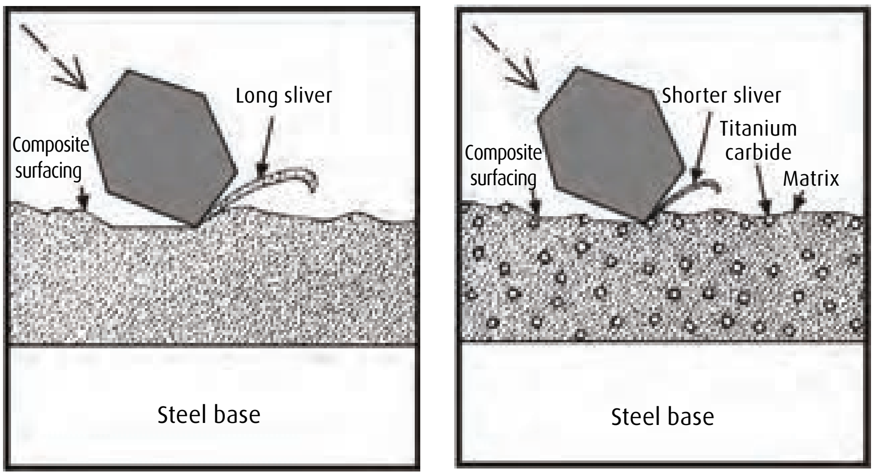
- 1045 steel is used as the basis for comparison
- Tool steel is only 1 and 3/4 times more abrasion resistant than 1045 steel
- Ni-Hard metal is 8 times more resistant than 1045 steel
- Composite surfacing is over 20 times more resistant than 1045 steel.

For example, many of the best Afrox surfacing alloys derive their high abrasion resistance from very hard carbides dispersed throughout a softer, tougher matrix. Bulk hardness tests (Rockwell or Brinell) which measure the average hardness of both the carbide and matrix together over a relatively large area, often register the same hardness as that of other conventional metals. But in actual performance, a carbide-containing surfacing alloy has substantially better abrasive wear resistance, as indicated in the graph (Fig. 11).

Similarly, when comparing several surfacing alloys with each other (Fig. 12), equally high bulk hardness ratings is not the only factor assuring resistance to wear. Resistance (especially to low- and high-stress abrasion) depends rather on a combination of both hardness and the metallurgical microstructure of the alloy. The microstructure of alloys varies according to the ratio of carbides to matrix and the type of carbides in the alloy. The alloy with the hardest, most evenly dispersed carbides along with the highest percentage of carbides will have the best resistance to low-stress and high-stress abrasion.

Comparison of Hard Surfacing Deposits: Hardness vs. Abrasion Resistance

Fig. 12



Tube-Alloy 258-0 - Martensitic
Average deposit hardness - 58 HRc

Better abrasion resistance than carbon steel, abrasive particle still scratches slivers out of surface

Tube-Alloy 258 Tic-0 - Titanium Carbide
Average deposit hardness - 58 HRc

Even greater abrasion resistance since abrasive particle scratches out less matrix before hitting small titanium carbides

Afrox hard surfacing alloys fall not only into the alloy classifications, but also into two groups based on their primary usage:

1. Build-up alloys

2. Overlay alloys

Build-up alloys have good resistance to impact wear but only moderate resistance to abrasive wear. Such alloys may be used as wear surfaces themselves but more frequently they are employed as a base for a harder, abrasion resistant overlay. Both austenitic manganese and low alloy martensitic alloys are used for build-up.

Overlay alloys are hard overlays that have excellent abrasion resistance and fair to poor impact resistance. Due to their hardness, these alloys are usually limited to a specific number of layers. Certain martensitic alloys and all of the carbide alloys are used for overlay.

Useful Hardfacing Data

Identification of Metals

The ability to recognise different types of metals is of considerable importance in welding and/or hardfacing. Different metals often require different welding techniques and in some cases careful selection of hardfacing products.

In many cases, a metal can be identified by machine drawings or specifications. There will, however, be a number of occasions when there will be a reasonable doubt as to what metal a certain item is made from. The following is a guide to the identification of most common metals and should prove adequate for most welding purposes.

File Test

It is often possible to distinguish mild steel and wrought iron (which are welded in the same manner) from other steels by filing, using a known piece of mild steel for comparison purposes.

Holding the unknown piece of steel firmly, in a vice if required, take one firm cut at it using the corner of a large file. The file should only be pushed in the forward direction while in contact with the metal. Do a similar cut, using similar speed and pressure on the known piece of mild steel.

If they behave in a similar manner, that is, they both cut to similar depths and if the file feels to have the same amount of 'drag', etc., it is very likely that the unknown piece is either mild steel or wrought iron and can be welded as such.

If they do not behave in a similar manner, it is almost definite that the piece is either high carbon or alloy steel. It is possible to differentiate between these two using a spark test.

Spark Test

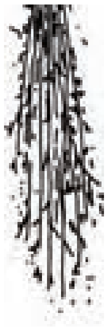
Different types of steels will react differently when held against the wheel of a power grinder. For distinguishing between different types of steels by this technique, it is advisable to have some pieces of known types to use as comparisons.

The piece of steel is held firmly against the rotating wheel in such a manner that the sparks can be observed as they leave the wheel. The appearance of the spark pattern is then compared with those shown in Fig. 13 and if possible, with those obtained from pieces of steel of known types. It is important when comparing pieces of steel by spark test that the same pressure is used to hold the specimen against the wheel in each case.

Identification of Common Metals

Metal	Appearance of the metal surface in its common rough condition	Appearance of freshly filed metal	Appearance of fractures and relative toughness of metal	Further test required to identify type
Grey cast iron	Dark grey or rusty, rough, sandy surface	Light grey, fairly smooth	Dark grey, rough granular surface. Very brittle	Chisel test
White cast iron	As above	Generally too hard to file. Shiny white when ground	Medium grey colour. Very tough to quite brittle depending on type and condition	Nil
Mild steel, wrought iron, cast steel, alloy steels, high carbon steel, 11-14% manganese steel	Dark grey or rusty. Can be smooth or rough depending on application	Bright grey, very smooth surface. Some alloy steels are too hard to file	Fine grey surface may be tough to quite brittle	File test Spark test Magnet test Chisel test
Stainless steel	Bright silvery grey if polished. Rough dull grey if not polished	Bright silvery grey. Smooth surface. Some are too hard to file		

Fig. 13

Wrought Iron	**Mild Steel** **Cast Steel**	**White Cast Iron**	**Grey Cast Iron**
 Colour - straw yellow Average stream with power grinder - 165 cm Volume - large Long shafts ending in forks and arrow-like appendages Colour - white	 Colour - white Average length of stream with power grinder - 178 cm Volume - moderately large Shafts shorter than wrought iron and in forks and appendages. Forks become more numerous and sprigs appear as carbon content increases	 Colour - red Colour - straw yellow Average stream length with power grinder - 50 cm Volume - very small Sprigs - finer than grey iron, small and repeating	 Colour - red Colour - straw yellow Average stream length with power grinder - 63 cm Volume - small Many sprigs, small and repeating
High Carbon Steel	**Stainless Steel** **Alloy Steel**	**Malleable Iron**	**Nickel & Monel**
 Colour - white Average stream length with power grinder - 140 cm Volume - large Numerous small and repeating sprigs	 Colour - straw yellow Stream length varies with types and amount of alloy content Colour - white Shafts may end in forks, buds or arrows, frequently with break between shaft and arrow	 Colour - straw yellow Average stream length with power grinder - 76 cm Volume - moderate Longer shafts than grey iron ending in numerous small, repeating sprigs	 Colour - orange Average stream length with power grinder - 25 cm Short shafts with no forks or sprigs

Magnet Test

It is possible to distinguish between austenitic steels and the ferritic and martensitic types by their magnetic properties.

Many items subject to impact such as crusher jaws, impact bars, swing hammers, etc. are made from 11 - 14% manganese steels. These appear in many respects to be similar to mild steel or low alloy steels and are difficult to distinguish by normal visual inspection, file tests and spark tests. Their main feature is that they will not be attracted by a magnet. Hence, any doubtful steels should be checked with a magnet and, if they are not strongly attracted, treated as manganese steels.

Stainless steels also can be magnetic or non-magnetic. Always check with a magnet prior to welding. If non-magnetic (no attraction), they are the austenitic type. If they are magnetic, they are either ferritic or martensitic and should be treated as such.

Chisel Test

It is often difficult to determine whether a machine component is cast iron or cast steel simply by appearance. One of the most reliable tests is to try and remove a small piece with a sharp cold chisel.

Cast iron will come away in distinct chips when the chisel is hit with a hammer. Cast steel, on the other hand, is more ductile and will peel away in slivers.

WELDING PROCEDURES FOR SURFACING ELECTRODES AND WIRES

Afrox Covered Surfacing Electrodes

In general, Afrox electrodes have excellent operating characteristics in the flat position; vertical surfaces may be overlayed by building a series of horizontal beads on a 'shelf'. As with most welding electrodes, the smaller sizes have better operating characteristics when welding vertical surfaces. For maximum deposition rates, use higher amperages and a wide weave technique. For most Afrox electrodes, weaving up to four electrode diameters is satisfactory. To minimise penetration and thus weld metal dilution, use lower amperages. Holding a longer arc (higher voltage) will produce a wider, flatter bead and will increase heat input into the base metal. When welding on manganese steel castings, currents as low as possible should be used to prevent overheating of the base metal. The surface to be built up should be ground to remove the work hardened area, cracked or spalled metal, and any other foreign material. Peening is recommended on heavy build-ups.

Afrox Flux Cored Open Arc Surfacing Wires

Tube Alloy Flux Cored Wires

General Operating Parameters							
1,2 mm dia		1,6 mm dia		2,0 mm dia		2,8 mm dia	
Use 12 - 25 mm stick out DC reverse polarity		Use 25 - 38 mm stick out DC reverse polarity		Use 25 - 38 mm stick out DC reverse polarity		Use 38 - 50 mm stick out DC reverse polarity	
A	V	A	V	A	V	A	V
120 - 160	19 - 23	225 - 275	23 - 25	275 - 350	26 - 28	350 - 400	24 - 27
160 - 190	24 - 25	275 - 350	24 - 27	350 - 400	27 - 29	400 - 450	26 - 29
190 - 230	26 - 27	350 - 400	26 - 29	450 - 475	28 - 32	450 - 500	28 - 32

Corewear Flux Cored Open Arc Wires

General Operating Parameters					
2,0 mm dia		2,4 mm dia		2,8 mm dia	
Use 40 - 50 mm stick out DC reverse polarity		Use 50 - 60 mm stick out DC reverse polarity		Use 50 - 60 mm stick out DC reverse polarity	
A	V	A	V	A	V
200 - 400	25 - 35	280 - 340	28 - 29	350 - 400	28 - 29

Afrox Metal Cored Submerged Arc and Gas Assisted Cored Surfacing Wires

Submerged Arc Welding of Cylindrical Components

Tube Alloy Metal Cored Submerged Arc Wires

General Operating Parameters					
2,4 mm dia		3,2 mm dia		4,0 mm dia	
Use 25 - 32 mm stick out, travel speed of 305 - 406 mm/min		Use 32 - 38 mm stick out, travel speed of 356 - 456 mm/min		Use 32 - 38 mm stick out, travel speed of 406 - 508 mm/min	
A	V	A	V	A	V
350 - 400	25 - 26	400 - 450	26 - 28	450 - 500	28 - 30
400 - 450	26 - 27	450 - 500	27 - 30	500 - 600	29 - 32
450 - 500	28 - 29	500 - 550	29 - 32		

Corewear Flux Cored Gas Assisted Wires

General Operating Parameters					
1,2 mm dia		1,6 mm dia		2,0 mm dia	
Use CO_2 gas 15-25 ℓ/m DC reverse polarity		Use CO_2 gas 15 - 25 ℓ/m DC reverse polarity		Use CO_2 gas 15 - 25 ℓ/m DC reverse polarity	
A	V	A	V	A	V
150 - 300	25 - 35	200 - 400	25 - 35	300 - 500	23 - 35

Afrox open arc wires require no external shielding gas and have a steady arc with globular transfer. Spatter and noise levels are minimal, with complete slag coverage, which removes easily. Increasing amperage will increase deposition rate, penetration (higher base metal dilution) and heat input into the base metal. Increasing voltage will widen and flatten the weld bead. Excessive voltage will result in porosity. Control of wire extension (stick out) is important with excessively short stick out resulting in scattered internal porosity and excessively long stick out resulting in increased spatter. Afrox open arc wires can be used with either a variable or a constant voltage power source with the latter preferred. Constant and variable speed wire feeders are both being used successfully with the proper power source.

General Advantages of Afrox 1,2 mm and 1,6 mm Wires

1. Permits marked reduction in welding costs (as much as 2/3 cost saving) - deposition rate greater than that of manual electrode or gas shielded wires.
2. Simplicity of operation with lightweight guns and no gas lines.
3. With proper procedures, can be used to surface in the vertical position.
4. More adaptable on small thin parts and edges - holds corners.

It must be emphasised that 1,2 mm and 1,6 mm Afrox wires are not all-positional wires in the true sense of the word. They can be used to weld vertical surfaces with a horizontal stringer technique. A shelf may be required on the initial pass and amperages in the lower end of the range (approx. 200 A), fast travel speed and a nozzle angle inclined up 15° should be used.

For cylindrical submerged arc welding, the factors which control bead contour are: 1) arc voltage 2) amperage 3) rotation speed and 4) lead.

Arc Voltage. Arc voltage should be preset at approximately 26 - 30 V. A decrease in arc voltage will shorten the arc and tend to produce a higher, narrower bead. If the voltage is increased, the arc will become longer, penetration will be deeper and additional dilution with the base metal will result.

Amperage. The rate of wire burn-off and heat input are functions of the welding current. With 3,2 mm wire, a good starting point is 425 A, 4,0 mm 500 A. More metal will be deposited with higher amperages but higher heat input will result. As heat builds up, especially in parts of small diameter, the contour of the bead is more difficult to control.

Rotating Surface Speed. A good starting point is approximately 400 mm/min. If the surface speed is increased, a narrower bead will result. When decreased, a wider bead is deposited.

Lead. After the above three parameters have been set, the contour of the bead can be controlled by varying the amount of lead. Lead is the distance ahead of dead centre. Position the electrode ahead of dead centre sufficiently so the molten pool solidifies as it passes top dead centre.

Diameter	mm ahead of dead centre
75 - 450	20 - 25
450 - 1 000	25 - 38

On small diameters, the correct lead is particularly important since the molten slag tends to run before freezing. When insufficient lead is used, the bead will be convex and undercut the edges. When too much lead is used, the bead will be flat or concave and tend to have centreline cracks. The correct lead produces a bead having a slight crown and long lines of solidification.

DIN 8555 SPECIFICATION FOR HARDFACING CONSUMABLES

XXX	**XX**	**-**	**XX**	**-**	**XXX**	**-**	**XXXX**

Welding Process
G - Gas Welding
E - MMA
MF - FCAW
TIG - TIG
MSG - MIG
UP - SAW

Alloy Group	
1	Unalloyed < 0,4% C or low alloyed < 0,4% C and < 5,0% Cr, Ni, Mo, Mn
2	Unalloyed < 0,4% C or low alloyed < 0,4% C and < 5,0% Cr, Ni, Mo, Mn
3	Alloyed with properties of hot worked steel
4	Alloyed with properties of hot worked steel
5	Alloyed with > 5,0% Cr with low C up to 0,2%
6	Alloyed with > 5,0% Cr with C from 0,2 - 2,0%
7	Mn austenites with 11 - 18% Mn and up to 3% Ni
8	CrNiMn austenites
9	CrNi steel resistant to rust, acid and heat
10	High C, high Cr without other carbide formers
20	Co based, CrW alloyed with or without Ni or Mo
21	Carbide based sintered cast or cored
22	Ni based Cr alloyed CrB alloyed
23	Ni based Mo alloyed with or without Cr
30	Cu based Sn alloyed
31	Cu based Al alloyed
31	Cu based Ni alloyed

Method of Production
GW - Rolled
GO - Cast
GZ - Drawn
GS - Sintered
GF - Cored
UM - Covered

Hardness Level	**Hardness Range**
150	125 - 175 HB
200	175 - 225 HB
250	225 - 275 HB
300	275 - 325 HB
35	325 - 375 HB
400	375 - 450 HB
40	37 - 42 HRc
45	42 - 47 HRc
50	47 - 52 HRc
55	52 - 57 HRc
60	57 - 62 HRc
65	62 - 67 HRc
70	67+ HRc

Weld Metal Properties	
C	Corrosion resistant
G	Resists abrasive wear
K	Work hardens
N	Non-magnetic
P	Impact resistant
R	Rust resistant
S	Cutting ability HSS
T	High temp strength
Z	Heat resistant above 600°C

Example MSG 1 0-GF-60-G

Is a MIG wire with Hi C%, Hi Cr% without other carbide formers, it is a cored wire having a hardness in the range of 57 - 62 HRc and is resistant to abrasion

MSG	10		-	GF	-	60		-	G	Rust resistant

Hardfacing Electrodes

Afrox 300

Afrox 300 is a basic coated, AC/DC all-position electrode depositing a tough chromium alloy weld metal with a hardness of 250 - 300 HV (up to 30 HRc). The weld metal may be hardened to above 480 HV (48 HRc) by heating to 900°C and quenching in oil. The weld deposit is capable of withstanding moderate rolling loads, mild abrasion and frictional loading with good resistance to impact.

Applications

Afrox 300 is suitable for rebuilding worn steel or low alloy machine parts, which require machining after welding. It can also be used as a buffer layer between base material and harder overlays. Typical components to be welded with this electrode include shafts, mine car wheels, track links, dragline chains, worn rail ends, tractor rails, drive sprockets, etc. Afrox 300 may be multi-layered.

Classifications		
DIN	8555	E1-UM-300-P
AWS	5.13: 2019	EFe1 (nearest)
EN	14700:2005	EFe1 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 - 0,1	**% Chromium**	3,0 - 3,5
% Manganese	0,35 - 0,9	**% Molybdenum**	0,1 max
% Silicon	0,7 max		

Typical Hardness	
HRc	26 - 31

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	110 - 145	4,0	W075603
4,0	350	140 - 180	4,0	W075604
5,0	450	180 - 240	6,0	W075605

Afrox 350

Afrox 350 is a basic coated, all-position electrode depositing a tough chromium alloy weld metal. The weld metal is capable of withstanding high impact and rolling loads with good resistance to mild abrasive wear.

Applications

Afrox 350 is suitable for welding rail ends and railway lines and various other applications where moderate hardness and machinability is required.

Classifications		
DIN	8555	E1-UM-350-P
AWS	5.13: 2019	EFe1 (nearest)
EN	14700:2005	EFe1 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,06 - 0,08	**% Silicon**	0,4 - 0,6
% Manganese	0,6 - 0,9	**% Chromium**	3,2 - 4,9

Typical Hardness	
HRc	32 - 40

Packing Data
(AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
5,0	450	170 - 250	6,0	W075609

Afrox 400

Afrox 400 is a rutile coated, AC/DC electrode depositing a tough chromium manganese alloy weld metal with a hardness of 320 - 400 HV (32-40 HRc). The weld deposit is hard enough to resist serious deformation under fairly heavy impact and rolling loads, yet has good resistance to mild abrasive wear. The electrode has a smooth soft arc with low spatter volume and can be used in all positions.

Applications

Afrox 400 is suitable for metal-to-metal wear applications involving abrasion and/or impact loads. The electrode is recommended for applications where maximum hardness consistent with reasonable machinability is required (machinable with carbide-tipped tools only). Typical applications include tractor idlers, track rolls, dragline pins, drive sprockets and gears, cable sheaves, hot metal or slag ladle pins, etc. The low open circuit voltage allows this electrode to be used on small AC machines.

Classifications		
DIN	8555	E1-UM-350-P
AWS	5.13: 2019	EFe1 (nearest)
EN	14700:2005	EFe1 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,1 - 0,2	**% Chromium**	2,4 - 4,0
% Manganese	0,3 - 1,0	**% Molybdenum**	0,1 max
% Silicon	0,5 - 1,0		

Typical Hardness	
HRc	37 - 47

Packing Data
(AC DC- 50 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	350	120 - 160	5,0	W075634

Afrox 452

Afrox 452 is a basic coated AC/DC all-position electrode depositing a weld containing chromium, nickel and molybdenum. The weld metal, which comprises metallic carbides in a martensitic matrix, has a hardness of 420 - 480 HV (43 - 48 HRc). The weld metal provides good resistance to abrasion and impact under rolling and to impact loads in wet and dry conditions.

Applications

This versatile electrode is suitable for use in applications where frictional loads and metal-to-metal wear conditions occur. The weld metal is extremely resistant to breakout or spalling, which makes it eminently suitable to use on permanent way crossings, rail ends, excavator bucket lips, tractor drive sprockets and track links, crane drive wheels, etc. The deposit, which is machinable with carbide-tipped tools, is also suitable for use as a low cost buffer layer for the deposition of high alloy wear resistant deposits.

Classifications		
DIN	8555	E1-UM-45-GP
AWS	5.13: 2019	EFe2 (nearest)
EN	14700:2005	EFe3 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,17 - 0,25	**% Chromium**	2,0 - 3,0
% Manganese	0,9 - 1,4	**% Nickel**	1,6 - 2,2
% Silicon	0,2 - 0,4	**% Molybdenum**	0,65 - 0,95

Typical Hardness	
HRc	43 - 48

Packing Data
(AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	350	110 - 170	5,0	W075674
5,0	450	170 - 270	6,0	W075675

Afrox 600

Afrox 600 is a basic coated AC/DC electrode depositing a martensitic weld metal having a hardness of approximately 470 - 700 HV (47 - 60 HRc). The weld metal has good resistance to fine mineral abrasion with moderate resistance to impact.

Applications

Afrox 600 has been designed for application involving metal to mineral conditions such as those experienced by earth moving equipment working in sandy conditions. Typical uses are grader blades, earth scoops, bucket lips, grousers, conveyor screws, blast hole augers, etc.

Classifications		
DIN	8555	E4-UM-55-G
AWS	5.13: 2019	EFe3 (nearest)
EN	14700:2005	EFe2 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,45 - 0,6	**% Chromium**	5,0 - 8,0
% Manganese	0,3 - 1,1	**% Molybdenum**	0,3 - 0,6
% Silicon	0,4 - 1,3		

Typical Hardness	
HRc	47 - 60

Packing Data
(AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	110 - 145	4,0	W075613
4,0	450	140 - 180	6,0	W075614
5,0	450	180 - 240	6,0	W075615

Afrox 650A

Afrox 650A is a basic coated AC/DC all-position electrode depositing a weld metal containing chromium, molybdenum and vanadium. The weld metal which has an approximate hardness of 550 - 650 HV (53 - 58 HRc) is grindable only and has good resistance to abrasion with moderate to high impact resistance. Due to its high alloy content, the deposited weld metal has excellent hardness to 500°C.

Applications

Afrox 650A deposits a martensitic steel weld metal which is suitable for use on a wide variety of tool and metal-to-metal applications such as guillotine blades, punches, dies, pneumatic drills, chisels, axes, ripper teeth and wood chipper anvils.

Classifications		
DIN	8555	E6-UM-55-GS
AWS	5.13: 2019	EFe3 (nearest)
EN	14700:2005	EFe3 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,45 - 0,65	**% Chromium**	5,5 - 7,5
% Manganese	0,5 - 1,25	**% Molybdenum**	4,5 - 6,5
% Silicon	0,1 - 0,5	**% Vanadium**	0,5 - 0,1

Typical Hardness	
HRc	53 - 58

Packing Data (AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	80 - 120	4,0	W075623
4,0	350	120 - 160	4,0	W075624

Afrox CrMn

Afrox CrMn is a rutile coated electrode designed for joining and surfacing 11 - 14% manganese steels. The deposited weld metal will work harden under impact load to a hardness of 480 - 590 HV. The electrode is recommended for use in the downhand position only.

Applications

Afrox CrMn can be used to reclaim worn austenitic manganese parts or as a buffer layer on other grades of steels prior to hardfacing. The deposit is extremely crack resistant and will rapidly work harden, making it ideally suited for welding on railway crossings, dredger buckets, crusher jaws, loader buckets and other ground engaging equipment.

Classifications		
DIN	8555	E8-UM-200/55-KP
AWS	5.13: 2019	EFe MnCr (nearest)
EN	14700:2005	EFe9 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,5 - 0,9	**% Silicon**	0,1 - 0,5
% Manganese	15,0 - 18,0	**% Chromium**	12,0 - 15,0

Typical Hardness	
As Deposited	22 HRc
Work Hardened	48 - 55 HRc

Packing Data
(AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
5,0	350	170 - 220	4,0	W075629

Afrox NiMn

Afrox NiMn is a basic coated electrode designed to provide a non-magnetic austenitic 11 - 14% manganese deposit for service involving high impact. The deposits are extremely tough, non-porous, crack-free and work hardened readily under impact loading to approximately 440 - 600 HV (45 - 55 HRc). The electrode is recommended for downhand welding only.

Applications

Although primarily intended for reclaiming worn parts made from 11 - 14% manganese steel (Hadfield manganese steel), Afrox NiMn can also be used for joining this material or hardfacing carbon steel components subject to severe impact loads. Under these conditions, an austenitic stainless steel buffer layer should be applied. This electrode can be used on cast manganese steel railway crossings, dredger buckets, crusher jaws, swing hammers, blow bars and grizzlies.

Classifications		
DIN	8555	E6-UM-55-GS
AWS	5.13: 2019	EFe Mn-A (nearest)
EN	14700:2005	EFe9 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,5 - 0,9	**% Nickel**	2,75 - 6,0
% Manganese	11,0 - 16,0	**% Chromium**	0,5 max
% Silicon	1,3 max		

Typical Hardness	
As Deposited	24 HRc
Work Hardened	45 - 55 HRc

Packing Data (DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	350	130 - 170	4,0	W075664
5,0	450	170 - 220	6,0	W075665

Afrox CR70

Afrox CR70 deposits a tough eutectic of austenite and metal carbide that can withstand impact at medium loads under abrasive conditions. The weld metal has a hardness of approximately 550 HV (52 HRc), which it can retain up to 400°C.

Applications

The hardness and resistance to impact make the electrode suitable for use in a large variety of applications, which include sugar mill roll roughening, excavator bucket lips and teeth, dragline buckets, conveyor screws, rock chutes, etc.

Classifications		
DIN	8555	E10-UM-55-GPR
AWS	5.13: 2019	EFe Cr-A4 (nearest)
EN	14700:2005	EFe14 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	3,0 - 5,0	**% Silicon**	2,0 max
% Manganese	1,0 - 2,5	**% Chromium**	22,0 - 28,0

Typical Hardness	
HRc	49 - 59

Packing Data (AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	450	140 - 180	5,0	W075644
5,0	450	170 - 210	5,0	W075645

Afrox CR70 MR

Afrox CR70 MR is a hard surfacing electrode specifically designed for wear resistant applications within the sugar industry. The tough eutectic structure of metal carbides in austenite can withstand impact under relatively abrasive conditions.

Applications

It is recommended for mill roll roughening and for surfacing hammers and knives used in the sugar milling industry.

Classifications		
DIN	8555	E10-UM-55-GPR
AWS	5.13: 2019	EFe Cr-A4 (nearest)
EN	14700:2005	EFe14 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	3,0 - 5,0	**% Silicon**	2,0 max
% Manganese	1,0 - 2,5	**% Chromium**	22,0 - 28,0

Typical Hardness	
HRc	49 - 59

Packing Data
(AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	450	140 - 180	5,0	W075648

AZUCAR 80

AZUCAR 80 deposits a tough eutectic of austenite and metal carbide that can withstand impact at medium loads under abrasive conditions. The weld metal has a hardness of approximately 550 HV (52 HRc), which it can retain up to 400°C.

Applications

The hardness and resistance to impact make the electrode suitable for use in a large variety of applications, which include sugar mill roll roughening, excavator bucket lips and teeth, dragline buckets, conveyor screws, rock chutes, etc.

Classifications		
DIN	8555	E10-UM-55-GPR
AWS	5.13: 2019	EFe Cr-A4 (nearest)
EN	14700:2005	EFe14 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	3,0 - 5,0	**% Silicon**	2,0 max
% Manganese	1,0 - 2,5	**% Chromium**	22,0 - 28,0

Typical Hardness	
HRc	49 - 59

Packing Data (AC DC+ 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	110 - 160	5,0	W189653
4,0	450	140 - 180	5,0	W189654

AZUCAR 100

AZUCAR 100 is a chromium carbide hardfacing electrode for use in the downhand position only. The weld metal is unmachinable, but can be ground. The deposited metal is highly resistant to abrasive wear with moderate impact and is recommended for general hardfacing applications on carbon steels, 14% manganese steels and cast iron. Deposits should be limited to two layers to eliminate relief checks.

Applications

The electrode is recommended for general hardfacing applications on carbon steel, alloy steel and cast iron parts. Typical components welded are dredger buckets, excavator shovels, dragline teeth, bulldozer cutting edges and agricultural implements.

Classifications		
DIN	8555	E10-UM-60-GPR
AWS	5.13: 2019	EFe Cr-A8 (nearest)
EN	14700:2005	EFe14 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	3,5 - 4,5	**% Silicon**	1,5 max
% Manganese	0,5 - 2,0	**% Chromium**	33,0 - 38,0

Typical Hardness	
Matrix	49 - 59 HRc
Carbides	1 500 HV

Packing Data
(AC DC+/- 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	450	160 - 200	5,0	W189644

Afrox Cobalarc 1

Afrox Cobalarc 1 is a chromium carbide hardfacing electrode for use in the downhand position only. The weld metal is unmachinable, but can be ground. The deposited metal is highly resistant to abrasive wear with moderate impact and is recommended for general hardfacing applications on carbon steels, 14% manganese steels and cast iron. Deposits should be limited to two layers to eliminate relief checks.

Applications

The electrode is recommended for general hardfacing applications on carbon steel, alloy steel and cast iron parts. Typical components welded are dredger buckets, excavator shovels, dragline teeth, bulldozer cutting edges and agricultural implements.

Classifications		
DIN	8555	E10-UM-55-GPR
AWS	5.13: 2019	EFe Cr-A8 (nearest)
EN	14700:2005	EFe14 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	3,5 - 4,5	**% Silicon**	1,5 max
% Manganese	0,5 - 2,0	**% Chromium**	33,0 - 38,0

Typical Hardness	
Matrix	49 - 59 HRc
Carbides	1 500 HV

Packing Data (AC DC+/- 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
4,0	450	160 - 200	5,0	W075684
5,0	450	160 - 240	5,0	W075685

Afrox Cobalarc 9

Afrox Cobalarc 9 is a complex carbide type hardfacing electrode containing molybdenum and vanadium. The deposited weld metal consists of primary carbide needles in a matrix of carbide/austenite eutectic. The material is highly resistant to abrasive wear with high-impact loading. The electrode is suitable for use in the downhand position only, deposits relief check and should be limited to two layers only.

Applications

Cobalarc 9 is suitable for use on railway tampers, sizing screens, dredger buckets and lips, augers, rolling mill guides and pump impellers.

Classifications		
DIN	8555	E10-UM-60-GP (nearest)
AWS	5.13: 2019	EFe Cr-A7 (nearest)
EN	14700:2005	EFe14 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	4,0 - 5,0	**% Chromium**	25,0 - 29,0
% Manganese	1,0 - 1,5	**% Molybdenum**	2,0 min
% Silicon	1,5 max	**% Vanadium**	1,0 max

Typical Hardness	
Matrix	55 - 65 HRc
Carbides	1 500 HV

Packing Data
(AC DC+/- 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	100 - 145	5,0	W075593
4,0	450	160 - 200	5,0	W075594
5,0	450	160 - 240	5,0	W075595

Hardfacing Gas Assisted Wires

MIG 410

MIG 410 is a solid wire depositing a 410 stainless steel weld metal. It offers good resistance to fire cracking and corrosion frequently encountered in steel mill rolls and produces sound, porosity-free, crack-free weld deposits. A preheat of 200ºC is generally needed to provide crack-free welds.

Applications

MIG 410 can be used on hydrocrackers, reaction vessels, distillation plants, refineries, furnaces, lining, run-out rolls, valve bodies, turbine parts and burner nozzles.

Classifications		
DIN	8555	MSG5-GZ-300-CG

Typical Chemical Analysis (All weld metal)			
% Carbon	0,06 - 0,12	**% Silicon**	0,25 - 0,5
% Manganese	0,6 max	**% Chromium**	12,0 - 13,5

Typical Hardness	
HRc	25 - 35

Packing Data

Diameter (mm)	Spool Mass (kg)	Spool Type	Item Number
1,2	15,0	Wire Basket	W077375
1,6	15,0	Wire Basket	W077376

MIG 420

MIG 420 is a solid wire depositing a martensitic stainless steel weld metal. It offers good resistance to fire cracking and corrosion frequently encountered in steel mill rolls. It produces sound, porosity-free, crack-free weld deposits.

Applications

MIG 420 can be used for cladding mild low alloy carbon steels, offshore oil, chemical and petrochemical plants.

Classifications		
DIN	8555	MSG5-GZ-50-CG

Typical Chemical Analysis (All weld metal)			
% Carbon	0,38	**% Chromium**	13,15
% Manganese	0,46	**% Nickel**	0,18
% Silicon	0,31	**% Molybdenum**	0,06

Typical Hardness	
HRc	48 - 55

Packing Data			
Diameter (mm)	**Spool Mass (kg)**	**Spool Type**	**Item Number**
1,2	15,0	Wire Basket	W077381
1,6	15,0	Wire Basket	W077382

Recommended shielding gas: Argoshield®, Stainshield® (MIG), Argon (TIG)

MIG 600Br/TIG 600

MIG 600Br/TIG 600 is a solid wire for hardfacing parts subject to severe wear. It deposits a martensitic weld metal, which can withstand moderate impact and high abrasion.

Applications

MIG 600Br/TIG 600 is ideal for the surfacing of components subject to severe abrasion combined with moderate impact. Typical components include earth moving buckets, impact rollers, conveyor rollers, percussion drill bits, ripper teeth and any earth engaging equipment used in sandy conditions.

Classifications		
DIN	8555	MSG6-GZ-60-G

Typical Chemical Analysis (All weld metal)			
% Carbon	0,45	**% Silicon**	3,0
% Manganese	0,4	**% Chromium**	9,0

Typical Hardness	
HRc	55 - 60

Packing Data
MIG

Diameter (mm)	Spool Mass (kg)	Spool Type	Item Number
1,0	15,0	Wire Basket	W077060
1,2	15,0	Wire Basket	W077061
1,6	15,0	Wire Basket	W077064

Packing Data
TIG

Diameter (mm)	Tube Mass (kg)	Item Number
1,6	5,0	W077385

Tube Alloy 255-G

Tube Alloy 255-G is a metal cored, gas shielded wire depositing a premium chrome carbide alloy that is extremely resistant to abrasion. It will outlast competitive martensitic wires by 9 to 1.

Applications

Tube Alloy 255-G is suitable for use on ammonia knives, augers, bucket teeth and lips, bulldozer end bits and blades, cement chutes, coal feeder screws, coal pulveriser hammers and tables, coke chutes, coke pusher shoes, conveyor screws, crusher jaws and cones, crusher rolls, cultivator chisels and sweeps, dragline buckets, dredger cutter heads and teeth, dredge pump inlet nozzle and side plates, grizzly bars and fingers, manganese pump shells, muller tyres, ore and coal chutes, pipeline ball joints, pug mill paddles, ripper shanks, road rippers, scraper blades, screw conveyors, sheep's foot tampers, sizing screens and sub soiler teeth.

Classifications		
DIN	8555	MF10-GF-60-G

Typical Chemical Analysis (All weld metal)			
% Carbon	5,3	**% Silicon**	0,4
% Manganese	1,0	**% Chromium**	18,0

Typical Mechanical Properties	
Abrasion Resistance	Excellent
Impact Resistance	Poor
Machinability	Grinding is difficult
Flame Cutting	Cannot be flame cut
Thickness	3 layers max
Microstructure	Massive chrome carbide in an austenite-carbide matrix
Deposit will relief check crack	
Maintains hot hardness to 675°C	

Typical Hardness		
Layer	**1020 Steel**	**Mn Steel**
1	58 HRc	47 HRc
2	61 HRc	51 HRc
3	65 HRc	54 HRc

Welding Data (DC+)				
Diameter (mm)	**Current**		**Electrode Stick Out**	**Deposition Rate (kg/hr)**
	Amps (A)	**Volts (V)**		
1,2	150 - 180	22 - 24	13 - 25	3,2

Packing Data			
Diameter (mm)	**Spool Mass (kg)**	**Spool Type**	**Item Number**
1,2	11,3	Spool	W077073

Recommended shielding gas: Fluxshield®, Stainshield® (MIG)

Tube Alloy 258-G

Tube Alloy 258-G is a metal cored, gas shielded wire depositing a martensitic alloy steel of the H-12 tool steel type. It has excellent resistance to adhesive metal-to-metal wear as well as good resistance to impact and abrasion. It will maintain its hardness up to 500ºC.

Applications

Tube Alloy 258-G is suitable for use on clean out rings, die holders, dummy blocks, extrusion dies, forming dies, forging dies, header dies, hot forming dies, gripper dies, guide rolls, mandrels and swaging dies. It can also be used in submerged arc welding with a neutral flux.

Classifications		
DIN	8555	MF6-GF-55-G

Typical Chemical Analysis (All weld metal)			
% Carbon	0,4	**% Molybdenum**	1,45
% Manganese	1,0	**% Tungsten**	1,25
% Silicon	0,55	**% Vanadium**	0,4
% Chromium	5,0		

Typical Mechanical Properties	
Abrasion Resistance	Good
Impact Resistance	Good
Machinability	Grind only
Flame Cutting	Difficult
Microstructure	Martensitic
Magnetic	
Heat treatable and forgeable	

Typical Hardness

Layer	As Deposited on A36 Plate	Tempered 10 hr @ 500ºC
1	52 HRc	-
2	53 HRc	-
3	57 HRc	54

Welding Data (DC+)

Diameter (mm)	Current		Electrode Stick Out	Deposition Rate (kg/hr)
	Amps (A)	Volts (V)		
1,2	160 - 190	24 - 25	13 - 25	3,2
1,6	275 - 350	24 - 27	25 - 38	4,5

Packing Data

Diameter (mm)	Spool Mass (kg)	Spool Type	Item Number
1,2	11,3	Spool	W077071
1,6	11,3	Spool	W077078

Recommended shielding gas: Stainshield®

Hardfacing Open Arc Cored Wires

Tube Alloy Build Up-O

Tube Alloy Build Up-O is a self-shielded wire depositing a low alloy steel. It is designed for build-up on carbon and low alloy steels only. The weld metal has good compressive strength, impact and crack resistance, making it excellent as a base for more abrasion resistant overlays.

Applications

Tube Alloy Build Up-O is suitable for use on bucket teeth and lips, crane wheels, dragline buckets and dragline chains, dredger ladder rolls, gear teeth, kiln trunnions, mine car wheels, spindles, steel shafts and wobbler ends.

Classifications		
DIN	8555	MF1-GF-300-P
AWS	A5.21	E R C Fe 1-A

Typical Chemical Analysis (All weld metal)			
% Carbon	0,12	**% Silicon**	0,8
% Manganese	2,8	**% Chromium**	1,2

Typical Mechanical Properties	
Abrasion Resistance	Fair
Impact Resistance	Very good
Machinability	Excellent
Flame Cutting	Can be flame cut
Microstructure	Low carbon martensitic
Magnetic	

Typical Hardness

Layer	1020 Steel	4130 Steel
1	34 HRc	41 HRc
2	30 HRc	32 HRc
3	30 HRc	29 HRc

Welding Data (DC+)

Diameter (mm)	Current		Electrode Stick Out	Deposition Rate (kg/hr)
	Amps (A)	Volts (V)		
1,6	275 - 350	24 - 27	25 - 38	4,5

Packing Data

Diameter (mm)	Spool Mass (kg)	Spool Type	Item Number
1,6	11,3	Spool	W077096

Tube Alloy 258-O

Tube Alloy 258-O is a self-shielded wire depositing a martensitic alloy steel of the H-12 tool steel type. It has excellent resistance to adhesive metal-to-metal wear as well as good resistance to impact and abrasion. It will maintain its hardness up to 500°C.

Applications

Tube Alloy 258-O is suitable for use on coupling boxes, dragline chains, kiln trunnions, mill guides, spindles and wobbler ends.

Classifications		
DIN	8555	MF6-GF-55-G
AWS	A5.21	E R C Fe 8

Typical Chemical Analysis (All weld metal)			
% Carbon	0,45	**% Chromium**	6,0
% Manganese	1,4	**% Molybdenum**	1,5
% Silicon	0,8	**% Tungsten**	1,5

Typical Mechanical Properties	
Abrasion Resistance	Good
Impact Resistance	Good
Machinability	Grind only
Flame Cutting	Difficult
Microstructure	Martensitic
Magnetic	
Heat treatable and forgeable	

Typical Hardness

Layer	1020 Steel	4130 Steel
1	49 HRc	51 HRc
2	53 HRc	54 HRc
3	57 HRc	57 HRc

Welding Data (DC+)

Diameter (mm)	Current		Electrode Stick Out	Deposition Rate (kg/hr)
	Amps (A)	Volts (V)		
1,2	160 - 190	24 - 25	13 - 25	3,2
1,6	275 - 350	24 - 27	23 - 38	4,5

Packing Data

Diameter (mm)	Spool Mass (kg)	Spool Type	Item Number
1,2	11,3	Spool	W077070
1,6	11,3	Spool	W077077

Tube Alloy AP-O

Tube Alloy AP-O is a self-shielded wire depositing a high chromium austenitic manganese alloy. The deposit will work harden readily.

Applications

Tube Alloy AP-O is suitable for use in joining austenitic manganese steels to themselves, carbon steels and alloy steels. It is also suitable for use on bucket teeth and lips, crusher jaws and cones, grizzly bars and fingers, hammer mills, hydroelectric turbines, impactor crusher bars, muller tyres, sizing screens and interparticle crushers.

Classifications		
DIN	8555	MF8-GF-200/55-GKNP
AWS	A5.21	E R C MnCr

Typical Chemical Analysis (All weld metal)			
% Carbon	0,4	**% Silicon**	0,3
% Manganese	16,5	**% Chromium**	13,0

Typical Mechanical Properties	
Abrasion Resistance	Fair
Impact Resistance	Excellent
Machinability	Difficult
Flame Cutting	Cannot be flame cut
Microstructure	Austenitic
Hardness (As Deposited)	18 - 24
Hardness (Work Hardened)	50 - 55
Non-magnetic	

Welding Data (DC+)				
Diameter (mm)	**Current**		**Electrode Stick Out**	**Deposition Rate (kg/hr)**
	Amps (A)	**Volts (V)**		
2,8	400 - 450	26 - 29	38 - 51	6,4

Packing Data			
Diameter (mm)	**Spool Mass (kg)**	**Spool Type**	**Item Number**
2,8	27,2	Coil	W077069

Duracor 59-O

Duracor 59-O is a self-shielded flux cored wire, which deposits a weld metal containing chromium carbides in an austenite carbide weld matrix. It provides excellent abrasion resistance. Normally a deposit thickness of two layers is recommended to prevent weld cracking, but up to five layers may be applied with the correct procedure.

Applications

Duracor 59-O is suitable for the hardfacing of sugar cane hammers and knives, mining machinery, buckets, dipper teeth, pulveriser rings, coal crushers and other parts subject to severe abrasive wear.

Classifications		
DIN	8555	MF6-GF-60-G (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	4,9	**% Silicon**	1,0
% Manganese	1,5	**% Chromium**	29,5

Typical Mechanical Properties	
Abrasion Resistance	Excellent
Impact Resistance	Poor
Machinability	Grinding is difficult
Flame Cutting	Cannot be flame cut
Thickness	3-5 layers max
Microstructure	Massive chrome carbide in an austenite-carbide matrix
Deposit will relief check crack	

Typical Hardness	
Layer	**1020 Steel**
1	54 HRc
2	57 HRc
3	60 HRc

Welding Data (DC+)			
Diameter (mm)	**Current**		**Electrode Stick Out**
	Amps (A)	**Volts (V)**	
2,8	400 - 450	26 - 29	38 - 51

Packing Data			
Diameter (mm)	**Spool Mass (kg)**	**Spool Type**	**Item Number**
2,8	25	Spool	W071728
2,8	250	Drum	W071729

Fluxes for Submerged Arc Welding

Hobart SWX HF-N

Hobart SWX HF-N Flux is totally neutral agglomerated flux, designed for welding with solid and tubular wires of the 400 series stainless steels. It can also be used with low alloy steel wires. It features clean slag removal with wires containing Nb and V, excellent recovery of the alloying elements from the tubular wires, such as Cr, Ni, Mo, Nb and V and accepts welding with twin-arc and oscillating technique, with currents up to 1 000 A. Should be used with wires containing at least 0,2% Si, in order to avoid porosity. The main application of MK-N Flux is the rebuilding of steel mill roll with tubular and solid wires of the 400 series stainless steels.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300°C at a flux depth of about 25 mm.

Typical Chemical Analysis (All weld metal)

Wire	Chemical Composition (%)									Hardness
	C	Mn	Si	S	P	Mo	Cr	Ni	Nb	V	HRc
Afrox TA887-S	0,14	0,88	0,55	-	-	1,50	12,5	3,13	0,18	0,23	38 - 40
WASA 414MM-S	0,15	0,90	0,50	0,013	0,022	1,2	12,5	2,0	0,17	0,18	42 - 45
Lincore ER423L	0,15	1,20	0,40	0,010	0,020	1,0	11,5	2,0	-	0,15	42 - 45
Stoody Thermaclad 423L	0,15	1,20	0,50	0,012	0,022	1,0	11,7	2,0	-	0,15	43 - 45
EB3	0,10	0,96	0,16	0,010	0,019	1,08	2,015	-	-	-	-
EM-12K	0,10	0,88	0,19	0,019	0,020	-	-	-	-	-	-

Packing Data

Pack Mass (kg)	Item Number
25,0	W071406

CAST IRON

Section 12 - Welding Consumables

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Welding of Cast Iron

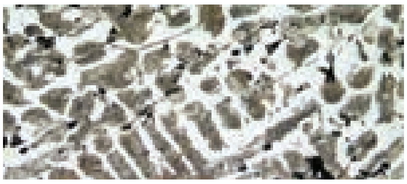
Cast irons, like steels, are essentially alloys of iron and carbon, but whereas the carbon content of steel is limited to a maximum of 2%, cast irons generally contain more than 2% carbon.

To facilitate a better understanding of these materials, they can be divided into five groups, based on composition and metallurgical structure: white cast iron, malleable cast iron, grey cast iron, ductile cast iron and alloy cast iron.

White Cast Iron

White cast iron derives its name from the white, crystalline crack surface observed when a casting fractures. Most white cast irons contain <4,3% carbon, with low silicon contents to inhibit the precipitation of carbon as graphite.

It is used in applications where abrasion resistance is important and ductility not required, such as liners for cement mixers, ball mills, certain types of drawing dies and extrusion nozzles.



Microstructure white cast iron (x200)

White cast iron is generally considered unweldable. The absence of any ductility that can accommodate welding-induced stresses in the base metal and heat affected zone adjacent to the weld results in cracking during cooling after welding.

Malleable Cast Iron

Malleable cast iron is produced by heat treating white cast iron of a suitable composition. Iron carbide can decompose into iron and carbon under certain conditions. This reaction is favoured by high temperatures, slow cooling rates and high carbon and silicon contents.

Ferritic Malleable Cast Iron

At room temperature, the microstructure therefore consists of temper carbon nodules in a ferrite matrix, generally known as ferritic malleable cast iron. The compact nodules of temper carbon do not break up the continuity of the tough ferritic matrix, resulting in high strength and improved ductility. The graphite nodules also serve to lubricate cutting tools, which accounts for the very high machinability of malleable cast iron.

Microstructure of ferritic malleable cast iron (x200)

Ferritic malleable cast iron has been widely used for automotive, agricultural and railroad equipment; expansion joints and railing castings on bridges; chain-hoist assemblies; industrial casters; pipe fittings; and many applications in general hardware.

Perlitic Malleable Cast Iron

If full graphitisation is prevented and a controlled amount of carbon remains in the iron during cooling, finely distributed iron carbide plates nucleate in the iron at lower temperatures. This can be achieved by alloying with manganese, or by replacing the second-stage anneal by a quench (usually in air or oil).

Microstructure of perlitic malleable cast iron (x200)

Due to the presence of iron carbide in the microstructure, the strength and hardness of these castings are increased over those of ferritic malleable cast iron.

Grey Cast Iron

Grey cast iron is one of the most widely used casting alloys and typically contains between 2,5% and 4% carbon and between 1% and 3% silicon. With proper control of the carbon and silicon contents and the cooling rate, the formation of iron carbide during solidification is suppressed entirely, and graphite precipitates directly from the melt as irregular, generally elongated and curved flakes in an iron matrix saturated with carbon.

When a grey iron casting fractures, the crack path follows these graphite flakes and the fracture surface appears grey because of the presence of exposed graphite.

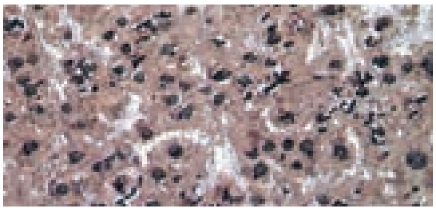
Microstructure of grey cast iron (x200)

The strength of grey cast iron depends almost entirely on the matrix in which these graphite flakes are embedded. Slow cooling rates and high carbon and silicon contents promote full graphitisation, and the majority of the carbon dissolved in the iron at high temperatures is deposited as graphite on the existing flakes during cooling. The structure then consists of graphite flakes in a ferrite matrix, referred to as ferritic grey cast iron.

If graphitisation of the carbon dissolved in the iron at high temperatures is prevented during cooling, iron carbide precipitates out and the matrix is perlitic (referred to as perlitic grey cast iron). Ferritic grey cast iron is normally soft and weak.

Ductile Iron

Ductile cast iron, also known as nodular iron or spheroidal graphite (SG) iron, is very similar in composition to grey cast iron, but the free graphite in these alloys precipitates from the melt as spherical particles rather than flakes. This is accomplished through the addition of small amounts of magnesium or cerium to the ladle just before casting. The spherical graphite particles do not disrupt the continuity of the matrix to the same extent as graphite flakes, resulting in higher strength and toughness compared with grey cast iron of similar composition.



Microstructure of SG cast iron with bulls eye ferrite (x200)

Typical applications are agricultural (tractor and implement parts); automotive and diesel (crankshafts, pistons and cylinder heads); electrical fittings, switch boxes, motor frames and circuit breaker parts; mining (hoist drums, drive pulleys, flywheels and elevator buckets); steel mill (work rolls, furnace doors, table rolls and bearings); and tool and die (wrenches, levers, clamp frames, chuck bodies and dies for shaping steel, aluminium, brass, bronze and titanium).

Mechanical Properties

Due to the low toughness and ductility of cast iron (especially white and grey cast iron), standard tensile and impact toughness tests have limited applicability, and elongation and absorbed energy values are not always available. Some of the mechanical properties of the different types of cast iron are shown in the table below. The wide variation in mechanical properties within a particular class of cast iron, as shown below, can be attributed to a variation in microstructure.

The machinability of grey, malleable and ductile cast irons is superior to that of carbon steel, and these alloys even outperform free-cutting steel. The excellent machinability can be attributed to the lubricating effect of the graphite particles in the microstructure. Grey cast iron has a very high damping capacity (ability to quell vibrations) and is therefore well suited for bases and supports, as well as for moving parts.

Welding

Cast irons include a large family of ferrous alloys covering a wide range of chemical compositions and metallurgical microstructures. Some of these materials are readily weldable, while others require great care to produce sound welds. Certain cast irons are considered unweldable.

A major factor contributing to the difficulty of welding cast iron is its lack of ductility. If cast irons are loaded beyond their yield points, they break rather than deform to any significant extent. Weld filler metal and part configuration should therefore be selected to minimise welding stresses.

MMA, flux cored arc, MIG, TIG and gas welding processes are normally used with nickel-based welding consumables to produce high-quality welds, but cast iron and steel electrodes can also produce satisfactory welds in certain alloys.

Iron castings are generally welded to:

- Repair defects in order to salvage or upgrade a casting before service,
- Repair damaged or worn castings, and
- Fabricate castings into welded assemblies.

Repair of defects in new iron castings represents the largest single application of welding cast irons. Defects such as porosity, sand inclusions, cold shuts, washouts and shifts are commonly repaired. Fabrication errors, such as inaccurate machining and misaligned holes, can also be weld repaired.

Due to the widely differing weldability of the various classes of cast iron, welding procedures must be suited to the type of cast iron to be welded.

White Cast Iron

Because of its extreme hardness and brittleness, white cast iron is considered unweldable.

Malleable Cast Iron

During welding, the ductility of the heat affected zone (HAZ) of malleable cast iron is severely reduced because graphite dissolves and precipitates as iron carbide. Although post weld annealing softens the hardened zone, minimal ductility is regained. Despite these limitations, malleable cast irons can be welded satisfactorily and economically if precautions are taken.

Because most malleable iron castings are small, preheating is seldom required. If desired, small welded parts can be stress relieved at temperatures up to 550°C. For heavy sections and highly restrained joints, preheating at temperatures up to 200°C and a post weld malleabilising heat treatment are recommended. However, this costly practice is not always followed, especially when the design of the component is based on reduced strength properties of the welded joint.

Ferritic malleable grades display the best weldability of the malleable cast irons, even though impact strength is reduced by welding. Perlitic malleable irons, because of their higher combined carbon content, have lower impact strength and higher crack susceptibility when welded. If a repaired area must be machined, welding should be performed with a nickel-based electrode.

MMA welding cast iron, using low carbon steel and low hydrogen electrodes at low currents, produces satisfactory welds in malleable iron. If low carbon steel electrodes are used, the part should be annealed to reduce the hardness in the weld (due to carbon pick-up) and in the HAZ.

Grey Cast Iron

As grey cast iron contains graphite in flake form, carbon can readily be introduced into the weld pool, causing weld metal embrittlement. Consequently, techniques that minimise base metal dilution are recommended. Care must be taken to compensate for shrinkage stresses, and the use of low strength filler metals helps reduce cracking without sacrificing overall joint strength.

Grey cast iron welds are susceptible to the formation of porosity. This can be controlled by lowering the amount of dilution with the base metal, or by slowing the cooling rate so that gas has time to escape. Preheat helps reduce porosity and reduces the cracking tendency. A minimum preheat of 200°C is recommended, but 315°C is generally used.

The most common arc welding electrodes for grey cast iron are nickel and nickel-iron types. These electrodes have been used with or without preheating and/or post weld heat treatment. Cast iron and steel electrodes must be used with high preheats (550°C) to prevent cracking and the formation of hard deposits.

Ductile Cast Iron

Ductile cast irons are generally more weldable than grey cast irons, but require specialised welding procedures and filler materials. Perlitic ductile iron produces a larger amount of martensite in the HAZ than ferritic ductile iron and is generally more susceptible to cracking.

MMA, using nickel-iron electrodes, is the most common welding technique for welding ductile iron. Most castings do not require preheating, but preheats of up to 315°C are used on large components.

Electrodes should be dried to minimise hydrogen damage and porosity. If machinability or optimum joint properties are desired, castings should be annealed immediately after welding.

Table of Mechanical Properties of a Range of Cast Irons

Cast Iron	Tensile Strength (MPa)	Compressive Strength (MPa)	Hardness (HB)	Elongation (%)	Toughness (J)
White	200 – 410	Not available	321 – 500	Very low	Very low
Malleable	276 – 724	1 350 – 3 600 (perlitic and martensitic)	110 – 156 (ferritic) 149 – 321 (perlitic and martensitic)	1 – 10	4 – 12 J @ 20°C
Grey	152 – 431	572 – 1 293	156 – 302	<0,6	Very low
Ductile	345 – 827	359 – 920	143 – 302	2 – 20	16 – 27 J @ 20°C

Typical Applications for the Filler Metal

Types used for Welding Cast Iron

Filler Type	Typical Application
Cast Iron	Oxy-acetylene and arc welding of grey, ductile and blackheart malleable irons where good colour match is required. Different consumables give either a flake or a nodular graphite structure.
Ni	Joining and repair of grey irons and for surfacing high dilution welds in stronger grades. Produces a soft peenable deposit. Special electrode coverings are available to help repair deep cavities and blow holes.
NiFe	Joining and repair of ductile, blackheart malleable and higher strength grey irons. Also used to join cast iron to dissimilar metals and for welding austenitic irons. Can also be used on irons with high sulphur and phosphorus levels.
NiFeMn	Similar applications to NiFe fillers, but a stronger, more crack resistant deposit is produced.
NiCu	Used when a soft peenable deposit with good colour match is required on grey, nodular and blackheart malleable irons. Also useful for welding castings of unknown type and composition.
CuSn	Mostly used for its good sliding and anti-seizing properties (i.e. for surfacing applications, particularly on grey irons).
CuAl	Similar applications to CuSn, but with poorer surfacing properties, yet higher strength.
CuMnNiAl	Similar application to CuAl fillers, but used where higher strength is required.

Practical Considerations

Base Metal Preparation

Proper preparation of a casting prior to welding is very important. All traces of the defect must be removed from the casting, usually by chipping, grinding, arc gouging or flame gouging. Dye-penetrant inspection is recommended to ensure complete removal of all defects. Thorough cleaning of the joint faces and adjacent material prior to welding is essential to ensure successful repair welding and to prevent porosity and wetting difficulties.

Castings that have been in service are often saturated with oil or grease. Exposure to high temperatures during the weld thermal cycle can cause dissociation of these hydrocarbon compounds, resulting in the formation of porosity in the weld. For this reason, any surface oil or grease must be removed prior to welding, using solvents or steam cleaning. The surface skin of the casting, which may contain burned-in sand or other impurities from the mould, should also be removed. Castings that have been in service for extended periods of time may also require degassing by heating the casting uniformly to about 370°C for 30 minutes, or for a shorter time to almost red heat (approximately 540°C), using an oxy-fuel gas torch or circulating air furnace.

If localised degassing is preferred, the weld area can be heated by depositing a weld pass, which usually becomes very porous, and then removing it by grinding. This welding and grinding operation is repeated until the weld metal is sound. The weld may then be completed as specified in the welding procedure. Castings that have been impregnated with a plastic or glass sealer should not be repair welded, because the sealer may inhibit fusion or produce excessive porosity in the weld.

It is also important that the outer surface of the casting and any ground surfaces be wiped with mineral spirits, such as acetone, to remove residual surface graphite prior to welding. Residual graphite inhibits wetting and prevents complete joining and fusion. When wetting difficulties are encountered, the following cleaning methods can be used:

- Electrochemical cleaning in a molten salt bath operating at a temperature of 455–510°C in a steel tank. By passing direct current through the bath, a surface essentially free of graphite, sand, silicon, oxides and other contaminants can be produced.
- Abrasive blasting with steel shot is suitable for preparing the surfaces of ductile and malleable cast iron, but should not be used for grey cast iron.
- Searing the surfaces to be welded with an oxidising flame or heating the casting to about 900°C in a strongly decarburising atmosphere, may be suitable in some applications.

Before any cleaning procedures are used in production, wetting tests should be conducted, using the proposed filler metal and welding procedure. The filler metal should be applied to a clean, flat surface and then examined visually. If the surface is not uniformly wetted, it has not been cleaned sufficiently.

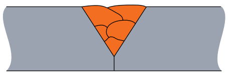
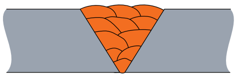
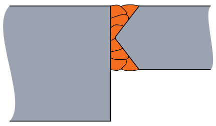
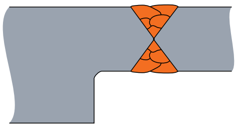
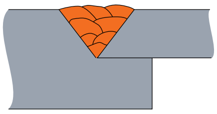
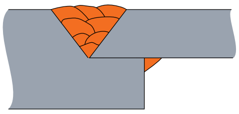
Special Welding Techniques for Cast Irons

Improved weld performance can be achieved by application of several special techniques. These include:

- Joint design modifications
- Groove face grooving
- Studding
- Peening
- Special deposition sequences and electrode manipulation.

Joint Design Modification

Full penetration welds are better than partial penetration ones, since the crevice left unfused can act as a stress concentration, increasing the risk of cracking. It is therefore advisable, where possible, to modify joint design to allow full penetration weld to be made, as shown below. Welds at changes in thickness can suffer uneven expansion and contraction stresses during the welding cycle, and also are located at stress concentrations. A change in design to move the weld to a region of constant thickness is therefore beneficial in some cases, since the weld is then removed from the 'danger area'. A backing fillet weld can also be used to support a weld in a region of stress concentration.

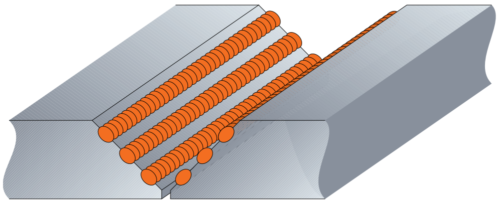
Poor Design	Improved Design
Partial penetration welds	**Full penetration welds**
	
Uneven thickness	**Constant thickness**
	
Without backing fillet weld	**With backing fillet weld**
	

Modifications to joint design that would lead to the minimisation of stress concentrations and therefore also reduce the risk of cracking in cast iron welds

Groove Face Grooving

Grinding or gouging grooves into the surface of the prepared weld groove, then filling the grooves with a weld bead, before filling the whole joint, as shown opposite, is sometimes recommended. This reduces the risk of cracking by deflecting the path of a crack. Also, as with conventional buttering, the beads that are in contact with the casting, and therefore most highly diluted, are deposited first, when the stresses on the fusion line and heat affected zone of the weld are lowest.

Grooving Joint Face

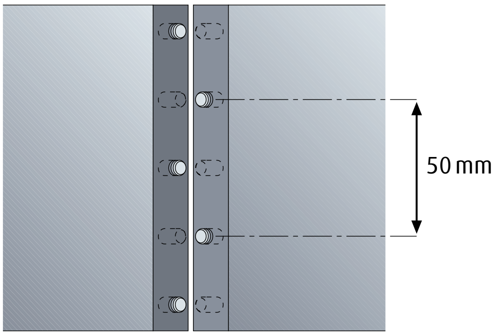


The technique of grooving the joint face before filling. This interrupts the line of the heat affected zone

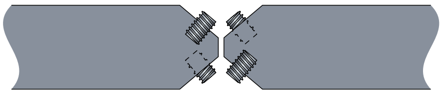
Studding

Improved joint strength can be achieved by driving or threading studs into the joint face. These should be staggered as shown below, so that a stud does not face another directly opposite it across the joint. Provided the studs are of a material compatible with the filler metal, this technique can help reduce underbead cracking in the HAZ or along the fusion line.

Staggered Studs (Top view)



Staggered Studs (Cross section)



Screwing or driving staggered studs into the joint face before welding to improve joint strength

Peening

By hammering (peening) a deformable weld bead, and thereby putting it into a state of compressive stress, the tensile stresses caused by thermal contraction can be opposed, thus reducing the risk of cracking in and around the weld. This requires a ductile weld metal. Nickel fillers are very suitable and, when welding brittle grey cast irons, this process is extremely useful. When stronger joints are required and iron-nickel consumables are used, then peening must be done at higher temperatures, while the metal is still sufficiently soft. Peening can be mechanised or done manually. For manual work, a 13–19 mm ballpeen hammer is used to strike moderate blows perpendicular to the weld surface. Mechanised hammers should operate at 620 kPa and at 750–1 000 mm/min.
The hammer head should be no wider than the weld bead and should have a radius equal to half the width.

Deposition Techniques and Electrode Manipulation

Arc Welding

Stringer or weave techniques can be used in depositing the weld bead, though weaving should be kept to within three times the electrode core diameter. Minimum dilution will result from using the stringer technique in the flat position, with the arc directed at the weld pool rather than the base metal. When re-striking the arc, this should be done on deposited metal, rather than base metal, though any slag must first be removed. This can be done with a cold chisel or chipping hammer.

In long welds, or welds on thick base material, depositing short, staggered beads will help minimise distortion, by balancing contraction stresses. Buttering of thick joint faces before filling in the rest of the joint is recommended. This is particularly effective if the buttering layers are of a composition more tolerant to dilution by the base metal.

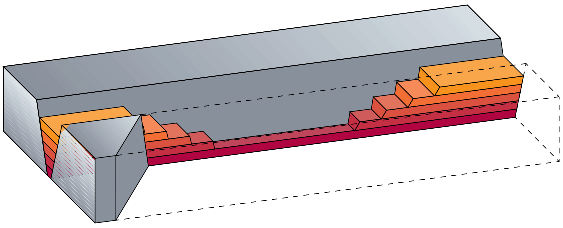
To minimise penetration, short circuit dip-transfer modes should be used with MIG, MAG and flux cored welding processes, and arc lengths in MMA welding should be kept as short as possible while still maintaining good weld shape. In general, the welding current should be kept as low as possible within the range specified by the consumable manufacturer.

Oxy-Acetylene Welding

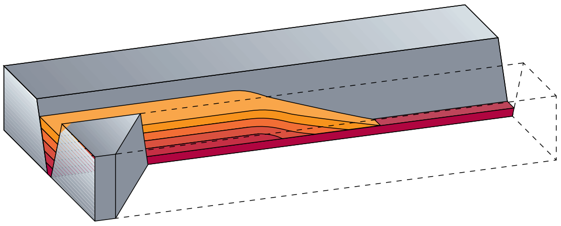
When depositing cast iron by the gas welding process, the torch flame should not be oxidising, as the resulting loss of silicon promotes the formation of brittle white iron in the deposit. Similarly, the tip of the inner cone of the flame should be kept between 3 and 6 mm from the casting surface, and should not actually touch. The welding rod should be melted by immersion into the molten weld pool, and not melted directly by the torch flame.

Two types of sequence are recommended for depositing cast iron by gas welding. With the so-called ‘block’ sequence, filler metal can either be deposited in blocks of ~2,5 cm, before filling between the blocks. With the so-called ‘cascade’ sequence, thin layers are deposited, with each one being slightly longer than the preceding one. Both the block and cascade sequences are illustrated below.

Block Sequence of Bead Deposition



Cascade Sequence of Bead Deposition



Braze Welding

Since this process is particularly sensitive to the wetting of the base metal surface by the filler, cleanliness of the iron before welding is essential. This means that smeared graphite on the surface after grinding must be removed. The bronze welding rod is melted by contact with the base metal after preheating by the gas flame to 425–480°C. The slightly oxidising inner cone of the flame should not be brought into contact with the consumable rod or the base metal. The rounded edges recommended for the joint faces in bronze welding increase the interface area between the casting and the deposited metal.

Cracking

All cast irons have a common problem affecting their weldability, namely their high carbon contents. Welding of cast iron is associated with rapid cooling of the weld pool and adjacent base metal, compared with the slower cooling rates experienced during casting, and tends to produce undesirable microstructures, such as iron carbide and high-carbon martensite. Martensite and iron carbide are both very brittle and may cause cracking, either spontaneous or during service. The degree of embrittlement depends on the amount of iron carbide and martensite formed, which in turn depends on the cast iron composition and thermal treatment. The presence of hard, brittle martensite in the HAZ also increases the risk of hydrogen-induced cracking.

Martensite in the HAZ may be tempered to a lower strength or a more ductile structure during post weld heat treatment, or it may be totally eliminated by ensuring very slow cooling rates after welding. Multiple-pass welding and minimum preheat and interpass temperatures are commonly specified to retard the cooling of cast iron welds and to prevent the transformation to martensite. Alternatively, welding procedures designed to reduce the size of the HAZ, and thus minimise cracking, can be used. Methods of accomplishing this include:

- Reduction of heat input
- Use of small-diameter electrodes
- Use of low melting point welding rods and wires
- Use of lower preheat temperatures.

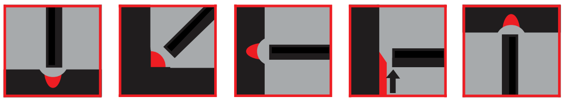
Cast Irons

Type	MMAW	FCAW	Gas Welding	Gas Brazing
Grey Cast Iron	Afrox Ferroloid 1 Afrox Ferroloid 2 Afrox Ferroloid 3 Afrox Ferroloid 4 Afrox Transcast 55	Filmax FN55 Filmax Ni-1	Super Silicon	Fluxobronze M15 Afrox M15 Bronze Afrox Nickel Bronze DB
SG and Nodular Cast Iron	Afrox Ferroloid 1 Afrox Ferroloid 2 Afrox Ferroloid 3 Afrox Ferroloid 4 Afrox Transcast 55	Filmax FN55 Filmax Ni-1	Super Silicon	Fluxobronze M15 Afrox M15 Bronze Afrox Nickel Bronze DB
White Cast Iron (Chilled Iron)	NR	NR	NR	NR
Malleable Cast Iron	Afrox Ferroloid 1 Afrox Ferroloid 2 Afrox Ferroloid 3 Afrox Ferroloid 4 Afrox Transcast 55	Filmax FN55 Filmax Ni-1	Super Silicon	Fluxobronze M15 Afrox M15 Bronze Afrox Nickel Bronze DB

NOTES
1 Use Afrox Transcast 55 for joining, build-up and crack repairs.
2 Use Ferroloid 4 for cosmetic repairs.
NR = Not Recommended

Cast Iron Electrodes

Afrox Ferroloid 1



Afrox Ferroloid 1 is a Monel® cored electrode which deposits a machinable nickel-copper weld on cast iron without preheating. The weld metal gives an excellent colour match with the casting, thus making the electrode eminently suitable for the repair and rebuilding of components. The electrode has a smooth arc and the deposit is sound and neat in appearance. The slag is easily removed.

Applications

This electrode is suitable for the repair of all commercially available irons such as grey, blackheart malleable and nodular spheroidal graphite irons, with or without preheating.

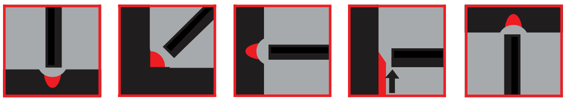
Classifications		
AWS	A5.15	ENiCu-B (carbon content modified)
EN ISO	1071	ENiCu-B (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,40 - 1,10	**% Copper**	25,0 - 30,0 max
% Manganese	2,25 max	**% Nickel**	60,0 - 70,0
% Silicon	0,75 max	**% Iron**	3,0 - 6,0
% Sulphur	0,025 max		

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	65 - 95	5,0	W075803
4,0	350	100 - 130	5,0	W075804

Afrox Ferroloid 2



Afrox Ferroloid 2 is an all-position, basic coated electrode for the strength welding of cast iron and for joining mild steel to cast iron. The electrode uses a mild steel core wire and deposits a steel weld metal, which tends to rust. A good colour match between the weld and casting should not be expected.

Applications

Afrox Ferroloid 2 is used mainly for the repair of grey, i.e. failed iron castings and defective components with and without the application of a preheat. In both cases, the weld metal and heat affected zone are unmachinable after welding and finishing can only be achieved by grinding.

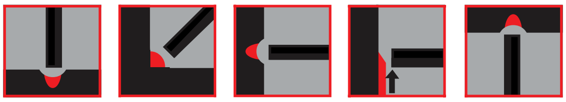
Classifications		
AWS	A5.15	ESt
EN ISO	1071	ESt (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Sulphur**	0,03 max
% Manganese	0,30 max	**% Iron**	Bal.
% Silicon	0,03 max	**% Phosphorous**	0,03 max

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	70 - 105	5,0	W075813

Afrox Ferroloid 3



Afrox Ferroloid 3 is an all-positional electrode depositing a nickel-iron alloy weld which is machinable without undue difficulty. The weld metal after machining provides a close colour match with the casting. The electrode has a smooth soft arc and is easy to use with a small slag volume, which is readily removable.

Applications

This electrode has been specifically designed for the strength welding of high duty cast iron, such as meehanite, malleable and spheroidal graphite or nodular irons. It is ideal for welding thick sections of different types of cast irons to each other or to steel. It can be used to weld high-phosphorous castings and to join thin sections of grey cast iron to themselves or to other ferrous materials. Although preheating is recommended, the electrode can be used where no preheat has been applied.

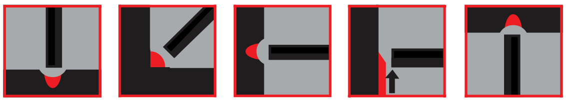
Classifications		
AWS	A5.15	ENiFe-CI
EN ISO	1071	ENiFe-2 (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	2,0 max	**% Iron**	Bal.
% Manganese	1,0 max	**% Nickel**	45,0 - 60,0 max
% Silicon	4,0 max	**% Copper**	2,5 max
% Sulphur	0,03 max		

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	**Electrode Length (mm)**	**Current (A)**	**Pack Mass (kg)**	**Item Number**
2,5	350	70 - 90	5,0	W075822
3,15	350	90 - 120	5,0	W075823
4,0	350	120 - 140	5,0	W075824

Afrox Ferroloid 4



Afrox Ferroloid 4 is a nickel cored electrode designed to produce machinable welds in cast iron, without any preheat. When used in the recommended manner, the fusion zone is extremely narrow with hard areas of heat affected iron at a minimum. Welds are free from cracks and porosity, and exhibit mechanical properties adequate for cast iron. The colour match of the deposit approximates that of cast iron.

Applications

This electrode has been specifically designed for the rectification and repair of all commercial grades of cast iron, where machining, after welding, is to be carried out. Preheating and post weld heat treatment is not required in many applications where the location of the defect or shape of design is such that high stresses are not developed. Control of heat input is essential, particularly avoiding local heat build-up.

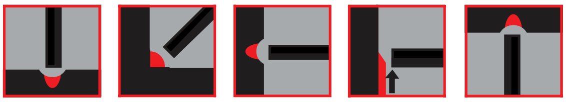
Classifications		
AWS	A5.15	ENi-CI
EN ISO	1071	ENi-Cl (nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	2,0 max	**% Iron**	8,0 max
% Manganese	1,0 max	**% Nickel**	90,9 min
% Silicon	4,0 max	**% Copper**	2,5 max
% Sulphur	0,03 max		

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	350	40 - 90	5,0	W075832
3,15	350	60 - 105	1,0	W072833
3,15	350	60 - 105	5,0	W075833
4,0	350	90 - 135	5,0	W075834

Afrox Transcast 55



Afrox Transcast 55 is an all-position electrode having a bimetal core wire and depositing a nickel iron alloy weld metal, which is machinable without undue difficulty. The weld metal after machining provides a close colour match with the casting. The low electrical resistance of the core wire avoids heat build-up in the electrode and ensures consistent arc and flux characteristics.

Applications

This electrode has been specifically developed for strength welding of high duty cast irons such as alloyed cast iron, meehanite, and malleable and nodular irons. It is ideal for welding various types of cast irons to each other or to steel.

It may also be used to weld high phosphorous castings and to join sections of grey iron to same or to ferrous materials. Although preheating is recommended, the consumable can be used without preheating the parent material.

Classifications

AWS	A5.15	ENiFe-CI
EN ISO	1071	ENiFe-2 (nearest)

Typical Chemical Analysis (All weld metal)

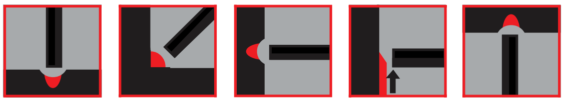
% Carbon	2,0 max	**% Iron**	Bal.
% Manganese	1,0 max	**% Nickel**	45,0 - 60,0
% Silicon	4,0 max	**% Copper**	2,5 max
% Sulphur	0,03 max		

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,15	350	80 - 125	Sleeve (2 electrodes)	W072933
3,15	350	80 - 125	1,0	W072934
3,15	350	80 - 125	5,0	W075933
4,0	350	90 - 150	5,0	W075934

Cast Iron MIG & TIG Wires

Afrox Filmax Ni-1
Afrox TIG Ni-1



Afrox Ni-1 solid wires for TIG and MIG welding are designed to give a low carbon pure nickel deposit with the addition of titanium for refinement and de-oxidation. They are used for joining pure nickel to itself, for buffer layers, and for cladding joint faces and flanges. The solid wire is also useful for welding cast iron to give a soft low strength deposit. Afrox Filmax Ni-1 is also excellent for metal spraying.

Applications

Applications include tanks and vessels, process pipework and heat exchangers, in chemical plants for salt production, chlorination and evaporation of caustic soda. Also used for handling corrosive alkalis and halides. Repair and rebuilding of standard grades of grey cast irons and malleable cast irons.

Materials to be Welded
ASTM-ASME BS DIN Proprietary alloys
UNS N02200 NA11 2.4066 Nickel 200 and 201 (Special Metals)
UNS N02201 NA12 2.4068 Nickel 99.6 and 99.2 (VDM) 2.4061

Classifications		
AWS	A5.15	ENi-CI
EN	18274	Ni 2061 (NiTi3)

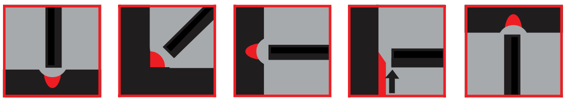
Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	93,0 min
% Manganese	1,0 max	**% Titanium**	2,0 - 3,5 max
% Silicon	0,75 max	**% Copper**	0,25 max
% Sulphur	0,015 max	**% Iron**	1,0 max
% Phosphorous	0,03 max	**% Aluminium**	1,5 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	355 MPa
Tensile Strength	585 MPa
% Elongation on 4d	35
% Elongation on 5d	31
% Reduction of Area	65
Hardness cap/mid	155/185 HV

Packing Data
(DC+ AC 70 OCV min)

MIG			TIG			
Diameter (mm)	Pack Mass (kg)	Item Number	Diameter (mm)	Pack Mass (kg)	Consumable Length (mm)	Item Number
1,2	15,0	W077673	2,0	5,0	1 000	W077668
-	-	-	2,4	5,0	1 000	W077669

Afrox Filmax FN55



Afrox Filmax FN55 solid MIG welding wire is designed to deposit Fe-55% Ni weld metal for the repair and joining of cast iron. The NiFe alloy is suitable for welding all grades of cast iron but particularly for spheroidal graphite (SG), nodular or ductile irons and some alloy cast irons. It provides compatible strength, ductility and toughness, coupled with good machinability. The NiFe consumables can also be used on some of the high alloy austenitic irons (Ni-Resist). The flake graphite grades are welded with a preheat of 300-350°C but the SG grades are best buttered using low heat input, and low temperature techniques to avoid HAZ hot cracking. Note the martensitic Ni-Hard cast irons and white irons are generally considered to be unweldable because they are too crack-sensitive. The NiFe consumables are also suitable for welding transition joints between cast iron and cast steels, and cast iron and mild/low alloy steels.

Applications

Typical components are machine bases, pump bodies, engine blocks, gears and transmission housings.

Materials to be Welded
ASTM/UNS BS
A602, A47, A338, A220 2789 – SG irons
6681 – Ductile irons

Classifications		
DIN	17745	2.4472
BS	2901Pt5	NA47

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	52,0 - 60,0
% Manganese	1,0 max	**% Iron**	Bal.
% Silicon	0,5 max	**% Copper**	0,5 max
% Sulphur	0,02 max	**% Cobalt**	2,0 max
% Phosphorous	0,03 max		

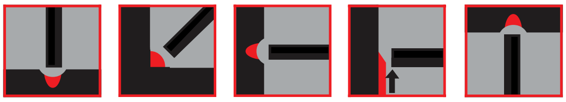
Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	230 MPa
Tensile Strength	400 MPa
% Elongation on 4d	24
Hardness cap/mid	150 HV

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Pack Mass (kg)	Item Number
1,0	15,0	W077695
1,2	15,0	W077696

Cast Iron Oxy-Fuel Rods

Afrox M15 Bronze



A widely used brazing and bronze welding rod depositing metal which has good tensile strength. This versatile brazing rod is ideally suited for sheet metal work such as motor bodies, tubular and galvanised iron fabrication as well as for copper and for brazing cast iron, and heavy steel sections. The product may be used for fusion-weld brass.

Classifications		
AWS	A5.27	R CuZn-C
Rod Identification		
M15	Stamped	

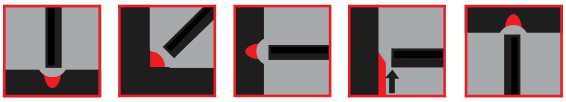
Typical Chemical Analysis (All weld metal)			
% Copper	56,0 - 60,0	**% Iron**	0,25 - 1,2
% Manganese	0,01 - 0,50	**% Tin**	0,80 - 1,10
% Silicon	0,04 - 0,15	**% Zinc**	Bal.

Typical Mechanical Properties	
Melting Range	860°C - 890°C
Tensile Strength	460 MPa
Approximate Brinell Hardness	125 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Neutral (depending on base metal)
Flux	Use with Afrox M15 Brazing Flux (Item Number W001553)

Packing Data **(DC+ AC 70 OCV min)**			
Diameter (mm)	**Electrode Length (mm)**	**Pack Mass (kg)**	**Item Number**
2,0	750	5,0	W000504
3,2	750	5,0	W000500
5,0	750	5,0	W000501
6,3	750	5,0	W000502

Afrox Fluxobronze M15



A general purpose flux coated bronze alloy used for bronze welding and brazing copper, cast iron, steel sheet and for light assembly work. This low fuming brass rod is fast flowing and leaves minimal flux residue. The fast flowing nature of the alloy reduces heat input which causes distortion.

Classifications		
AWS	A5.27	R CuZn-C

Typical Chemical Analysis (All weld metal)			
% Copper	56,0 - 60,0	**% Iron**	0,25 - 1,2
% Manganese	0,01 - 0,50	**% Tin**	0,08 - 1,10
% Silicon	0,04 - 0,15	**% Zinc**	Bal.

Typical Mechanical Properties (All weld metal in the as welded condition)	
Melting Range	860°C
Tensile Strength	440 MPa
Approximate Brinell Hardness	120 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Neutral

Packing Data

Diameter (mm)	Electrode Length (mm)	Pack Mass (kg)	Item Number
2,5	450	5,0	W000375
3,2	450	5,0	W000376

Afrox Nickel Bronze DB

A versatile 10% nickel bronze alloy rod suitable for bronze welding and brazing of steel, cast iron and copper alloys. Since the weld deposit work hardens in service, the rod is ideal for building up worn or broken parts such as gear teeth, bearings, valve seats and faces. It is widely used for maintenance work.

Typical Chemical Analysis (All weld metal)			
% Copper	46,0 - 50,0	**% Lead**	0,05 max
% Nickel	9,0 - 11,0	**% Aluminium**	0,01 min
% Silicon	0,04 - 0,25	**% Zinc**	Bal.
% Phosphorous	0,25 max		

Typical Mechanical Properties	
Melting Range	800°C - 910°C
Tensile Strength	530 MPa
Approximate Brinell Hardness	
As Deposited	150 HB
Work Hardened	320 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Neutral (depending on base metal)
Flux	Use with Afrox M15 Brazing Flux (Item Number W001553)

Packing Data

Diameter (mm)	Electrode Length (mm)	Pack Mass (kg)	Item Number
1,5	700	5,0	W000520
3,2	700	5,0	W000521

Cast Iron Fluxes

Afrox Cast Iron Flux

Afrox Cast Iron Flux is a grey powder with a melting point of 850ºC recommended for use when grey cast irons are welded with Afrox Super Silicon cast iron rods. This flux may be used with water to form a paste.

Packing Data	
Container Mass (g)	**Item Number**
500 (jar)	W001524

Afrox M15 Brazing Flux

Afrox M15 Brazing Flux is a white powdered flux with a melting point of 800°C. It is recommended for use when brazing or bronze welding mild steel, copper, brass, cast iron, and galvanised iron. For galvanised work, mix powder with water to form a paste and paint onto both sides of joint to protect heated zinc from flame and atmosphere.

Packing Data	
Container Mass (g)	**Item Number**
500 (jar)	W001553

COPPER

Section 12 - Welding Consumables

Copper 650
Copper & Copper Alloys 651
Copper MIG & TIG Wires 654
Oxy-Fuel Welding & Brazing Rods 658
Copper/Phosphorous & Copper/Silver Brazing Alloys 661
Copper Brazing Fluxes 662

Copper & Copper Alloys

Copper is a metal with some very important properties, the main ones being its high electrical conductivity, its high thermal conductivity, its excellent resistance to corrosion, and its ease of fabrication, either hot or cold.

Copper is also ductile and malleable and has a relatively low melting point at just over 1 080°C.

The three basic commercial grades of copper that are available are:

- Tough pitch copper, containing up to 0,1% oxygen
- Phosphorous deoxidised (PDO) copper, containing up to 0,04% phosphorous
- Oxygen-free copper, containing no deoxidants.

The phosphorous deoxidised grade was originally developed to overcome problems encountered when flame welding tough pitch copper. It is now the standard commercial weldable grade used for pressure vessels and radiators. Oxygen-free grades have significantly higher electrical conductivity than oxygen-containing grades and are therefore used widely as electrical conductors.

Types

Copper and copper alloys are generally grouped by compositional type and identified in standards by number or letter/number designations. However, it has been, and still is, common practice to refer to copper and copper alloys by their traditional names, such as brass and bronze, rather than by letters and number designations.

Copper and copper alloys may be divided into groups by general composition, and each group contains a range of specific alloys. The main groups considered here are:

- Unalloyed copper
- Beryllium copper
- Brasses
- Bronzes
- Silicon bronzes
- Aluminium bronzes
- Cupro-nickels.

Welding

As has been stated earlier, copper has a very high thermal conductivity and a high coefficient of expansion. These provide the main problems encountered during welding of unalloyed copper. High levels of preheat and heat inputs are required for fusion welding. These in turn can cause distortion problems. Copper is also susceptible to hot cracking so heavy restraint needs to be avoided.

The thermal conductivity of many copper alloys is relatively low and welding without preheat may be possible. However, several alloys will crack readily when welded if too much heat is put into the weld area or if welding is carried out under restraint. Any copper alloys containing lead should not be welded.

Welding Processes

Copper and its alloys can be welded, most frequently using inert gas shielded processes, such as MIG and TIG. MMA is used occasionally for welding some copper alloys and gas welding and brazing are also used for some applications.

TIG welding bronze statue

Shielding gases for TIG or MIG welding may be pure argon or helium-argon mixtures, such as the Afrox Copashield®. Pure argon tends to produce a narrow penetration profile that is not very deep. This means that high levels of preheat are required to avoid fusion defects. Helium-argon mixtures with between 50% and 75% helium increase the energy available to the weld so that good weld fusion and penetration can be achieved at minimum preheat temperatures.

High power density processes, like laser and electron beams, are also suitable for welding copper and copper alloys.

The submerged arc and flux cored wire processes are not used for welding copper or copper alloy systems.

Welding Copper

Unalloyed Copper

Tough pitch copper contains oxygen and welding this type of copper can result in weld metal porosity and embrittlement if hydrogen is present. The oxygen and hydrogen combine to form steam and 'steam porosity' is likely to occur if these types of copper are welded with the oxy-acetylene process. Oxygen-free and PDO grades of copper have better weldability than tough pitch copper.

The usual welding processes for copper are MIG and TIG. Filler metals, such as AWS A5.7 type ERCu or BS 2901-3 type C1A, with the addition of de-oxidants, should be used to control porosity.

With all coppers, the main problem is that heat is rapidly dissipated from the weld and this can lead to fusion defects if enough heat is not put into the joint area. Preheat is, therefore, recommended for thicknesses above 5 mm. Preheat levels range from about 200°C at 5 mm to 600°C and above at 20 mm. Highest preheats are required when welding with argon shielding gas but may be lowered or avoided if helium or helium gas mixtures are used, due to the increase in the heat input these gases provide.

Beryllium Copper

Welding of beryllium copper is not carried out extensively, but when it is, the preferred processes are MIG and TIG. Filler metals used to weld unalloyed coppers are used for copper beryllium alloys, since filler metals containing beryllium are not available.

However, welding can present a few problems. Cracking in the HAZ, due to the presence of age-hardening precipitates, may occur if insufficient preheat is applied. Also, beryllium will oxidise rapidly and be given off as fume if the arc region is not properly protected with inert shielding gas. The main problem here is that fume containing beryllium oxide is highly toxic and can cause death.

Welding of copper alloys containing beryllium must be carried out with care and the use of fume extraction equipment and personal respiratory protection is essential.

Brasses

Brasses are not readily weldable, since the application of a welding arc causes the zinc to boil off as zinc oxide fume. Zinc oxide may be identified during welding as dense white fumes rising from the brass, impairing the welder's visibility and leaving white 'cobwebs' on equipment and surrounding attachments as further evidence. Zinc oxide will cause zinc fume fever if inhaled in sufficient quantities.

Loss of zinc from the vicinity of the weld can affect the properties of the material and also causes porosity in the weld metal.

If it is essential to weld brass, use of TIG welding, with a silicon bronze filler rod such as AWS A5.7 type ERCuSi-A or BS 2901-3 type C9 would be the preferred option. Zinc will inevitably be lost from the brass and some weld metal porosity will occur, but may be kept to a minimum with care.

Welding of free-machining brass, containing significant amounts of lead, should not be attempted since it will almost certainly crack.

Silver brazing or soldering of brass is a better idea than welding and can be carried out using suitable braze metals and fluxes.

Bronzes

Bronzes, such as phosphor bronze and gunmetal, are not normally welded during manufacture, but may require repairs to be carried out from time to time. They are not the easiest materials to weld and are frequently brazed or soldered rather than welded.

Phosphor bronzes are likely to suffer hot cracking when welded, but reasonable results can be achieved using MIG or TIG welding with copper-tin filler metals such as AWS A5.7 type ERCuSn-A or BS 2901-3 type C10. Moderate preheat is normally required and high restraint should be avoided.

Gunmetal too may be welded similarly with care (provided it does not contain lead), but hot cracking is a distinct possibility.

'Leaded' phosphor bronzes and gunmetals are generally considered to be unweldable and hot cracking is virtually certain to result if attempts are made to weld these materials.

Bell metal is very difficult to weld because it is hard and brittle and prone to hot cracking. However, cracked church bells have been successfully repair-welded using gas welding and TIG welding with strips of matching bell metal composition as filler metal. High preheat, continuous heating throughout the welding process, and very slow cooling after welding are essential measures to be adopted to prevent cracking.

Aluminium Bronzes

Aluminium bronzes are generally weldable, usually without preheat since the thermal conductivity of aluminium bronze is relatively low. Welding with MMA electrodes is possible, but MIG and TIG are the preferred welding processes. When TIG welding with argon shielding gas, the use of AC current is necessary to break down the tenacious aluminium oxide film, but DC electrode negative may be used with helium-rich shielding gas.

Matching aluminium bronze filler metals are generally used when welding these alloys, and include fillers such as AWS A5.7 types ERCuAl-A2 and ERCuAl-A3, or BS 2901-3 types C12Fe and C13.

Porosity is likely to be a problem in multi-pass welds if correct cleaning procedures are not adopted, and high restraint may induce cracking.

Silicon Bronzes

Silicon bronzes are reasonably weldable and, again, preheat is generally not required. MMA electrodes are available, but the preferred welding processes are MIG and TIG. Silicon bronze filler metals with about 3% silicon are used and fillers of this type conform to specifications such as AWS A5.7 types ERCuSi-A or BS 2901-3 types C9.

Although an oxide film is likely to form on the weld, it is still standard practice to use DC electrode negative when TIG welding with either argon shielding gas or with a helium-argon mixture.

Hot cracking is a potential problem with silicon bronzes and so excessive heating and high restraint should be avoided.

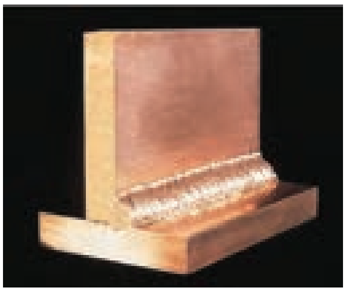
Cupro-Nickels

Cupro-nickel alloys are readily weldable and may be welded using MMA, MIG, or TIG welding processes, generally without preheat. High quality welds can be obtained with all these welding processes.

Electrodes and filler metals conforming to 70/30 copper-nickel are readily available. These conform to specifications such as AWS A5.7 types ECuNi (MMA) and ERCuNi (MIG and TIG) or BS 2901-3 type C18. Filler metal conforming to 90/10 copper-nickel is listed in BS 2901-3 as type C16. Fillers for cupro-nickels usually include titanium as deoxidant, to prevent the formation of porosity.

Argon or Copashield® shielding gases are generally preferred for MIG and TIG welding, the latter often being carried out using DC electrode negative.

Contaminants such as sulphur, phosphorous and lead are detrimental to cupro-nickels and are likely to cause cracking. Thorough cleaning of these alloys before welding is required.



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Copper-Based Filler Selection Guide

Base Metal	**Copper**	**Tin Bronze**	**Red Brass**	**Yellow Brass**	**Nickel Silver**	**Aluminium Bronze**	**Silicon Bronze**	**Copper Nickel**
Carbon & Low Alloy Steel	Aluminium Bronze	Tin Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze
Cast Iron	Aluminium Bronze	Tin Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze
Copper Nickel	Aluminium Bronze	Tin Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Copper Nickel
Silicon Bronze	Tin Bronze	Tin Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Silicon Bronze	
Aluminium Bronze	Aluminium Bronze	Tin Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze	Aluminium Bronze		
Nickel Silver	Silicon Bronze	Tin Bronze	Tin Bronze	Aluminium Bronze	Aluminium Bronze			
Yellow Brass	Silicon Bronze	Tin Bronze	Tin Bronze	Aluminium Bronze				
Red Brass	Tin Bronze	Tin Bronze	Tin Bronze					
Phosphor Bronze	Tin Bronze	Tin Bronze						
Copper	Cuprofil CuSn							

Copper MIG & TIG Wires

Afrox Cuprofil

Afrox Cuprofil is a deoxidised copper filler wire for the welding of pure copper where maximum thermal and electrical conductivity are required. Afrox Cuprofil should be shielded with pure argon, pure helium or an argon/helium mixture (Copashield®) for thicker sections. Flow rates of 10-18 ℓ/min should be used.

Applications

Applications include plate for chemical plant and moulds, stills and calorifiers, rods and wires for electrical components and tubes for heat exchangers.

Materials to be Welded	
Oxygen-free copper	
BS grade	C103, UNS C10200, ISO Cu-OF/Cu-OFS

Classifications		
AWS	A5.7	ERCu
DIN	1733	SG-CuSn (2.1006)
BS	2901Pt3	C7
EN	24373	Cu1898 (CuSn1)

Chemical Analysis (All weld metal)			
% Copper	98,0	**% Lead**	0,01 max
% Aluminium	0,01 max	**% Iron**	0,03 max
% Silicon	0,1 - 0,5	**% Phosphorous**	0,015 max
% Manganese	0,1 - 0,5	**% Arsenic**	0,03 max
% Nickel	0,05 max	**% Others Total**	0,10 max
% Tin	0,5 - 1,0		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	210 - 245 MPa
Hardness	60 - 80 HB

Typical Physical Properties	
Melting Range	1 020 - 1 050
Density kg/dm³	8,9
Electrical Conductivity at 20°C sm/mm²	15 - 20
Thermal Conductivity at 20°C W/(m/K)	120 - 145

Packing Data

Diameter (mm)	Pack Mass (kg)	Item Number
1,2	15,0	W033130
1,6	15,0	W033131

Afrox Filmax Silicon Bronze R
Afrox TIG Silicon Bronze

Afrox Filmax Silicon Bronze R and Afrox TIG Silicon Bronze are pure copper filler wires deoxidised with 3% silicon for welding a wider range of copper alloys than Afrox Cuprofil and Afrox TIG Cu including overlaying of steels and cast irons. The Afrox Filmax Silicon Bronze R wire is optimised for laser brazing. Afrox Filmax Silicon Bronze R should be shielded with pure argon, pure helium or an argon/helium mixture (Copashield®) for thicker sections. Flow rates of 10 - 18 ℓ/min should be used. Afrox TIG Silicon Bronze should be shielded with pure argon but pure helium provides deeper penetration, higher travel speeds and allows preheat to be reduced.

Applications

Applications include plate for chemical plant and moulds, stills and calorifiers, rods and wires for electrical components and tubes for heat exchangers. Also excellent for MIG brazing and laser brazing onto galvanised steel for automotive body panels.

Materials to be Welded

General purpose including phosphorus deoxidised copper, silicon bronze, nickel silver and some brasses.

Classifications		
AWS	A5.7	ERCuSi-A
DIN	1733	SG-CuSi3 (2,1461)
BS	2901Pt3	C9
EN	24373	CU6560 CuSi3Mn1

Chemical Analysis (All weld metal)			
% Copper	Bal.	**% Tin**	0,2 max
% Aluminium	0,01 max	**% Iron**	0,3 max
% Zinc	0,02 max	**% Silicon**	2,8 - 4,0*
% Manganese	0,75 - 1,5	**% Lead**	0,02 max
% Phosphorous	0,02 max	**% Others Total**	0,4 max

* For Afrox Filmax Silicon Bronze R the % silicon is 2,8% - 3,1%

Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	330 - 370 MPa
% Elongation on 5d	40 max
Hardness	80 - 90 HB

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,0	15,0	W033122	1,6	5,0	1 000	W077610
1,2	15,0	W077616	2,4	5,0	1 000	W077611
1,6	15,0	W033126	3,2	5,0	1 000	W077612

Afrox Filmax CuAl-8
Afrox TIG CuAl-8

Afrox Filmax CuAl-8 and Afrox TIG CuAl-8 is an iron-free aluminium bronze. It is recommended for use as a surfacing metal for wear resistant surfaces having relatively light loads, for resistance to corrosive media such as salt or brackish water, and for resistance to many commonly used acids in varying concentrations and temperatures. This alloy is not recommended for joining, but is excellent for metal spraying and overlaying. Afrox Filmax CuAl-8 should be shielded with pure argon, pure helium or an argon/helium mixture (Copashield®) for thicker sections. Flow rates of 10 - 18 ℓ/min should be used.

Applications

Used to overlay on surfaces needing a bronze wearing surface.

Shipbuilding:	Propellers, pumps, shafts and valves, bearings, main shafts
Chemical industry:	Gate valves, sleeves, pipes, heat exchangers and gear housings
Automotive industry:	Maintenance of car parts and tools, bearings in general and galvanised steel sheets
Construction industry:	Overlaying of aluminium bronze with steel base materials

Classifications		
AWS	A5.7	ERCuAl-Al
DIN	1733	SG-CuAl8 (2.0921)
BS	2901Pt3	C28
EN	24373	Cu6100 CuA17 (nearest)

Chemical Analysis (All weld metal)			
% Copper	Bal.	**% Zinc**	0,02 max
% Aluminium	7,5 - 9,5	**% Lead**	0,02 max
% Silicon	0,2 max	**% Iron**	0,5 max
% Manganese	1,0 max	**% Others Total**	0,4 max
% Nickel	0,8 max		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	390 - 450 MPa
% Elongation on 5d	45 max
Hardness	80 - 110 HB
Hardness (Work Hardened)	140 HB

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	15,0	W077595	2,4	5,0	1 000	W077726
1,6	15,0	W077596	-	-	-	-

Afrox Filmax Aluminium Bronze
Afrox TIG Aluminium Bronze

Afrox Filmax Aluminium Bronze and Afrox TIG Aluminium Bronze are solid copper filler wires containing approximately 10% aluminium and 1% iron. These alloys are suitable for welding 5 - 11% aluminium bronzes plus other copper alloys as listed below. For brasses, the weld colour is similar and the presence of aluminium in the filler helps to suppress zinc volatilisation during welding. It can also be used for joining dissimilar alloys, e.g. copper to steel, copper to cast iron, brass to steel, aluminium bronze to steel, etc. These alloys are also suitable for welding components which are subject to sea water corrosion. Afrox Filmax Aluminium Bronze should be shielded with pure argon, pure helium or an argon/helium mixture (Copashield®) for thicker sections. Flow rates of 10 - 18 ℓ/min should be used. Afrox TIG Aluminium Bronze should be shielded with pure argon but pure helium provides deeper penetration, higher travel speeds and allows preheat to be reduced.

Applications

Applications include corrosion resistant and spark resistant pumps, castings, machinery parts, heat exchangers for offshore, marine and mining equipment.

Materials to be Welded	
Aluminium bronze	UNS C61400, BS CA101 - 103, BS 1400 AB1 (cast), Alloy D
Beryllium copper	Cu + 0,5 - 2% Be, closest strength
Brass	Cu + Zn
Aluminium brass	e.g. Yorkalbro Cu - 22% Zn - 2% Al
Manganese bronze	Cu + 20 - 45% Zn + 1 - 3% Mn
Silicon bronze	Cu + 1 - 3,5% Si

Classifications		
AWS	A5.7	ERCuAl-A2
DIN	1733	SG-CuAl10Fe (2.0937)
BS	2901Pt3	C13
EN	24373	Cu6180 CuAi

Chemical Analysis (All weld metal)			
% Copper	Bal.	**% Zinc**	0,02 max
% Aluminium	9,0 - 11,0	**% Lead**	0,02 max
% Silicon	0,1 max	**% Iron**	0,75 - 1,5
% Manganese	1,0 max	**% Others Total**	0,40 max
% Nickel	1,0 max		

Typical Mechanical Properties (All weld metal in the as welded condition)	
Tensile Strength	390 - 500 MPa
% Elongation on 5d	45 max
Hardness	90 - 120 HB
Hardness (Work Hardened)	140 - 160 HB

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	15,0	W033142	1,6	5,0	1 000	W077585

Oxy-Fuel Welding & Brazing Rods

Afrox M15 Bronze

A widely used brazing and bronze welding rod depositing metal which has good tensile strength. This versatile brazing rod is ideally suited for sheet metal work such as motor bodies, tubular and galvanised iron fabrication as well as for copper and for brazing cast iron, and heavy steel sections. The product may be used for fusion-weld brass.

Classifications		
AWS	A5.27 R	CuZn-C
EN	24373	Cu4700 CuZn40Sn
Rod Identification		
M15	Stamped	

Typical Chemical Analysis (Wire analysis)			
% Copper	56,0 - 60,0	**% Iron**	0,25 - 1,2
% Manganese	0,01 - 0,5	**% Tin**	0,8 - 1,1
% Silicon	0,04 - 0,15	**% Zinc**	Bal.

Physical and Mechanical Properties	
Melting Range	860°C - 890°C
Tensile Strength	460 MPa
Approximate Brinell Hardness	125 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Neutral (depending on base metal)
Flux	Use with Afrox M15 Brazing Flux (Item Number W001553)

Packing Data

Diameter (mm)	**Consumable Length (mm)**	**Pack Mass (kg)**	**Item Number**
2,0	750	5,0	W000504
3,2	750	5,0	W000500
5,0	750	5,0	W000501
6,3	750	5,0	W000502

Afrox Fluxobronze M15

A general purpose flux coated bronze alloy used for bronze welding and brazing copper, cast iron, steel sheet and for light assembly work. This low fuming brass rod is fast flowing and leaves minimal flux residue. The fast flowing nature of the alloy reduces heat input which causes distortion.

Classifications		
AWS	A5.27 R	CuZn-C
EN	24373	Cu4700 CuZn405n

Typical Chemical Analysis (Wire analysis)			
% Copper	56,0 - 60,0	**% Iron**	0,25 - 1,2
% Manganese	0,01 - 0,5	**% Tin**	0,8 - 1,1
% Silicon	0,04 - 0,15	**% Zinc**	Bal.

Physical Mechanical Properties	
Melting Range	860°C
Approximate Tensile Strength of Deposited Metal	440 MPa
Approximate Brinell Hardness	120 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Neutral

Packing Data

Diameter (mm)	Consumable Length (mm)	Pack Mass (kg)	Item Number
2,5	450	5,0	W000375
3,2	450	5,0	W000376

Afrox Nickel Bronze DB

A versatile 10% nickel bronze alloy rod suitable for bronze welding and brazing of steel, cast iron and copper alloys. Since the weld deposit work hardens in service, the rod is ideal for building up worn or broken parts such as gear teeth, bearings, valve seats and faces. It is widely used for maintenance work.

Classifications		
EN	24373	Cu7730 CuZn40Ni10

Chemical Analysis (Wire analysis)			
% Copper	46,0 - 50,0	**% Lead**	0,05 max
% Nickel	9,0 - 11,0	**% Aluminium**	0,01 max
% Silicon	0,04 - 0,25	**% Zinc**	Bal.
% Phosphorous	0,25 max		

Physical Mechanical Properties	
Melting Range	800°C - 910°C
Approximate Tensile Strength of Deposited Metal	530 MPa
Approximate Brinell Hardness	
As Deposited	150 HB
Work Hardened	320 HB

Brazing/Welding Parameters	
Process	Oxy-acetylene
Flame Setting	Slightly oxidising
Flux	Use with Afrox M15 Brazing Flux (Item Number W001553)

Packing Data

Diameter (mm)	Consumable Length (mm)	Pack Mass (kg)	Item Number
1,5	700	5,0	W000520
3,2	700	5,0	W000521

Copper/Phosphorous & Copper/Silver Brazing Alloys

Product	Item Number	Diameter (mm)	Pack Mass (kg)	Description	Specification & Classification	Colour Code	Nominal Composition (%)					Melting Range (°C)	Tensile Strength (MPa)
							Ag	Cu	Zn	P	Other		
Silfos 15	W001221 W001321 W001222 W001322	1,5 1,5 3,0 3,0	1,0 5,0 1,0 5,0	These 'self-fluxing' alloys are recommended for fluxless brazing of copper to copper. They should not be used where the nickel content of the alloy exceeds 10% or on ferrous or nickel alloys due to brittleness. The silver bearing alloys possess greater ductility than the copper phosphorous types and are recommended where the joints are subject to significant levels of stress or vibration.	BS 1845 CP 1 DIN 8513 L-ag15P*	Blue	15	Rem	-	4,5	-	645 - 700	637
Eezibraze 2	W001233 W001333 W001232 W001332 W001235	1,5 1,5 3,0 3,0 4,5	1,0 5,0 1,0 5,0 1,0		BS 1845 CP 2 DIN 8513 L-Ag 2*	Yellow	2	Rem	-	6,5	-	645 - 740	490
Copperflo 1	W001244	2,0	-		BS 1845 CP 3 DIN 8513 L-Cu7P*	Grey	-	Rem	-	7,5	-	714 - 800	-
Copperflo 2	W001249	3,0	-		-	Pink	-	-	-	6,0	-	690 - 800	-
Copperflo 3	W001251	3,0	-		BS 1845 CP 6	Orange	-	Rem	-	6,2	-	714 - 850	-

Copper Brazing Fluxes

Afrox M15 Brazing Flux

Afrox M15 Brazing Flux is a white powdered flux with a melting point of 800°C. It is recommended for use when brazing or bronze welding mild steel, copper, brass, cast iron, and galvanised iron. For galvanised work, mix powder with water to form a paste and paint onto both sides of joint to protect heated zinc from flame and atmosphere.

Packing Data	
Container Mass (g)	**Item Number**
500 (jar)	W001553

ALUMINIUM

Section 12 - Welding Consumables

Aluminium 663
Welding of Aluminium 664
Aluminium Electrodes 669
Aluminium MIG & TIG Wires 670
Aluminium Brazing Flux 675

Welding of Aluminium

Aluminium is a light, ductile, readily worked metal, with good thermal and electrical properties. It has a tenacious oxide film on the surface that gives it good corrosion resistance. It is also the most abundant metal on earth.

Aluminium alloys may be sub-divided into two main groups – cast alloys and wrought alloys. Wrought materials also come in a wide variety of product forms.

Wrought alloys are further sub-divided into heat treatable and non-heat treatable alloys.

Heat treatable alloys are based on aluminium-copper, aluminium-silicon-magnesium and aluminium-zinc-magnesium alloy systems. They can develop high strength by solution treatment followed by age hardening at elevated temperatures.

Non-heat treatable alloys include pure aluminium, and those based on aluminium-manganese, aluminium-silicon, and aluminium-magnesium. They can be strengthened only by cold work.

Types

Cast Alloys

Aluminium alloy castings may be produced in sand moulds, in metal moulds, and by gravity or pressure die-casting. The castings possess rigidity and good corrosion resistance, with strength and ductility generally of secondary importance.

Alloying elements frequently used in aluminium castings are copper, silicon, magnesium, zinc, iron, manganese and nickel. Cast alloys are of two main types:

- Those which rely solely on alloying for their properties, such as AlMg and AlSi alloys
- Those for which heat treatment can be used to enhance properties, like the AlCu alloys.

As yet, there is no agreed international standard numbering system for castings. Each country uses its own identification method. In the UK, casting alloys are prefixed by the letters ‘LM’, followed by a one or two digit number; in the US, casting alloys are given a two or three digit number, some prefixed with a letter. Similar systems are also used in South Africa.

Many aluminium casting alloys are based on the AlSi or AlCu systems. The AlSi system has good fluidity and can be used for intricately shaped cast sections. Silicon reduces hot shortness and the tendency for castings to crack on solidification. These alloys have good corrosion properties and often have copper as a second element to enhance their strength.

There are only a few AlMg casting alloys, for while they have good corrosion properties in marine environments, and good strength, they are somewhat more difficult to cast than AlSi alloys.

Wrought Alloys

Wrought alloys consist of cast material that has been worked by processes such as forging, extrusion, drawing, or rolling, thereby improving the homogeneity and enhancing the mechanical properties of the material. This renders many forms of wrought alloys more suitable for welded construction.

Wrought alloys may be:

- Hot or cold rolled, to produce plate, sheet, strip or foil
- Extruded, to give bars, sections or tube
- Drawn, to make wire, bolts, screws, rivets or tube
- Forged, to give a variety of shapes.

Wrought aluminium alloys are of two main types:

- Heat treatable (those that can be strengthened by heat treatment)
- Non-heat treatable (those that can only be strengthened by cold working).

Wrought aluminium alloys are also further classified into groups according to the main alloying element or elements. Each group, or ‘series’, has a four-digit designation conferred by the International Standards Organisation (ISO). The first number relates to the main alloying element(s), the second number to the alloy modification (zero being the original alloy) and the next two numbers indicate the order in which the alloys were developed and subsequent variations. A letter following the four-digit number indicates a national variation in composition. For instance, alloy 1200A is a compositional variation of alloy 1200.

Wrought aluminium alloys, in numerical series order, are described briefly below. Some of the alloys in each series, and their approximate compositions, are given in tables in each section. Elements are only quoted if included as a deliberate addition, with a minimum requirement, or as a maximum and minimum range in specifications. Other elements may be present as impurities with a maximum limit.

Mechanical Properties

Aluminium is ductile and malleable, enabling it to be manufactured in many different forms by such methods as hot rolling, cold rolling, extrusion, forging, drawing, stamping, spinning, pressing or bending.

Aluminium has good toughness, even down to cryogenic temperatures (below -100°C), because no ductile to brittle phase transition takes place, even with rapid cooling.

Although the strength of pure aluminium is low compared with steel and other common engineering materials, it can be improved by cold working or by alloying with different elements, and these alloys can be further improved with heat treatment or cold working. The elements most commonly used to form alloys with aluminium are copper, magnesium, silicon, manganese and zinc, singly or in combinations.

Alloying with these elements can strengthen aluminium by one of two mechanisms:

- Strength may be increased by the presence of alloying elements that become entrapped in solid solution within the aluminium by a process called solid solution hardening. Alloys that are solid solution hardened can be cold worked to further increase strength and this is called work hardening. Work hardening the material involves cold rolling, extrusion, pressing, drawing, etc. and the strength achieved depends on the amount of cold work applied, and may be described as the 'temper' of the alloy. Alloys of this type include AlMn and AlMg, and they are known as non-heat treatable alloys.

- The properties of some aluminium alloys may be improved by heat treatment, a process in which precipitation of constituents held in solid solution is allowed to take place by holding at a suitable temperature. The process is usually described as ageing or age hardening. If age hardening takes place at room temperature, it is referred to as natural ageing. But if elevated temperatures are used, this is called artificial ageing. Alloys of this type include AlCu, AlMgSi and AlZnMg, which are known as heat treatable alloys.

Welding

Although, at first sight, it appears to be a relatively simple alloy system to weld, compared with steel, because no solid state phase change occurs, there are several important factors influencing the weldability of aluminium and its alloys. There are some general factors covering all alloys and some individual alloy characteristics, the latter making some alloys more difficult to weld than others.

The main factors to be considered and dealt with in detail in welding aluminium are:

- The presence of a tenacious, refractory, surface oxide film, which, if not removed before welding, can cause lack of fusion or porosity
- The high solubility of hydrogen in liquid aluminium which, compared with its solubility in solid aluminium, can lead to porosity in weld metal
- The tendency for some alloys, notably 2XXX, 6XXX and 7XXX series alloys, to suffer hot cracking or HAZ liquation cracking
- The reduction in mechanical properties that occurs across the weld zone when aluminium alloys are welded.

Welding Processes

Aluminium and many of its alloys can be readily welded, most frequently using inert gas shielded processes, such as MIG and TIG. MMA is still used occasionally, particularly for site repair work, but it is difficult to obtain good quality welds with the consumables available.

MIG welding of aluminium is always carried out with a completely inert gas shield, traditionally argon, but now increasingly helium-argon mixtures, such as the Afrox Alushield® range, which help to increase penetration and to reduce the incidence of porosity.

It must be remembered that aluminium and its alloys must not be MIG welded using active gases like carbon dioxide, or $ArCO_2$ mixtures, since these will lead to severe oxidation and failure to produce a weld.

TIG welding must also be carried out using inert gas shield, argon or argon-helium mixtures, not only to prevent oxidation of the weld, but also to prevent the tungsten electrode being consumed.

High power density processes, like laser and electron beam, and the more recently developed friction stir welding process, are also suitable for welding all alloys. Brazing and resistance welding techniques are applicable to some alloys.

The submerged arc and flux cored wire processes are not used for welding aluminium alloy systems.

Welding Casting Alloys

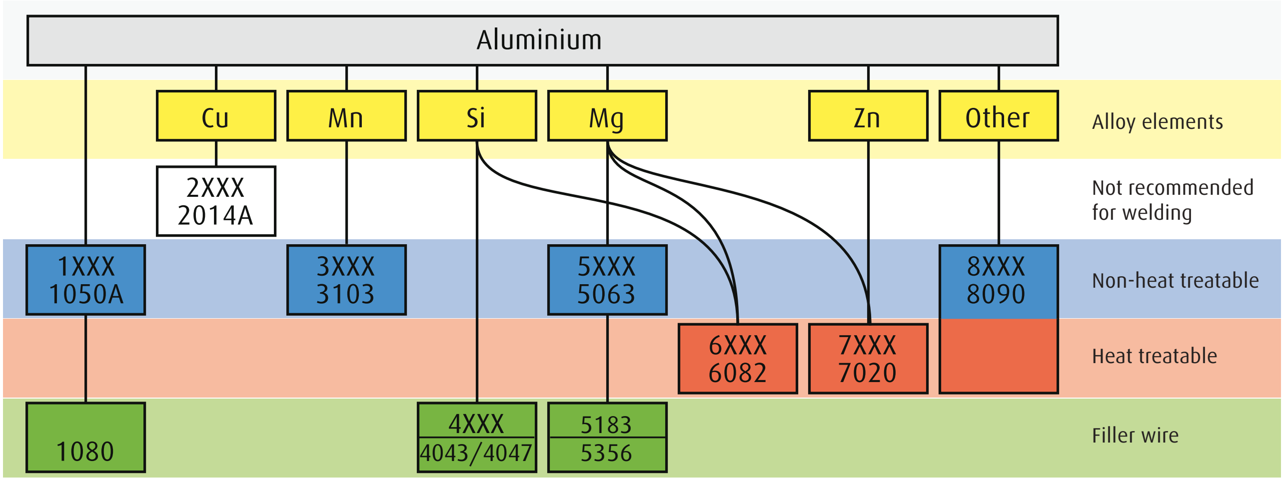
Aluminium castings find limited use in welded construction, principally because of their low ductility and high porosity content, but re-instatement and repair of castings by welding is often required. Many casting alloys, notably those containing copper, are not recommended for welding as they are very crack sensitive. Pure aluminium, and alloys based on AlSi and AlMg, may be welded with appropriate filler metals.

Welding Wrought Alloys

A brief résumé of the welding characteristics of each group of alloys is given below.

1XXX series: Non-alloyed aluminium

The 1XXX alloys are readily welded using filler metals of matching composition. It is also possible to use AlSi or AlMg filler metals for some applications. They may be welded using all main processes, including MIG, TIG, MMA, gas welding and brazing as well as resistance and friction welding methods.



2XXX series: Copper as main alloying element

These alloys are virtually unweldable because the formation of aluminium-copper intermetallics in weld metal renders them brittle. They tend to crack if attempts are made to weld them using fusion welding processes, although the use of Al-12% Si filler may sometimes give reasonable results. Non-fusion techniques, such as friction welding and friction stir welding may give some success.

3XXX series: Manganese as main alloying element

The 3XXX series alloys are weldable alloys, welded with matching filler metals, but are welded infrequently, the main joining method being brazing. Furnace brazing and gas torch brazing are suitable methods.

4XXX series: Silicon as main alloying element

These alloys are weldable by all processes using AlSi filler metals where appropriate. However, as stated before, a major use for these alloys is as welding wire containing 5% Si or 12% Si.

5XXX series: Magnesium as main alloying element

Alloys with magnesium contents under about 3%, such as 5251 and 5454, are susceptible to cracking and it is usual to use higher magnesium fillers to overcome this tendency. Alloys with more than 4,5% Mg are readily welded.

MIG and TIG are the most frequently used welding processes for these alloys. They tend not to respond well to MMA or to gas welding and brazing.

6XXX series: Magnesium and silicon as main alloying elements

These alloys should be welded with care, since, with less than 1% Si and 1% Mg, they have a tendency to crack in the HAZ by a mechanism called liquation cracking, if high heat inputs are used. To avoid weld metal cracking, they require a MIG or TIG filler metal containing 5% Mg or 5% Si to be used. Care must be taken not to mix the two filler compositions or cracking will result.

7XXX series: Zinc as main alloying element

The series includes both weldable and unweldable grades, although even the weldable alloys are prone to suffer HAZ liquation cracking. It is usual to use filler metals containing zinc and magnesium, although it is possible to use Al-5,5% Mg fillers in some instances. MIG and TIG tend to be the main processes used on these alloys.

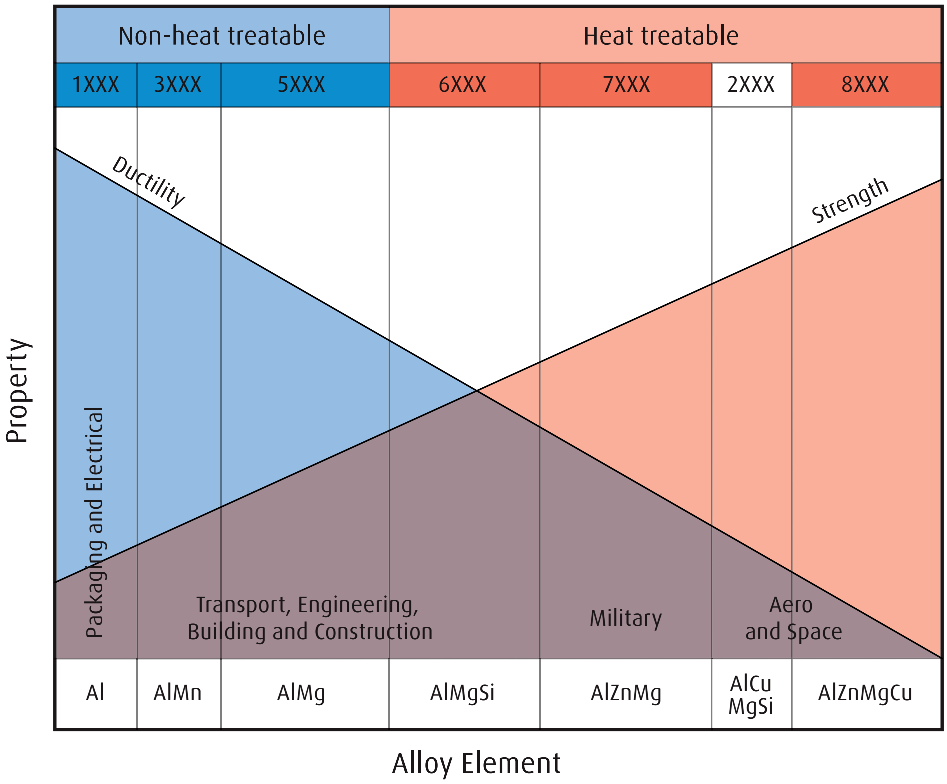
8XXX series: Miscellaneous alloys

Most of the alloys in this series are not commonly welded, and some are not weldable. However, there have been developments in aluminium-lithium alloys for aerospace applications that have led to weldable grades becoming available.

Cutting

Cutting processes that use an electric arc in a stream of inert gas may be used to cut all aluminium alloys. The cut surfaces are generally quite smooth and clean, but the plate retains narrow, melted and partially melted zones which, with heat treatable alloys, may lead to intergranular cracking. Corrosion properties may also be adversely affected in the immediate HAZ of the cut. It is, therefore, advisable to trim back by about 3 mm from the cut surface to give a sound welding surface, free from possible stress raisers.

It should be noted that some standards call for levels of up to 6 mm to be removed after cutting.



Relevant standards should be consulted to establish requirements.

Cutting Processes

There are several different thermal processes for cutting aluminium and its alloys, but the most frequently used is plasma cutting, with laser cutting also finding some applications.

For most industrial fabricators today, plasma cutting is probably the first choice as a cutting technique for aluminium from 3 mm to 50 mm and above in thickness. Plasma cutting gives a smooth cut surface, free from major contamination, but should be trimmed prior to welding, as described above.

Preheating of Aluminium and Aluminium Alloys

When to Preheat

Preheat is needed when there is a risk that, if a welding operation is carried out ‘cold’, an unsound weld could be produced. While it is not possible here to cover all eventualities, there are certain guidelines that can be followed in making the decision as to whether to preheat or not, and these are outlined here, categorised for convenience, by alloy type.

Aluminium Alloys

Aluminium alloys have a high thermal conductivity and preheat is used to provide additional heat to the weld area in order to help ensure full fusion of the weld. Application of preheat is also used to drive off any moisture in the surface oxide. Preheating may not be necessary when welding thin sheet, but becomes increasingly important as thickness, and therefore thermal conduction away from the weld, increases.

How Much Preheat to Apply

The actual preheat temperature required for a specific welding operation depends not only on the material or materials being welded, but also on the combined thickness of the joint, the heat input from the welding process being used and the amount of restraint imposed upon the components. There are no hard and fast rules regarding how much preheat to apply, but there are many publications available that give helpful guidance. These publications include national and international standards or codes of practice, guides from steel and aluminium alloy producers, and from consumable manufacturers. Some guidelines are included here and, as in the previous section, categorised for convenience by alloy type.

Aluminium Alloys

As a rule, aluminium alloys are only preheated to temperatures between 80°C and 120°C. Certain heat treatable aluminium alloys (AlSiMg) are sensitive to HAZ liquation cracking, if overheated, and preheat must be carefully controlled within this range. With less sensitive alloys, preheat may be increased up to a maximum of 180 - 200°C. Remember that aluminium alloys have relatively low melting points and care must be taken to avoid overheating, which can result in poor weld quality and cracking in some alloys.

Aluminium and Aluminium Alloys

Base Metal	1060, 1100, (1050), 3003	3004	5005, 5050	5052	5083	5086	5154, 5354	5454	5456	6005, 6061	7005	356,0 443,0
1060, 1100, (1050), 3003	1100 (1050) b, e	4043 d, e	4043 d, e	4043 d, e	5356 b, d	5356 b, d	4043 d, e	4043 d, e	5356 b, d	4043 e	5356 b, d	4043 e
3004		4043 d, e	4043 d, e	4043 d, e	5356 d	5356 d	5356 a	5356 a	5356 d	4043 d, e	5356 b, e	4043 e
5005, 5050			4043 d, e	4043 d, e	5356 d	5356 d	5356 a	5356 a	5356 d	4043 d, e	5356 b, d	4043 e
5052				5356 a, b	5356 d	5356 d	5356 a	5356 a	5356 d	5356 a, b	5356 a	4043 a, e
5083					5183 d	5356 d	5356 d	5356 d	5183 d	5356 d	5183 d	5356 b, d
5086						5356 d	5356 d	5356 d	5356 d	5356 d	5356 d	5356 b, d
5154, 5254							5356 a	5356 a	5356 a	5356 a	5356 d	4043 a
5454								5554 b, d	5356 d	5356 a, b	5356 a	4043 a, e
5456									5556 d	5356 d	5556 d	5356 b, d
6005, 6061, 6063, 6351										4043 a, e	5356 a, b	4043 a, e
7005											5356 d	4043 a, e
356,0 443,0												4043 c, e

Notes

1 The filler metal shown for each combination of base metals is that most commonly used. However, the specific filler metal depends on usage and type of joint and, in a number of cases, acceptable alternatives are recommended (footnotes a to c)

2 Filler metals conform to requirements of AWS specification A5.10-80

3 Exposure to specific chemicals or a sustained high temperature (over 150°F) may limit the choice of the metals. Filler alloys 5183, 5356, 5556 and 5654 should not be used in sustained elevated-temperature service

a 5813, 5356, 5554, 5556 and 5654 may be used. In some cases they provide: improved colour match after anodising treatment, higher weld ductility and higher weld strength. 5554 is suitable for elevated-temperature service. Castings welded with these filler metals should not be subjected to post weld artificial ageing

b 4043 may be used for some applications

c Filler metal with the same analysis as the base metal is sometimes used

d 5183, 5356 or 5556 may be used

e 4047 may be used for some applications

Aluminium Electrodes

Afrox Alumoid

Afrox Alumoid is a 12% silicon aluminium arc welding electrode with exclusive self-lifting slag. It is designed for arc welding wrought and cast aluminium alloys, alloyed with copper, silicon and magnesium. Also excellent for joining dissimilar grades of aluminium. Can also be used as a torch brazing alloy.

Classifications		
AWS	A5.3	E4047
DIN	1732	EL-AlSi12

Typical Chemical Analysis (All weld metal)			
% Manganese	0,04	**% Copper**	0,23
% Aluminium	Bal.	**% Magnesium**	0,04
% Silicon	11,8	**% Zinc**	0,08
% Iron	0,8		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	180 MPa
Tensile Strength	300 MPa
% Elongation	7

Packing Data				
Diameter (mm)	**Electrode Length (mm)**	**Current (A)**	**Pack Mass (kg)**	**Item Number**
2,5	350	50 - 80	Sleeve	W072112
3,25	350	70 - 120	Sleeve	W072113
2,5	350	50 - 80	2,0	W076112
3,25	350	70 - 120	2,0	W076113
4,0	350	110 - 150	2,0	W076114

Aluminium MIG & TIG Wires

Afrox Filmax 1050
Afrox TIG 1050

Afrox Filmax 1050 and Afrox TIG 1050 are high quality, commercially pure aluminium wires having a maximum of 0,5% alloying elements. Afrox MIG 1050 is suitable for spray arc and pulsed arc transfer using high purity argon on thin sections or an argon-helium mixture (Alushield®). For MIG welding, gas flow rates of 15 - 20 ℓ/min should be used on thicknesses greater than 4 mm. Afrox TIG 1050 should be used with a zirconiated tungsten electrode with pure argon or Alushield® at flow rates of 10 - 15 ℓ/min. For oxy-acetylene gas welding, a neutral flame should be used with aluminium welding flux (Item Number W001777).

Applications

The wire is recommended for welding unalloyed aluminium products, i.e. aluminium alloy types 1050, 1070, 1200 and equivalents. Applications in electronic, electrical and construction industries; equipment and containers for food, chemical, brewing and atomic energy industries and decorative assemblies in architecture and transport.

Classifications		
AWS	A5.10	Nearest equivalent ER1100
EN	18273	Al 1200 (A199,0)

Typical Chemical Analysis (Wire analysis)			
% Silicon	0,3 max	**% Magnesium**	0,05 max
% Iron	0,4 max	**% Zinc**	0,07 max
% Copper	0,05 max	**% Titanium**	0,05 max
% Manganese	0,05 max	**% Aluminium**	99,5 min

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	20 MPa
Tensile Strength	65 MPa
% Elongation on 4d	35

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	7,0	W033167	1,6	5,0	1 000	W030506
1,6	7,0	W077507	3,2	2,0	1 000	W030508

Recommended shielding gases: Argon or Alushield®

Afrox Filmax 4043
Afrox TIG 4043

Afrox Filmax 4043 and Afrox TIG 4043 are 95% aluminium, 5% silicon welding wires suitable for the welding of heat treatable base alloys, and more specifically, the 6XXX series. It has a lower melting point and more fluidity than the 5XXX series filler alloys and is preferred by welders because of its favourable operating characteristics. The ER4043 wires are also less sensitive to weld cracking with the 6XXX series base alloys. Afrox MIG 4043 is suitable for spray arc and pulsed arc transfer using high purity argon on thin sections or an argon-helium mixture (Alushield®) as a shielding gas on thicker sections. Flow rates of 15 - 20 ℓ/min should be used. Afrox TIG 4043 should be used with a zirconiated tungsten electrode with pure argon or an argon-helium mixture (Alushield®) for thick sections, at flow rates of 10 - 15 ℓ/min. For oxy-acetylene gas welding, a neutral flame should be used with aluminium welding flux (Item Number W001777).

Applications

Applications in the construction and automotive industry.

Materials to be Welded

Afrox Filmax 4043 and TIG 4043 wires are used to weld most aluminium alloys containing up to 7% silicon and can be used for welding wrought to cast aluminium materials, such as: BS 1470-1475 HE19, HE15, HE20 and HE30 material BS 1490 LM2 and LM6 castings Aluminium alloys (AAA).6061, 6062, 5052, 5154, 3003, 2024, 1050 and 1100 (after anodising, welding will be of a dark grey colour).

Classifications		
AWS	A5.10	ER4043
EN	18273	Al4043 (AlSi5)

Typical Chemical Analysis (Wire analysis)			
% Silicon	4,5 - 5,5	**% Zinc**	0,1 max
% Iron	0,4 max	**% Titanium**	0,15 max
% Copper	0,05 max	**% Beryllium**	0,0008 max
% Manganese	0,05 max	**% Aluminium**	Bal.
% Magnesium	0,05 max		

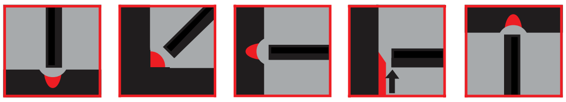
Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	40 MPa
Tensile Strength	120 MPa
% Elongation on 5d	8

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,0	7,0	W077517	1,6	2,0	1 000	W030511
1,2	7,0	W033183	2,4	2,0	1 000	W077513
-	-	-	3,2	2,0	1 000	W030513

Recommended shielding gases: Argon or Alushield®

Afrox Filmax 4047
Afrox TIG 4047



Afrox Filmax 4047 and Afrox TIG 4047 are 11 - 13% silicon wires, which have a lower melting point and higher fluidity than ER4043 type wires. Used as a substitute for an ER4043 type wire to increase silicon in the weld metal, minimise hot cracking and produce slightly higher fillet weld shear strength. Also suitable for sustained elevated temperature service, i.e. above 65°C. Afrox Filmax 4047 is suitable for spray arc and pulsed arc transfer using high purity argon on thin sections or an argon/helium mixture (Alushield®) on thicker sections. Flow rates of 15 - 20 ℓ/min should be used. Afrox TIG 4047 should be used with a zirconiated tungsten electrode with pure argon or an argon-helium mixture (Alushield®) for thick sections, at flow rates of 15 - 20 ℓ/min. With oxy-acetylene brazing, aluminium brazing flux (Item Numbers W001753 and W001755) should be used.

Applications

For welding, but normally for brazing aluminium sheets, for extrusions and castings. Also for automotive components, body panels, heat exchangers, etc.

Classifications		
AWS	A5.10	ER4047
EN	18273	Al 4047 (AlSi12)

Typical Chemical Analysis (Wire analysis)			
% Silicon	11,0 - 13,0	**% Zinc**	0,1 max
% Iron	0,5 max	**% Titanium**	0,15 max
% Copper	0,05 max	**% Beryllium**	0,0008 max
% Manganese	0,15 max	**% Aluminium**	Bal.
% Magnesium	0,05 max	(After anodising, welding will be of a different colour)	

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	60 MPa
Tensile Strength	130 MPa
% Elongation on 5d	5
% Melting Range	573 - 585°C

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,0	7,0	W077524	1,6	2,0	1 000	W000850
1,2	7,0	W077525	2,0	2,0	1 000	W077518
1,6	7,0	W077526	3,2	2,0	1 000	W000851

Recommended shielding gases: Argon or Alushield®

Afrox Filmax 5183
Afrox TIG 5183

Afrox Filmax 5183 and Afrox TIG 5183 are 4,7% magnesium, 0,7% manganese wires for the welding of the 5XXX series high magnesium (5%) alloys to themselves or to the heat treatable and 7XXX series alloys that need to meet and exceed tensile strength requirements of 40 000 psi (276 MPa). Afrox Filmax 5183 is suitable for spray arc and pulsed arc transfer using high purity argon on thin sections or an argon-helium mixture (Alushield®) as a shielding gas on thicker sections. Flow rates of 15 - 20 ℓ/min should be used. Afrox TIG 5183 should be used with a zirconiated tungsten electrode with pure argon or an argon-helium mixture (Alushield®) for thick sections, at flow rates of 10 - 15 ℓ/min. For oxy-acetylene gas welding, a neutral flame should be used with aluminium welding flux (Item Number W001777).

Applications

Applications found in the shipbuilding, railway and automotive industry. Also in marine fabrication and repairs, bicycle frames, cryogenic tanks and other high strength low temperature structural aluminium applications.

Classifications		
AWS	A5.10	ER5183
EN	18273	Al5183 (AlMg4,5,Mn,0,7)

Typical Chemical Analysis (Wire analysis)			
% Silicon	0,25 max	**% Zinc**	0,25 max
% Iron	0,4 max	**% Titanium**	0,07 - 0,15
% Copper	0,05 max	**% Beryllium**	0,0008 max
% Manganese	0,6 - 1,0	**% Aluminium**	Bal.
% Magnesium	4,3 - 5,2	**% Chromium**	0,05 - 0,25

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	275 MPa
Tensile Strength	125 MPa
% Elongation on 5d	17

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	7,0	W033156	3,2	2,0	1 000	W077532
-	-	-	4,0	2,0	1 000	W077533

Recommended shielding gases: Argon or Alushield®

Afrox Filmax 5356
Afrox TIG 5356

Afrox Filmax 5356 and Afrox TIG 5356 are 95% aluminium, 5% magnesium wires for general purpose welding of the 5XXX series alloys when 40 000 psi (276 MPa) is not required. Afrox Filmax 5356 is suitable for spray arc and pulsed arc transfer using high purity argon on thin sections or an argon-helium mixture (Alushield®) as a shielding gas on thicker sections. Flow rates of 15 - 20 ℓ/min should be used. Afrox TIG 5356 should be used with a zirconiated tungsten electrode with pure argon or an argon-helium mixture (Alushield®) for thick sections, at flow rates of 10 - 15 ℓ/min. For oxy-acetylene gas welding, a neutral flame should be used with aluminium welding flux (Item Number W001777).

Applications

Applications found in the construction of ships, bulk container, railway and the automotive industries.

Classifications		
AWS	A5.10	ER5356
EN	18273	Al5356 (AlMg5Cr)

Typical Chemical Analysis (Wire analysis)			
% Silicon	0,25 max	**% Zinc**	0,1 max
% Iron	0,4 max	**% Titanium**	0,07-0,15
% Copper	0,05 max	**% Beryllium**	0,0008 max
% Manganese	0,1 - 0,2	**% Aluminium**	Bal.
% Magnesium	4,5 - 5,6	**% Chromium**	0,1 - 0,3

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	240 MPa
Tensile Strength	125 MPa
% Elongation on 5d	17

Packing Data

MIG			TIG			
Diameter (mm)	Pack Mass (kg)	Item Number	Diameter (mm)	Pack Mass (kg)	Consumable Length (mm)	Item Number
0,8	7,0	W077541	1,6	2,0	1 000	W030522
1,2	0,5	W033153	3,2	2,0	1 000	W030521
1,6	7,0	W033176	-	-	-	-

Aluminium Brazing Flux

Afrox Aluminium Brazing Flux

Afrox Aluminium Brazing Flux is a white flux powder with a low melting point of 550ºC recommended for use with Afrox TIG 4047 aluminium brazing alloy. This flux may be used with water to form a paste.

Packing Data	
Container Mass (g)	**Item Number**
500 (jar)	W001753

NICKEL

Section 12 - Welding Consumables

Nickel 676
Welding of Nickel-Based Alloys 677
Nickel Electrodes 680
Nickel MIG & TIG Wires 685
Nickel Submerged Arc Wires 692

Welding of Nickel-Based Alloys

Nickel-based alloys have nickel as their main constituent, generally making up over 50% of these types of alloys. They are primarily used for their corrosion properties, but are also used for their heat resistance, low expansion characteristics and electrical resistance.

The most important group of general-purpose nickel alloys are the Inconel® types which are based on the heat resistant alloy 600 made of nickel, chrome and iron. These alloys are used in applications from cryogenic processes at -196°C to elevated temperatures of up to 1 000°C. They are also used in power generation for steam turbine power plants, aircraft gas turbines, nuclear power plants, furnaces as well as in the chemical and petrochemical industries.

Monel® 400 is an alloy made from nickel and copper, used in marine and offshore environments for the fabrication of heat exchangers, evaporators, piping and vessels as well as in the chemical, petrochemical, and power generation industries.

These alloys are known by many other proprietary alloy names in the industries in which they are used, such as Inconel®, Monel® and Incoloy® from Special Metals, Nicrofer® and Nicorros® from Krupp VDM, Pyromet® from Carpenter Alloys and Hastelloy® from Haynes International Inc. Generally, these alloys are readily joined by most welding processes.

Nickel alloys can be joined by all the common types of welding process such as Manual Metal Arc (MMA), Metal Inert Gas (MIG), Tungsten Inert Gas (TIG) and Submerged Arc Welding (SAW), but not by the forge welding or oxy-acetylene processes. For the majority of applications on wrought nickel alloys, no preheat or post weld heat treatment will be required. In certain special cases, a post weld heat treatment may be required for stress relief of a fabricated structure or to avoid age hardening and stress corrosion cracking problems in acid or caustic environments. Nickel and nickel alloys can however be susceptible to embrittlement by low melting point elements such as sulphur, lead and phosphorous. These elements can occur in grease, paint, oil crayons, inks, cutting fluids, shop dirt or processing chemicals. It is therefore important that components to be welded are completely free of these contaminants before welding begins.

Shielding Gases for Nickel Alloys

Either argon or helium or mixtures of the two can be used to weld nickel alloys. Any additions of oxygen, carbon dioxide or nitrogen will usually cause problems with porosity and result in erosion of the electrode in TIG welding. Argon with 5% hydrogen can be used and can be beneficial when welding pure nickel by reducing the formation of oxides.

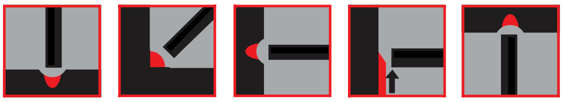
Afrox Products for Welding Nickel Alloys

Product	Specification	Alloys to be Welded	Applications
Afrox 182	AWS A5.11 ENiCrFe-3 EN ISO 14172 E6182	Inconel® 600 Nimonic 75	Nickel-based alloys to themselves and to mild, low alloy steels and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels.
Filmax NiCr-3 TIG NiCr-3	AWS A5.14 ERNiCr-3 EN ISO 18274 SNi6082		Transition welds between creep-resisting ferritic and austenitic steels such as 2CrMo (B3) and 316H.
Afrox 625	AWS A5.11 ENiCrMo-3 EN ISO 14172 ENi6625	Inconel® 625 Nicrofer® 6020hMo Nicrofer® 6022hMo Inconel® 601 Incoloy® 800H Incoloy® 825 UNS S31254 254SMO 904L 9% Ni steels Combinations of the above	For welding proprietary alloys 625 for high temperature strength and structural stability. Also widely used for corrosion resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. Also used in overlays on pumps, valves and shafts in offshore and marine environments. Other applications include furnace parts, petrochemical and power generation plants.
Filmax NiCrMo-3 TIG NiCrMo-3 SAW NiCrMo-3	AWS A5.14 ERNiCrMo-3		
Afrox C276	AWS A5.11 ENiCrMo-4 EN ISO 14172 ENi6276	Hastelloy® alloy C-276 Inco alloy C-276 Nicrofer® 5716hMoW	For welding proprietary alloy C276. The alloy has higher resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in sea water and chloride-induced stress corrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation. These consumables have good tolerance to dilution by most ferrous and high nickel alloys, and are suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties, below -196°C, allows its use for welding 5 - 9% Ni steels in cryogenic installations. Applications include pumps, valves, pipework and vessels for use in aggressive environments in chemical process plants; also in equipment for flue gas desulphurisation and critical equipment in offshore oil and gas production.
Filmax NiCrMo-4 TIG NiCrMo-4	AWS A5.14 ERNiCrMo-4		

Product	Specification	Alloys to be Welded	Applications
Filmax NiCu-7 TIG NiCu-7	AWS A5.14 ERNiCu-7	Monel® alloy 400, R405, K500 Nicorros®	For welding alloy 400 and similar parent metals to itself and to others in the Ni-Cu alloy system, such as pure nickel and cupro-nickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardening alloy. Castings of alloy 400 with up to about 1,5% Si are welded with Afrox NiCu-7, but higher grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking. For dissimilar joints between alloy 400 and other alloy steels, sensitivity to dilution by Fe (20 - 30%) or Cr (3 - 6%) can lead to low ductility (or bend test fissures) in weld metal close to the fusion boundary. Direct welds to mild steel or low alloy steels are satisfactory with dilution control, although ENiCrFe-X (ERNiCr-3 wire) is preferable and necessary for stainless steel and higher chromium alloys. Alternatively, the steel alloy can be buttered with pure nickel, and this procedure is also useful when surfacing with alloy 400 consumables. Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis. Applications include heat exchangers piping, vessels and evaporators in offshore, marine, chemical, petrochemical and power generation industries.
Metrode Nimrod 200Ti Filmax Ni-1 TIG Ni-1	AWS A5.11 ENi-1 EN ISO 14172 ENi2061 AWS A5.14 ERNi-1	Nickel 200 and 201 Nickel 99.6 and 99.2	These consumables give low carbon pure nickel weld metal with the addition of titanium for refinement and de-oxidation. They are used for joining pure nickel to itself, for buffer layers, and for cladding joint faces and flanges. The solid wire is also useful for welding cast iron to give soft low strength deposit. Applications include tanks and vessels, process pipework and heat exchangers, in chemical plants for salt production, chlorination and evaporation of caustic soda. Also used for handling corrosive alkalis and halides.

Nickel Electrodes

Afrox 182



Afrox 182 is a basic coated, semi-synthetic, high recovery, nickel-based electrode for the welding of nickel alloys and many dissimilar metal joints. Characteristics include smooth bead appearance, low spatter loss, and easy slag removal. Afrox 182 is suitable for the welding of alloys 600, 601, 800 and similar high nickel steels as well as 5% and 9% nickel steels. Afrox 182 is also suitable for dissimilar joints between nickel-based alloys and carbon and stainless steels, and can also be used for the joining of difficult to weld steels.

Applications

Applications include heat-resisting nickel-based alloys to themselves for use in furnace equipment up to about 900°C. Other applications include: mixed welds between most nickel-based alloys, including Monel® 400 and stainless, low alloy or CMn steels without need to preheat. Transition welds between creep-resisting ferritic and austenitic steels, such as 2CrMo and 316H for long-term service at an elevated temperature in petrochemical and power generation plants. Low temperature applications such as 3% or 5% Ni steels used for cryogenic vessels and pipework in service at or below -100°C. Stress relief may be carried out if required.

Materials to be Welded

Nickel alloys such as Inconel® 600 and Nimonic 75. Nickel-based alloys to themselves and to mild, low alloy and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels.

Storage and Re-baking

Re-dry at 250°C for 2 hours to restore to as-packed condition. Maximum 380°C, 3 cycles, 10 hours total.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Classifications		
AWS	A5.11	ENiCrFe-3
EN ISO	14172	ENi6182 (NiCr15Fe6Mn)

Typical Chemical Analysis			
% Carbon	0,10 max	**% Chrome**	13,0 - 17,0
% Manganese	5,0 - 9,5	**% Nickel**	60,0 min
% Silicon	1,0 max	**% Niobium**	1,0 - 2,5
% Sulphur	0,015 max	**% Iron**	2,0 - 9,0
% Phosphorous	0,02 max	**% Titanium**	1,0 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	350 MPa min
Tensile Strength	635 MPa min
% Elongation on 5d	32
Impact Energy at -196°C	65 J min
Hardness	190 HV

Packing Data (DC+)				
Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
3,2	350	100 - 140	5,0	W075943
4,0	350	140 - 180	5,0	W075944

Afrox 625

Afrox 625 is a basic coated electrode for the welding of nickel alloys, super austenitic alloys, cryogenic 9% nickel steels, and for dissimilar metal joints. The weld deposit is resistant to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. It is also used for welding heat resisting alloys, such as Inconel® 600 and 625 as well as Incoloy® 800 and 825. The electrodes are also used for the joining of these nickel alloys to low and high alloy steels and cast steels. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-based alloys. Useful properties from -269°C to above 1 000°C are achieved.

Applications

In addition to matching alloy 625, suitable for welding heat resisting alloys including Inconel® 601 (except severe sulphidising conditions), Incoloy® 800/800H, or combinations of these with other alloys for furnace equipment, petrochemical and power generation plants. Some other applications include: overmatching corrosion resistant welds in alloy 825, Hastelloy® G and G3, alloy 28, 904L, 6% Mo super austenitic stainless 254 SMO®. Also in overlays on pumps, valves and shafts, often in offshore and marine environments where high pitting resistance (PRE = 50) and tolerance to weld metal dilution are essential. Welds in high strength ferrous alloys including cryogenic 9% nickel steels and for reclamation of dies where rapid work hardening and toughness are required.

Storage and Re-baking

Re-dry electrodes for 2 hours at 250°C.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Materials to be Welded		
Matching Alloy 625		
ASTM-ASME	**DIN**	**BS**
UNS N06625	**2.4856**	**NA21**
A494 CW-6MC (cast)		
Proprietary Alloys		
Inconel® 625 (Inco)		
Nicrofer® 6020hMo (VDM)		
Nicrofer® 6022hMo (VDM)		
Other Alloys		

High Nickel Alloys	**Super Austenitic Alloys**
Inconel® 601 (Inco)	UNS S31254
Incoloy® 800H (Inco)	254 SMO® (Avesta)
Incoloy® 825	904L (Inco)
And equivalents	Similar alloys
Cryogenic	**Dissimilar**
9% Ni steels	Combinations of above

Classifications		
AWS	A5.11	ENiCrMo-3
EN ISO	14172	ENi6625 (NiCr22Mo9Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,1 max	**% Chrome**	20,0 - 23,0
% Manganese	2,0 max	**% Nickel**	55,0 min
% Silicon	0,8 max	**% Molybdenum**	8,0 - 10,0
% Sulphur	0,015 max	**% Niobium**	3,0 - 4,0
% Phosphorous	0,02 max	**% Iron**	7,0 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	780 MPa
% Elongation on 5d	35
Impact Energy at +20°C	80 J
Impact Energy at -196°C	50 J
Hardness	250 HV
Hardness (Work hardened)	450 HV

Packing Data and Operating Current (DC+)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	350	50 - 70	5,0	W075952
3,2	350	75 - 95	5,0	W075953
4,0	350	90 - 120	5,0	W075954

Afrox C276

Afrox C276 is an MMA electrode for the manufacture and repair of hot forming tools and for oxidation and corrosion resistant overlays. It is used for the manufacture and repair of drop forging dies, hot forming dies, pump impellers, retorts and valves. Not only can it be used for overlays, but it can be used for joining special alloys such as Hastelloy® C276 to itself or to stainless steels.

Afrox C276 is a heavily coated electrode with approximately 170% metal recovery. The electrode has excellent welding characteristics and de-slagging properties.

Alloy C276 has high resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in seawater and chloride-induced stress corrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation. In addition to fabrication welds in alloy C276, these consumables have good tolerance to dilution by most ferrous and high nickel alloys. Also suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties to below -196°C allow its use for welding 5 - 9% Ni cryogenic installations.

Applications

Applications include pumps, valves, pipework and vessels for use in aggressive environments in chemical process plants; also in equipment for flue gas desulphurisation and critical equipment in offshore oil and gas production.

Storage and Re-baking

Re-dry electrodes for 2 hours at 250°C.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Materials to be Welded	
Wrought	
ASTM	**DIN**
UNS N10276	2.4819 (NiMo16Cr15W)
Cast	
A494 CW-12MW	
A743/A744 CW-12M	
2.4883 (G-NiMo16Cr)	
Proprietary	
Hastelloy® alloy C-276 (Haynes)	
Inco alloy C-276 (Special Metals)	
Nicrofer® 5716hMoW (VDM)	

Classifications		
AWS	A5.11	ENiCrMo-4 (nearest)
EN ISO	14172	ENi6276 (NiCr15Mo15Fe6W4 nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,03 max	**% Nickel**	Bal.
% Sulphur	0,03 max	**% Molybdenum**	14,5
% Phosphorous	0,04 max	**% Tungsten**	4,2
% Chrome	14,5	**% Iron**	6,5

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	710 MPa
% Elongation on 5d	27
Hardness*	220 - 230 HB

*Work hardens to about 375 - 420 HB

Packing Data and Operating Current (AC/DC+)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	350	110 - 125	5,0	W075962
3,2	350	140 - 155	5,0	W075963
4,0	350	170 - 185	5,0	W075964

Nickel MIG & TIG Wires

Afrox Filmax Ni-1
Afrox TIG Ni-1

Afrox Ni-1 solid wires for TIG and MIG welding are designed to give a low carbon pure nickel deposit with the addition of titanium for refinement and de-oxidation. They are used for joining pure nickel to itself, for buffer layers and for cladding joint faces and flanges. The solid wire is also useful for welding cast iron to give a soft low strength deposit.

Applications

Applications include tanks and vessels, process pipework and heat exchangers, in chemical plants for salt production and chlorination and evaporation of caustic soda. Also used for handling corrosive alkalis and halides. Repair and rebuilding of standard grades of grey cast irons and malleable cast irons.

Materials to be Welded		
ASTM-ASME	**DIN**	**BS**
UNS N02200	2.4066	NA11
UNS N02201	2.4068	NA12
	2.4061	
Proprietary Alloys		
Nickel 200 and 201 (Special Metals)		
Nickel 99.6 and 99.2 (VDM)		

Classifications		
AWS	A5.14	ERNi-1
EN	18274	ENi2061 (NiTi3)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	93,0 min
% Manganese	1,0 max	**% Titanium**	2,0 - 3,5
% Silicon	0,7 max	**% Copper**	0,2 max
% Sulphur	0,015 max	**% Iron**	1,0 max
% Phosphorous	0,02 max	**% Aluminium**	1,5 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	355 MPa
Tensile Strength	585 MPa
% Elongation on 4d	35
% Elongation on 5d	31
% Reduction of Area	65
Hardness cap/mid	155/185 HV

Packing Data
(DC+ AC 70 OCV min)

MIG			TIG			
Diameter (mm)	Pack Mass (kg)	Item Number	Diameter (mm)	Pack Mass (kg)	Consumable Length (mm)	Item Number
1,2	15,0	W077673	2,0	5,0	1 000	W077668
-	-	-	2,4	5,0	1 000	W077669

Afrox Filmax NiCr-3
Afrox TIG NiCr-3

Afrox NiCr-3 is a solid wire for welding of nickel-based alloys and dissimilar joints between nickel alloys, ferritic and austenitic stainless steels. These weld metals have no directly equivalent parent material, although the composition is related to Inconel® 600. Mn and Nb are added to give high resistance to hot cracking, tolerance to dilution by many combinations of nickel-based and ferrous alloys, with stable properties over a wide range of service temperatures from -196°C to above 900°C.

Applications

Applications include heat-resisting nickel-based alloys to themselves for use in furnace equipment up to about 900°C. Other applications include: mixed welds between most nickel-based alloys, including Monel® 400 and stainless, low alloy or CMn steels without need to preheat. Transition welds between creep-resisting ferritic and austenitic steels, such as 2CrMo and 316H for long-term service at elevated temperature in petrochemical and power generation plants. Low temperature applications such as 3% or 5% Ni steels used for cryogenic vessels and pipework in service at or below -100°C. Stress relief may be carried out if required.

Materials to be Welded

Nickel alloys such as Inconel® 600, Nimonic 75. Nickel-based alloys to themselves and to mild, low alloy and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels.

Classifications		
AWS	A5.14	ERNiCr-3
EN	18274	ENi6082 (NiCr20Mn3Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 max	**% Nickel**	67,0 min
% Manganese	2,5 - 3,5	**% Titanium**	0,7 max
% Silicon	0,5 max	**% Niobium**	2,0 - 3,0
% Sulphur	0,015 max	**% Iron**	3,0 max
% Phosphorous	0,02 max	**% Copper**	0,50 max
% Chrome	18,0 - 22,0		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	360 MPa
Tensile Strength	640 MPa
% Elongation on 4d	40
Impact Energy at -196°C	100 J min

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	15,0	W077632	1,6	5,0	1 000	W077626
-	-	-	2,0	5,0	1 000	W077627
-	-	-	2,4	5,0	1 000	W077628

Afrox Filmax NiCrMo-3
Afrox TIG NiCrMo-3

Afrox NiCrMo-3 solid wires for TIG and MIG welding are designed to match the composition and properties of alloy 625. Originally developed to give high temperature strength and structural stability, alloy 625 is also widely used for its resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-based alloys. Useful properties from -269°C to above 1 000°C are achieved.

Applications

In addition to matching alloy 625, suitable for welding heat resisting alloys including Inconel® 601 (except severe sulphidising conditions), Incoloy® 800/800H, or combinations of these with other alloys for furnace equipment, petrochemical and power generation plants. Some other applications include: overmatching corrosion resistant welds in alloy 825, Hastelloys® G and G3, alloy 28, 904L, 6% Mo super austenitic stainless 254 SMO®. Also used for overlays on pumps, valves and shafts, often in offshore and marine environments where high pitting resistance (PRE = 50) and tolerance to weld metal dilution are essential. Welds in high strength ferrous alloys including cryogenic 9% nickel steels and for reclamation of dies where rapid work-hardening and toughness are required.

Materials to be Welded		
Matching Alloy 625		
ASTM-ASME	**DIN**	**BS**
UNS N06625	**2.4856**	**NA21**
A494 CW-6MC (cast)		
Proprietary Alloys		
Inconel® 625 (Inco)		
Nicrofer® 6020hMo (VDM)		
Nicrofer® 6022hMo (VDM)		
Other Alloys		
High Nickel Alloys	**Super Austenitic Alloys**	
Inconel® 601 (Inco)	UNS S31254	
Incoloy® 800H (Inco)	254 SMO® (Avesta)	
Incoloy® 825	904L (Inco)	
And equivalents	Similar alloys	
Cryogenic	**Dissimilar**	
9% Ni steels	Combinations of above	

Classifications		
AWS	A5.14	ERNiCrMo-3
EN	18274	ENi6625 (NiCr22Mo9Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 max	**% Titanium**	0,4 max
% Manganese	0,5 max	**% Niobium**	3,15 - 4,15
% Silicon	0,5 max	**% Iron**	1,0 max
% Sulphur	0,015 max	**% Copper**	0,5 max
% Phosphorous	0,015 max	**% Aluminium**	0,4 max
% Chrome	20,0 - 23,0	**% Molybdenum**	8,0 - 10,0
% Nickel	60,0 min		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	780 MPa
% Elongation on 4d	42
% Elongation on 5d	40
Impact Energy at -100°C	100 J
Impact Energy at -196°C	80 J
Hardness cap/mid	205/225 HV

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	15,0	W077648	1,6	5,0	1 000	W077642
-	-	-	2,0	5,0	1 000	W077643

Afrox Filmax NiCrMo-4
Afrox TIG NiCrMo-4

Afrox NiCrMo-4 solid wires for TIG and MIG welding are designed to match the composition and properties of parent alloy C276 with Ni-15% Cr-16% Mo-4% W-5% Fe. Carbon and silicon controlled as close as possible to the very low levels of the wrought alloy to minimise carbide and intermetallic phase precipitates which can reduce as-welded corrosion resistance. Cast versions of the alloy typically have higher carbon and silicon (like the original wrought Hastelloy® alloy C, now obsolete), but repair welds are usually solution treated for optimum corrosion resistance. Alloy C276 has high resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in seawater and chloride-induced stress corrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation. In addition to fabrication welds in alloy C276, these consumables have good tolerance to dilution by most ferrous and high nickel alloys, and are suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties to below -196°C allow its use for welding 5 - 9% Ni cryogenic installations.

Applications

Applications include pumps, valves, pipework and vessels for use in aggressive environments in chemical process plants; also in equipment for flue gas desulphurisation and critical equipment in offshore oil and gas production.

Materials to be Welded
Wrought
ASTM UNS N10276
Cast
A494 CW-12MW
A743/A744 CW-12M
2.4883 (G-NiMo16Cr)
Proprietary
Hastelloy® alloy C-276 (Haynes)
Inco alloy C-276 (Special Metals)
Nicrofer® 5716hMoW (VDM)

Classifications		
AWS	A5.14	ERNiCrMo-4
EN	18274	ENi6276 (NiCr15Mo16Fe6W4)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,02 max	**% Nickel**	Bal.
% Manganese	1,0 max	**% Tungsten**	3,0 - 4,5
% Silicon	0,08 max	**% Vanadium**	0,3 max
% Sulphur	0,015 max	**% Iron**	4,0 - 7,0
% Phosphorous	0,02 max	**% Copper**	0,5 max
% Chrome	14,5 - 16,5	**% Molybdenum**	15,0 - 17,0

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	500 MPa
Tensile Strength	740 MPa
% Elongation on 4d	46
% Elongation on 5d	43
% Reduction of Area	50

Packing Data

MIG			TIG			
Diameter (mm)	Pack Mass (kg)	Item Number	Diameter (mm)	Pack Mass (kg)	Consumable Length (mm)	Item Number
1,2	15,0	W077746	1,6	5,0	1 000	W077654

Afrox Filmax NiCu-7
Afrox TIG NiCu-7

Afrox NiCu-7 solid wires for TIG and MIG welding are designed to deposit 65% Ni-30% Cu weld metal based on Monel® alloy 400 with raised levels of manganese and titanium to suppress hot cracking and porosity. It is optimised to give the highest as welded ductility and strength attainable in weld metal of this type. For welding alloy 400 and similar parent material to itself and to others in the NiCu alloy system, such as pure nickel and cupronickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardened alloy. Castings of alloy 400 with up to about 1,5% Si are welded with Nimrod 190, but higher silicon grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking. For dissimilar joints between alloy 400 and other alloys or steels, sensitivity to dilution by Fe (20 – 30%) or Cr (3 – 6%) can lead to low ductility (or bend-test fissuring) in weld metal close to the fusion boundary. Direct welds to mild or low allow steels are satisfactory with dilution control, although ENiCrFe-X (ERNiCr-3 wire) is preferable and necessary for stainless and higher chromium alloys. Alternatively, the steel alloy can be buttered with pure nickel and this procedure is also useful when surfacing with alloy 400 consumables. Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis.

Applications

These include heat exchangers, piping, vessels and evaporators in the offshore, marine, chemical, petrochemical and power engineering industries.

Materials to be Welded		
ASTM-ASME	**DIN**	**BS**
UNS N04400	**2.4856**	**NA21**
UNS N04405	2,4361	NA1 (cast)
UNS N05500		2,4365 (cast)
A494 M-35-1 (cast)		
A494 M-35-2 (cast)		
Proprietary		
Monel® alloy 400, R405, K500 (Special Metals)		
Nicorros (VDM)		

Classifications		
AWS	A5.14	ERNiCu-7
DIN	1736	SG-NiCu30MnTi (2,4377)
BS2901	PT5	NA33

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	62,0 - 69,0
% Manganese	3,0 - 4,0	**% Copper**	28,0 - 34,0
% Silicon	1,0 max	**% Titanium**	1,5 - 3,0
% Sulphur	0,015 max	**% Iron**	2,5 max
% Phosphorous	0,02 max	**% Aluminium**	1,25 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	280 MPa
Tensile Strength	525 MPa
% Elongation on 4d	41
% Elongation on 5d	38
Impact Energy at -30°C	120 J

Packing Data						
MIG			**TIG**			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	15,0	W077688	1,6	5,0	1 000	W077682

Nickel Submerged Arc Wires

Afrox Subarc NiCrMo-3

Afrox Subarc NiCrMo-3 is a submerged arc welding wire and is designed to match the composition and properties of alloy 625. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-based alloys. Useful properties from -196°C to above 1 000°C are achieved.

Applications

Originally developed to give high temperature strength and structural stability, alloy 625 is also widely used for its resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. Recommended flux: Metrode NiCr Flux (Item Number W077702).

Materials to be Welded		
Matching Alloy 625		
ASTM-ASME	**DIN**	**BS**
UNS N06625	**2.4856**	**NA21**
A494 CW-6MC (cast)		
Proprietary Alloys		
Inconel® 625 (Inco)		
Nicrofer® 6020hMo (VDM)		
Nicrofer® 6022hMo (VDM)		
Other Alloys		

High Nickel Alloys	**Super Austenitic Alloys**
Inconel® 601 (Inco)	UNS S31254
Incoloy® 800H (Inco)	254 SMO® (Avesta)
Incoloy® 825	904L (Inco)
And equivalents	Similar alloys
Cryogenic	**Dissimilar**
9% Ni steels	Combinations of above

Classifications		
AWS	A5.14	ERNiCrMo-3
EN	18274	ENi6625 (NiCr22Mo9Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 max	**% Titanium**	0,4 max
% Manganese	0,5 max	**% Niobium**	3,15 - 4,15
% Silicon	0,5 max	**% Iron**	1,0 max
% Sulphur	0,015 max	**% Copper**	0,5 max
% Phosphorous	0,015 max	**% Aluminium**	0,4 max
% Chrome	20,0 - 23,0	**% Molybdenum**	8,0 - 10,0
% Nickel	60,0 min		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	430 MPa
Tensile Strength	715 MPa
% Elongation on 4d	50
% Elongation on 5d	47
Impact Energy at -196°C	100 J
Hardness cap/mid	235/255 HV

Packing Data		
	SAW	
Diameter (mm)	**Pack Mass (kg)**	**Item Number**
2,4	25,0	W077639
3,2	25,0	W077640

SILVER BRAZING ALLOYS

Section 12 - Welding Consumables

Silver Brazing Alloys 694
Fundamentals of Gas Welding & Brazing 695
Silver Brazing Flux 699
Uncoated Cadmium-Free Silver Brazing Alloys 700
Flux Coated Cadmium-Free Silver Brazing Alloys 701

Fundamentals of Gas Welding & Brazing

Welding Technique

Successful welding depends on the following factors:

1. Selection of the correct consumables
2. Selection of the correct flame setting
3. Selection of the correct application techniques
   a) Correct angle of rod to work
   b) Correct travel speed
4. Selection of the welding preparation

Silver Brazing

Choice of Filler Metal

An alloy is normally selected for its melting and flow characteristics.

The easiest filler materials to use are the high silver, free-flowing alloys, because of their low melting temperatures and narrow melting ranges. The higher the brazing temperature and the wider the melting range of the alloy, the more difficult the brazing operation will be.

Pre-Cleaning

It is important that the mating surfaces of the components to be brazed are free from oil, grease and any surface oxide layer prior to joining. Most engineering components require nothing more than degreasing before assembly.

Oxide removal can be accomplished either chemically or mechanically. Mechanical removal is preferable, because the surface is roughened and excellent bonding is obtained. A medium emery cloth provides about the right amount of surface roughness.

Oil and grease removal is best carried out by using a solvent degreasing agent, but hot, soapy water is better than nothing at all.

Fluxing

The choice of the correct flux is just as important as the choice of filler material. There are three desirable properties of a flux:

1. The flux must melt and become active below the melting point of the brazing alloy. Borax or borax based fluxes are not sufficiently molten at the low temperatures at which silver brazing alloys are used. A low temperature fluoride based flux, such as Easyflo, needs to be employed.
2. The flux must be capable of removing the oxides found on the parent materials. Easyflo flux will remove the oxides found on most common engineering materials such as mild steel, brass and copper. Special fluxes may be required on certain types of highly alloyed steels and tungsten carbide tool tips. It is also necessary to use a specially formulated flux on aluminium bronze or aluminium brasses containing more than 2% aluminium.
3. The flux must remain active at the brazing temperature for long enough to allow the brazing operation to be carried out. Fluxes are chemical compounds which dissolve oxides formed in heating. Like most chemical compounds, a flux eventually reaches the point where it is saturated and becomes unable to dissolve any more oxide. If the flux residues appear blackened and glassy, the flux has most likely been exhausted during heating, and a flux with higher time / temperature stability should be used.

Easyflo Flux

This is the accepted general-purpose flux for use with all low-temperature silver brazing alloys that have brazing temperatures not exceeding 800°C. It will successfully flux all the common engineering materials, and its residues are soluble in hot water. Where difficulty is encountered when removing residues, immersion in 10% caustic soda is suggested.

Flux Application

The best way to apply a flux is to paint it onto the joint as a paste before assembly. It is common to see operators heating the rod end and dipping it into the flux, and then applying both to the joint. This ‘hot rodding’ technique has the disadvantages that the flux does not protect the joint during the heating cycle and that the limited amount of flux applied does not allow alloy penetration into the capillary gap.

If a flux powder is used, it should be mixed to a double cream consistency with water and a few drops of detergent. It should also be applied to the joint by means of a paint brush. Too much flux will rarely result in a bad joint, but too little flux will invariably give joints of poor quality.

Heating the Joint and Applying the Alloy

When heating a joint for brazing, it is essential that it is slowly and evenly heated to the brazing temperature.

The type and size of flame used will depend on the parent materials and the mass of the components. Oxy-acetylene, air-acetylene and air-propane are commonly used, but care should be taken with the first due to the high flame intensity, which may melt the parent materials.

If the mass of metal is very large, more than one torch should be used to raise the components to temperature before the flux becomes exhausted.

As a temperature guide, either the colour of the metals or the condition of the flux may be used. The flux on a joint that has reached the correct temperature for brazing should be clear, fluid and flow over the joint area like water.

When the brazing temperature is reached, the filler metal is applied by touching the joint gap with the rod and applying some indirect or splash heat from the torch to the parent material. The molten filler metal will follow the heat from the flame as it is directed along the joint. The brazing alloy should be applied according to its flow characteristics; an alloy with free-flowing characteristics should be touched at one point on the joint, from where it will flow into and around the joint by capillary action. A less free-flowing alloy should be applied along or around the entire joint, building up a fillet of alloy.

If phosphorous bearing filler rods are used, such as Eesibraze 2, the colour of the metal should be a dull cherry red before the rod is applied to the joint gap.

Once brazing has been completed, the heating should be discontinued, as excess heating may cause metallurgical problems with the parent materials and porosity in the filler materials.

When the alloy has solidified, the joint can be quenched in water to help remove flux residues.

Quenching should only be carried out when it will not damage the properties of the parent metals, or result in cracking because of stresses caused by the thermal shock (e.g. in the case of tungsten carbide pieces).

Removal of Flux Residues

The method of residue removal depends on the type of flux that has been used. Easyflo flux residues can be quite simply removed by soaking in hot water, provided they are not in a burnt and blackened condition. Complete flux residue removal is usually possible within 10 – 15 minutes of soaking in water with a temperature of 60°C or above. After soaking, the joints should be scrubbed under running water to ensure complete cleanliness.

Acid pickling is not effective in removing flux unless the residues are in a burnt and blackened condition. If pickling is necessary, it should be carried out after the flux residue removal operation.

Health and Safety

Brazing alloys and fluxes contain elements which, if overheated, produce fumes that may be harmful or dangerous to health. Brazing should be carried out in a well ventilated area with operators positioned so that any fume generated will not be inhaled. Adequate ventilation to prevent an accumulation of fumes and gases should be used. Where fume levels cannot be controlled below the recognised exposure limits, use a local exhaust to reduce fumes and gases. In confined spaces without adequate ventilation, an air-fed breathing system should be used. When outdoors, a respirator may be required. Precautions for working in confined spaces should be observed.

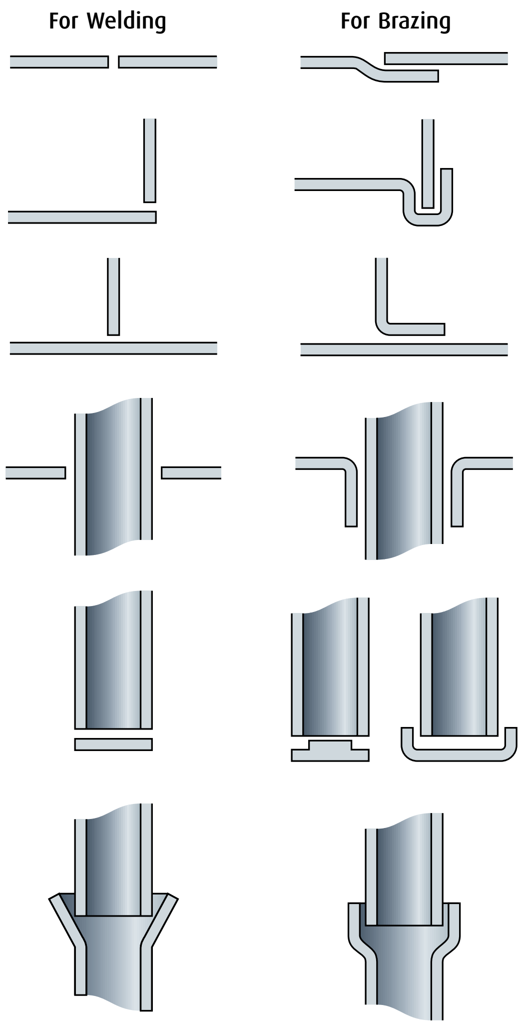
Apart from fume hazards, flux can be irritating to the skin and prolonged contact should be avoided.

Before use, read all the manufacturer's instructions, refer to the warning labels on the packaging and ask your employer for the Materials Safety Data Sheet (MSDS). You can obtain the MSDS by referring to our website at www.afrox.com or by calling 0860 020202.

Joint Design

The best brazed joints are those which have a capillary joint gap into which the molten filler metal can flow. A comparison of the different joint designs used in welding and brazing is shown below.

Typical Designs



The most common type of joint used for brazing is the lap joint, or the sleeve joint in the case of tubular components. To design a good lap joint, two criteria should be considered:

1. The joint gap
2. The degree of overlap

It is these two parameters that determine the ultimate joint strength, rather than the properties of the filler metal.

A correctly designed brazed joint will often be stronger than the parent materials from which it is constructed.

The best degree of overlap for a brazed joint is 3 – 4 t where t is the thickness of the thinnest parent metal part that makes up the joint.

The general rule for tubular parts is that the overlap should be one pipe diameter for sizes up to 25 mm diameter tube.

The most suitable joint gap depends mainly on the flow characteristics of the filler metal. The joint gaps for the various alloys listed in the following section have been indicated. The gaps quoted are those that should be present at the brazing temperature, the cold clearances being adjusted as necessary to account for any difference in the expansion properties of the parent materials.

Gas Welding

Welding Techniques

The heat generated by an oxy-fuel flame is used to melt the parent metal in the joint forming a weld pool. If a filler rod is to be used, it must also be melted into the weld pool. The flame envelope also protects the molten weld pool and the end of the filler rod from atmospheric contamination.

The weld is continuous and progresses at the speed at which the parent and filler materials can be melted to form the weld pool, but fast enough not to allow the weld pool to burn through the component creating a hole.

The filler rod, if used, is constantly fed into the weld pool at the rate required to give the correct bead width, depth of penetration and reinforcement height for the application. The length of the weld will dictate how much filler rod is required. Usually more than one length of rod will be needed and, when a new length of rod is needed, a stop and re-start will have to be effected. Stop-start can affect the quality of the weld if care is not taken to ensure the weld pool is free of contamination and enough time is given to allow the weld pool to become fully molten.

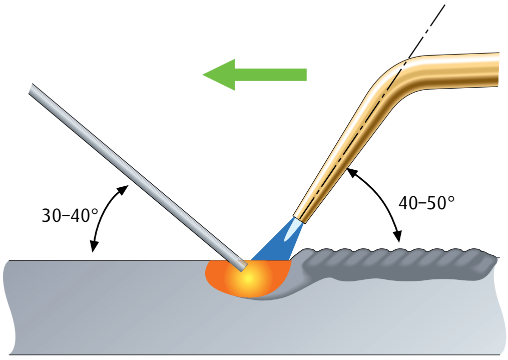
There are three recognised gas welding techniques used. These are:

- Leftward welding
- Rightward welding
- All position rightward welding.

Leftward Welding (or Forward Welding)

Leftward welding is the most common technique used in gas welding. In this technique, the flame follows the filler rod along the joint of the weld and, with the torch in the right hand, the movement is from right to left or from left to right if the torch is held in the left hand.

Leftward Welding Technique

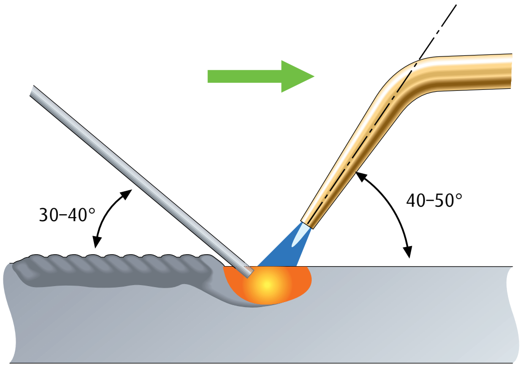


This technique can be used in all welding positions. The method is the same, with the flame following the filler rod, irrespective of the welding position.

Rightward Welding (or Backhand or Backward Welding)

With this technique, the filler rod follows the flame along the joint of the weld. With the torch in the right hand, the movement is from left to right and the opposite when the torch is in the left hand. Rightward welding is limited in its uses and is only used in the flat (1G, PA) position and for material thicknesses between 4 -16 mm thick. When welding butt joints of between 4 - 6 mm, no edge preparation is required. For thicker materials up to 16 mm, edge preparation will be required. However, it is possible to complete this joint in one pass.

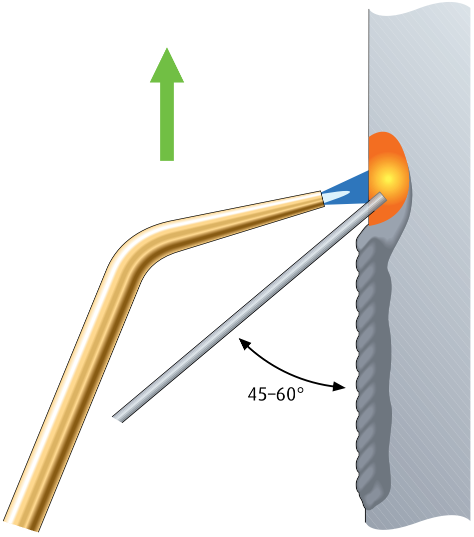
Rightward Welding Technique



All-Position Rightward Welding (APR)

With this technique, the wire can follow, precede or be in line with the flame, depending on the welding position used. The all-position rightward technique is for welding thicker materials in the vertical-up, vertical-down, horizontal-vertical and the overhead positions.

All-Position Rightward Welding Technique



The technique is mainly used for gas welding pipe of all diameters and wall thicknesses up to 6 mm in a single pass, with no edge preparation to the material. This technique was developed to compete with manual metal arc welding and is used mainly on construction sites for welding, heating and ventilating pipe-work.

Warning

Brazing can give rise to excessive noise, eye and skin burns due to the flame and its radiation, and can be a potential health hazard if you breathe in the emitted fumes and gases.

Brazing should be carried out in a well ventilated area, with operators positioned so that any fume generated will not be inhaled. Adequate ventilation to prevent an accumulation of fumes and gases should be used. Where fume levels cannot be controlled below the recognised exposure limits, use a local exhaust to reduce fumes and gases. In confined spaces without adequate ventilation, an air-fed breathing system should be used. When outdoors, a respirator may be required. Precautions for working in confined spaces should be observed.

Apart from fume hazards, flux can be irritating to the skin and prolonged contact should be avoided.

Before use, read all the manufacturer's instructions, refer to the warning labels on the packaging and ask your employer for the Materials Safety Data Sheet (MSDS). You can obtain the MSDS by referring to our website at www.afrox.com or by calling 0860 020202.

Silver Brazing Flux

Product	Item Number	Working Range (ºC)	Classification DIN 8511	Flux Form	Pack Size	Characteristics	Residue Removal
Easyflo Flux	W001852	550 - 800	F-SH1	Powder	250 g jar	-	-

Uncoated Cadmium-Free Silver Brazing Alloys

Product Name	Item Number	Diameter (mm)	Pack Size	Application	Classification	Chemistry (%)							Melting Range (°C)	Tensile Strength	Optimum Joint Gap (mm)
						Mn	Ag	Cu	Zn	Sn	Si	Ni			
Silverflo 55	W001055	1,5	100 g	The Silverflo range of cadmium-free alloys represents the ultimate safety precautions against cadmium fume. Cadmium content is controlled to 0,025% max. and the use of these alloys is highly recommended - for some applications it is obligatory, e.g. food handling equipment.	DIN L-Ag55n BS AG14	-	55	21	22	2	-	-	630 - 660	390 MPa	0,05 - 0,15
	W001056	1,5	1 kg												
	W001058	3,0	1 kg												
Silverflo 40	W001170	1,5	100 g		BS AG20	-	40	30	28	2	-	-	650 - 710	450 MPa	0,075 - 0,20
Silverflo 30	W001030	1,5	100 g	Silverflo 55 is the lowest melting point alloy in the group and has been widely adopted as a substitute for Easiflo1and Easiflo 2. Silverflo 40 is a general purpose alloy suitable for use on most engineering materials. Silverflo 30 is an economic alloy mainly used to braze copper and mild steel. Alloys with less than 25% silver are widely used on copper and steel. They give a good colour match on brass but require close temperature control due to their high melting points. Due to their relatively short melting range, these alloys are suitable for step brazing.	BS AG16	-	30	38	32	-	-	-	695 - 770	505 MPa	0,075 - 0,20
Fridgebraze Bare	W001561	1,5	2 kg	Fridgebraze was specially developed to overcome liquid embrittlement when brazing galvanised steel pipes used in the refrigeration industry.	-	1,1	24,5	39,6	34,2	-	0,4	0,2	670 - 730	470 MPa	0,075 - 0,20
	W001562	2,0	1 kg												

Flux Coated Cadmium-Free Silver Brazing Alloys

Product Name	Item Number	Diameter (mm)	Pack Size	Application	Classification	Colour Code	Chemistry (%)							Melting Range (°C)	Tensile Strength	Optimum Joint Gap (mm)
							Mn	Ag	Cu	Zn	Sn	Si	Ni			
Fluxcoat 402	W001197	1,5	100 g	Fluxcoat 402 is a general purpose alloy suitable for use on most engineering materials.	BS AG20	Yellow	-	40	30	28	2	-	-	650 - 710	450 MPa	0,075 - 0,2
	W001180	1,5	Sleeve													
Silvercoat 30	W001031	1,5	100 g	Silvercoat 30 is an economic alloy mainly used to braze copper and mild steel. Alloys with less than 25% silver are widely used on copper and steel. They give a good colour match on brass but require close temperature control due to their high melting points.	-	Light Yellow	-	30	38	32	-	-	-	695 - 770	505 MPa	0,075 - 0,2
	W001032	1,5	1 kg													
Silvercoat 18	W001018	1,5	100 g		-	Blue	-	18	45,75	36	0,25	-	-	785 - 815	470 MPa	0,075 - 0,2
	W001019	1,5	1 kg													

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