CAST IRON

Section 12 - Welding Consumables

Welding of Cast Iron

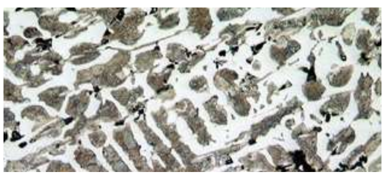
Cast irons, like steels, are essentially alloys of iron and carbon, but whereas the carbon content of steel is limited to a maximum of 2%, cast irons generally contain more than 2% carbon.

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.

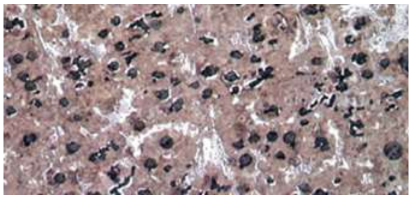
Microstructure of grey cast iron (x200)

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.

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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.

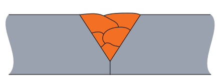
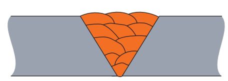
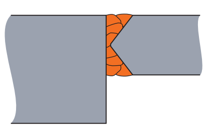
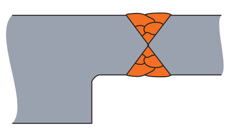
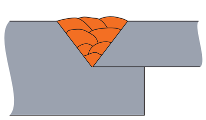
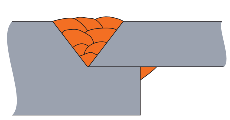
Special Welding Techniques for Cast Irons

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.

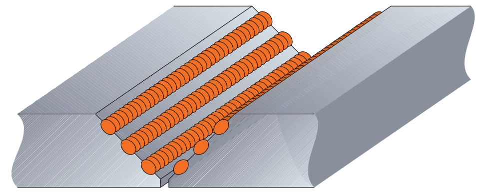
Poor Design	Improved Design
Partial penetration welds	**Full penetration welds**
	
Uneven thickness	**Constant thickness**
	
Without backing fillet weld	**With backing fillet weld**
	

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

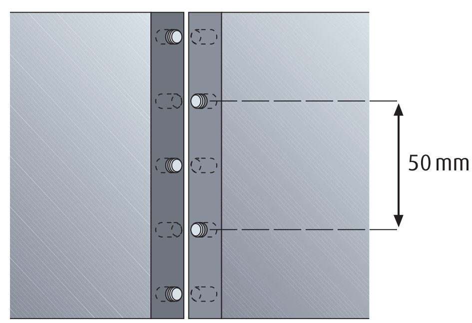


The technique of grooving the joint face before filling. This interrupts the line of the heat affected zone

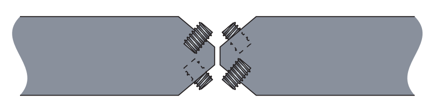
Studding

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.

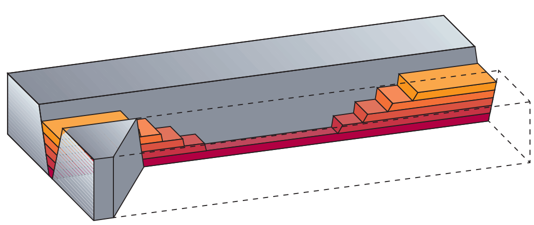
To minimise penetration, short circuit dip-transfer modes should be used with MIG, MAG and flux cored welding processes, and arc lengths in MMA welding should be kept as short as possible while still maintaining good weld shape. In general, the welding current should be kept as low as possible within the range specified by the consumable manufacturer.

Oxy-Acetylene Welding

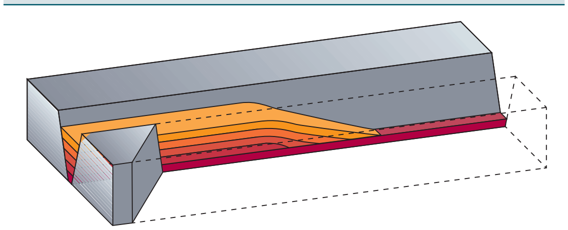
When depositing cast iron by the gas welding process, the torch flame should not be oxidising, as the resulting loss of silicon promotes the formation of brittle white iron in the deposit. Similarly, the tip of the inner cone of the flame should be kept between 3 and 6 mm from the casting surface, and 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.

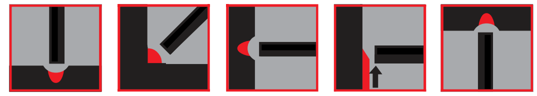
Cast Irons

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

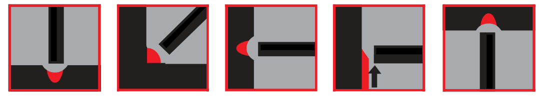
This electrode is suitable for the repair of all commercially available irons such as grey, blackheart malleable and nodular spheroidal graphite irons, with or without preheating.

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.

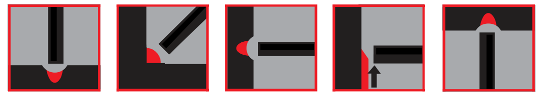
Classifications		
AWS	A5.15	ESt
EN ISO	1071	ESt (nearest)

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.

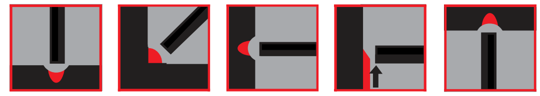
Classifications		
AWS	A5.15	ENiFe-CI
EN ISO	1071	ENiFe-2 (nearest)

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

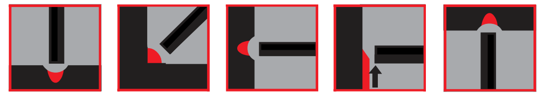
This electrode has been specifically designed for the rectification and repair of all commercial grades of cast iron, where machining, after welding, is to be carried out. Preheating and post weld heat treatment is not required in many applications where the location of the defect or shape of design 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-CI (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

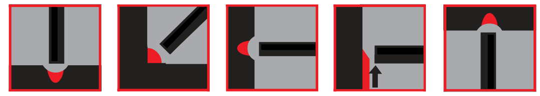
Classifications		
AWS	A5.15	ENi-CI
EN	18274	Ni 2061 (NiTi3)

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

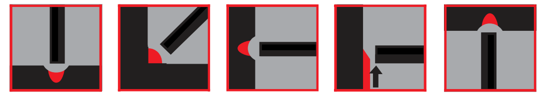
Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	52,0 - 60,0
% Manganese	1,0 max	**% Iron**	Bal.
% Silicon	0,5 max	**% Copper**	0,5 max
% Sulphur	0,02 max	**% Cobalt**	2,0 max
% Phosphorous	0,03 max		

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.

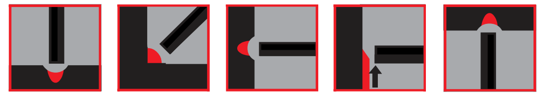
Typical Mechanical Properties	
Melting Range	860°C - 890°C
Tensile Strength	460 MPa
Approximate Brinell Hardness	125 HB

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

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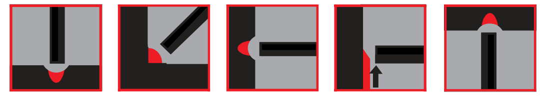
Afrox Nickel Bronze DB



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