WELD WITH COMPLETE CONFIDENCE

NIHONWELD

WELDING PRODUCTS

NON-FERROUS WELDING HANDBOOK
(CAST IRON, COPPER AND ALUMINUM)

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Industrial Welding Corporation
LEADER IN WELDING TECHNOLOGY

INTRODUCTION:

Industrial Welding Corporation (IWC) was established in 1982 by Mr. H. Ong Hai with over almost 50 years of experience in the welding industry. IWC's dedication and commitment to quality and research has made the company grow from a small producer to currently the biggest and most diverse manufacturer of welding electrodes/consumables in the Philippines.

IWC is the largest exporter of welding electrodes in the country, exporting to over 40 countries worldwide and continues to create new relationships in other countries every day. IWC believes in forming business relationships for long term business and friendship.

IWC will always strive and continue to improve existing products and develop new products for changing applications and needs. Quality is always first above everything else and IWC is proud to say that one can "WELD WITH COMPLETE CONFIDENCE" with our "WORLD CLASS QUALITY" products.



STATE OF THE ART LABORATORY EQUIPMENT AND MANUFACTURING FACILITIES REFLECTS OUR DEDICATION TO QUALITY, RESEARCH AND DEVELOPMENT OF NIHONWELD WELDING PRODUCTS.

APPROVALS:

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NIHONWELD HANDBOOK IN WELDING OF CAST IRON, COPPER AND ALUMINUM

This handbook is a comprehensive compilation of data about welding of cast iron, copper, aluminum and their alloys. It includes definitions, welding processes and classification of various cast iron, copper alloy and aluminum alloys. It also covers the problems and solution in welding these metals. It explains the wide range of Nihonweld welding products for welding aluminum, cast iron and copper base metals.

The Company Behind the Products

Industrial Welding Corporation is a leader in the fields of welding electrode and wire production. This leadership was earned through years of intensive research and development. It has provided the industry with various types of welding materials and processes for weld fabrication, repair, joining of cast iron, copper and aluminum with the result that the metals are joined better than before.

It is the responsibility of the Industrial Welding Corporation to provide creative research to expand the art of welding, to the development and production of new welding electrodes and wires which outperform traditional materials and meet the metallurgical needs of today and tomorrow.

We believe this handbook will explain the technology of welding copper, cast iron and aluminum in a lay-man language.

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What is Cast Iron?

The term “Cast Iron”, like term “steel” identifies a large family of ferrous alloys. Cast irons primally are alloys of iron that contain 2 to 4.5% carbon in graphite form, from 5 to 3% silicon and lesser amounts of sulfur, manganese and phosphorous. Wide variations in properties can be achieve by varying the balance between carbon and silicon, by alloying with various metallic or nonmetalic elements, and by varying melting, casting and heat treating practices.

Cast iron as the name implies, are intended to be cast to shape rather than formed in the solid state. Cast irons have low melting temperatures, are very fluid when molten, do not form undesirable surface films when poured, and undergo slight to moderate shrinkage during solidification and cooling. However, cast irons have relatively low impact resistance and ductility, which may limit their use.

Mechanical properties of cast irons especially strength, ductility and modulus of elasticity-depend strongly on structure and distribution of microstructural constituents. Physical properties such as thermal conductivity and damping capacity can strongly influenced microstructure. In any and cast iron, the microstructural feature that has the most significant effect on the properties is free graphite. Shape and distribution of free graphite are more useful than composition for classifying cast irons the composition ranges for different types of cast iron overlap, and in many instances iron of a given composition can be made into any of the four basic types by varying casting or heat treating practice. The structure of hte matrix surrounding the free graphite particles also influences mechanical properties.

Metallurgy of Cast Iron

A section through the ternary Fe-Fe3 C-Si diagram at 2% Si which approximates the silicon content of many cast irons provides a convenient reference for discussing the metallurgy of cast iron. The diagram in Fig.1 resembles the binary Fe-Fe3C diagram but exhibit important differences characteristic of ternary systems. Eutectic and eutectoid temperatures change from single values in the Fe-Fe3C system to temperature ranges in the Fe-Fe3C-Si system. The eutectic and eutectoid points shift to lower carbon contents.

Figure 1 represents the metastable equilibrium between iron and carbide (cementite), a metastable system. The silicon that is present to remain in solid solution in the iron, in both ferrite and austenite, and so does not affect the composition of the carbide phase but only the conditions and the kinetics of carbide formation on cooling. The designations a,y and Fe3C therefore, are used in the ternary system to identify the same phase that occur in the Fe-Fe3C binary system. Some of the silicon may precipitate along with the carbide, but it cannot be distinguished as a different phase. The solidification of certain composition does not occur in the metastable system, but rather in the stable system, where the products are iron and carbide. These composition encompass the gray, ductile and compacted graphite cast irons.

If the section through the ternary diagram at 2% Si is to be used in tracing out the phase changes that occur, its use can be justified only on the assumption that the silicon concentration remains 2% in all parts of the alloy under all conditions. This obviously is not strictly true, but there is little evidence that silicon segregates to any marked degree in cast iron. Thus it is only slightly inaccurate to use the constant-silicon section through the ternary diagram in the same as one would apply the Fe-Fe3C diagram to carbon steel.

Carbon equivalence (CE) is a method that often used to simplify evaluation of the effect of composition in unalloyed cast irons. CE equals total carbon content (TC) plus about one third the sum of the silicon and phosphorus contents.

$CE = TC + (\%Si + \%P)/3$ (Eq1)

Comparison of CE with the eutectic composition in the Fe-C system (4.3%) will indicate whether a cast iron will behave as a hypoeutectic or hypereutectic alloy during solidification. When CE is near the eutectic value, the liquid state persists to a relatively low temperature and solidification takes place over a small temperature range. The latter characteristic can be important in promoting uniformity of properties within a given casting.

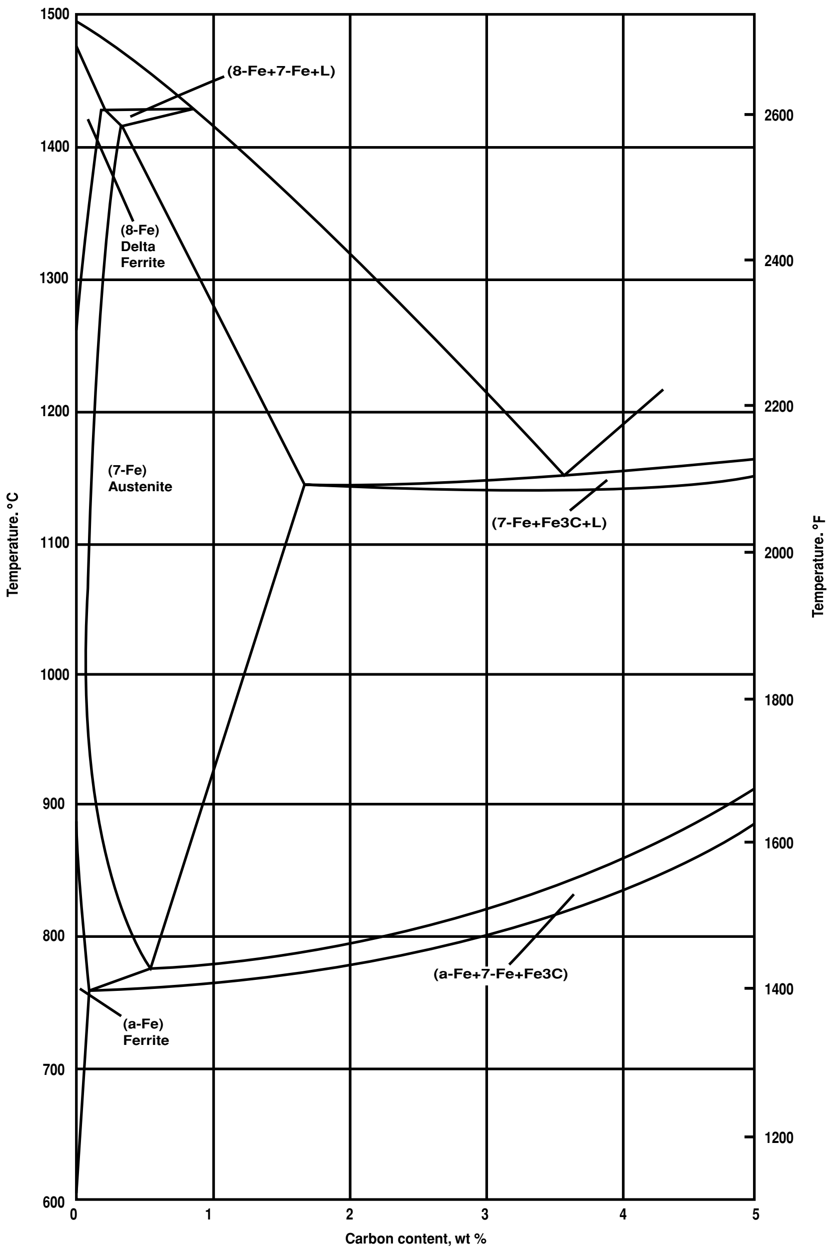
In hypereutectic irons (CE is greater than about 4.3%), there is a tendency for fish grahpite-proeutectic graphite that forms and floats free in the molten iron-to precipitate on solidification under normal cooling conditions. In hypoeutectic irons, the lower the CE, the greater the tendency for white or mottled iron to form on solidification.

White cast iron derive its name from the appearance of a white crystalline surface when featured. White iron is formed when the carbon in solution in the molten iron does not form graphite on solidification but remains combined with the iron, often in the form of massive carbides. White cast iron is produced from pig iron by cooling the casting rapidly. There is no time for the carbon to seperate from iron. Hence, white cast iron is hard, brittle and not easily machineable. A melting point is 1260°C slightly higher than that of gray iron. It has a tensile strength of 400,000 psi to 50,000 psi with non-existent ductillity. Weldability is diffcult even with oxy-acetylene welding. Arc welding is not recommended.

Gray cast iron derive its name from the appearance of a gray surface with ting facets when fractured. It is made from pig iron by allowing the casting to cool slowly. It is an alloy of iron, carbon and silicon. About 8% carbon is in carbide form. Phosphorus in trace quantities are usually present. When the composition of the iron and the cooling rate at solidification are suitable, a substantial portion of the carbon content seperates out of the liquid to form flakes of graphite. When a piece of the solidified alloy is broken, the fracture path follows the graphite flakes, and the fracture surfaces appear gray because of the predominance of exposed graphite.

Because the graphite flakes in gray cast iron strongly influence the mechanical propeties; their size and distribution are often specified in addition to mechanical and physical properties.

FIG. 1 **Section through the iron-iron carbide- silicon ternary equilibrium diagram at 2% silicon**



Presence of graphite flakes also makes gray iron more brittle than ductile iron. Gray iron can be machined easily and can be hardened by rapid cooling or quenching from a suitable elevated temperature. Coefficient of expansion is about 13nm/m c, thermal conductivity is about 46 w/m-k and tensile strength ranges from 10,000 psi to 60,000 psi.

High carbon, high silicon (ASTM Class 20) gray irons are ferritic in structure, with coarse graphite flakes throughout the matrix. Low carbon, low silicon iron such as class 50 irons are pearlitic.

Ductile cast iron derive its name from the fact that in the as cast form, it exhibits measurable ductility. By contrast, neither white or gray iron exhibits significant ductility in a standard tensile test. Ductile cast iron is also know as nodular iron or spherulitic-graphite cast iron, is very similar to gray iron in composition, but during casting of ductile iron the graphite is caused to nucleate as spherical particles, or spherulites, rather than as flakes. This is accomplished through the addition of a very small but definite amount of magnesium or cerium to the molten iron in a process step called nodulizing. Ductile iron is usually inoculated to control the size and distribution of the graphite spherulites, either before during or after the nodulizing step. Ductile iron is produced from the same types of raw materials as gray iron, but usually requires slightly higher purity. Casting properties of ductile iron such as fluidity are comparable to those of gray. The chief advantage of ductile iron over gray iron is its combination of high strength and ductility. Other advantage of ductile iron include a high modulus of elasticity, a linear stress-strain relationship for most of the region below the yeild point, and wide ranges of available yield and tensile strengths. Properties such as machinability and corrosion resistance are comparable to those of gray cast iron, except that ductile iron has better resistance to elevated temperature oxidation than gray iron. Like gray iron, ductile iron can be heat treated or alloyed to enhance certain properties, especially wear resistance.
It has a thermal conductivity of about 36 w/m-k, coefficent expansion of 11.2 nw/m-k and melting point is slightly below of that gray iron. Tensile strength ranges from 60,000 psi to 120,000 psi depending an alloy composition and process used to obtain the nodular structure.

Malleable Cast iron is cast as white iron, then malleablize by heat treatment to impart ductility and convert the carbon containing phase from iron carbide to a nodular form of graphite called temper carbon. The heat treatment also improves the impact and shock resistance. It contain 2% to 3% carbon in the combined form. There are three grades of malleable cast iron, ferrite malleable iron, pearlite malleable iron, and the martensitic malleable cast iron. Pearlitic and ferritic malleable iron are produced either by controlled heat treatment while cast iron or by alloying to prevent decomposition of carbides is while cast iron. Martensitic malleable iron is produced by quenching and tempering pearlitic malleable iron.

Malleable iron, like ductile iron, processes considerable ductility and toughness because of its combination of nodule shape graphite in a low-carbon metallic matrix. Because of the way in which graphite is formed in malleable iron, however the nodules are not trully spherical as they are in ductile iron but rather somewhat irregular aggregates.

Malleable iron and ductile iron are used for some of the same applications where ductility and toughness are important. In many instances, the choice between malleable and ductile iron is based on economy or availability rather than on properties. In certain applications, however, malleable iron has a clear-cut advantage. It is preferred for thin section castings, for parts that are to be pierced, coined or cold formed; for parts requiring maximum machinability; for parts that must retain good impact resistance at low temperatures; and for some parts requiring wear resistance (martensitic malleable iron). Coefficient expansion is about 11.88 nm/nmk and tensile strength ranges from 35,000 psi to 100,000 psi. (Ferritic iron has tensile strength of 60,000-100,000 psi). As in steel, ductility suffers with increased tensile strength. Malleable cast iron is stronger and tougher than gray cast iron and can be hardened by heat treatment. It has a coefficient expansion of about 11.88 nm/m-k.

Welding Processes for Cast iron

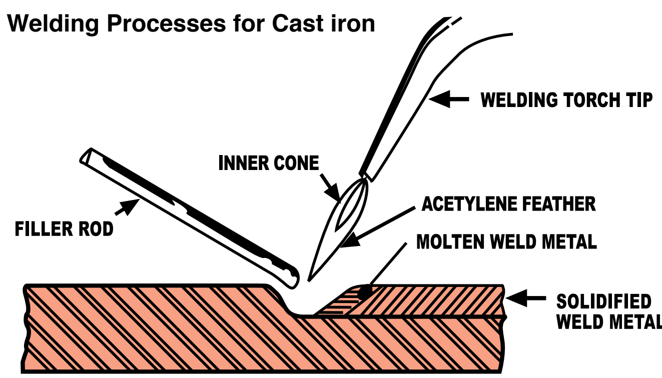


FIG. 2

They Oxy-Fuel Gas Welding is widely used on gray cast iron and to a smaller extent ductile iron and only to a minor extend on malleable iron. Cast iron filler metal or silver rod is melted together with the base metal to form the joint. An oxy-acetylene flame has a maximum temperature of about 6000°F, which is several thousand degrees less than that of a welding arc. Gas welding is therefore slower, and results in greater heat input and wider heat affected zones than those produced by arc welding. For this reason high products of 1100 to 1200°F are generally used for gas welding of cast irons. Good results have been obtained in gas welding ferritic ductile iron with ductile iron rods. A flux required in gas welding of cast iron to increase the fusible iron-silicate slag, as well as to and in the removal of slag. (See Fig. 2)

The shielded Metal Arc Welding using covered electrodes is the most widely used process in welding gray ductile and malleable cast irons. Cast irons, low carbon steels, nickel base alloys and copper base alloy covered with special fluxes as the filler metals are

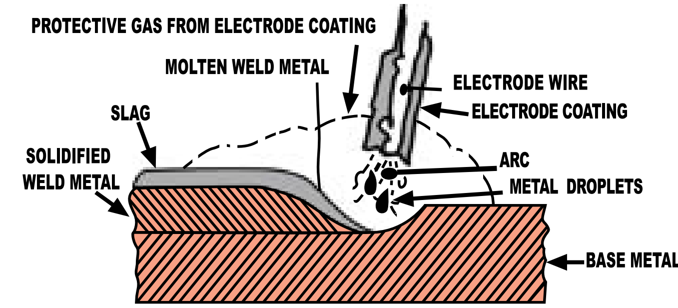


FIG. 3

Metal Arc Welding

used in Shielded Arc Welding of Cast Iron. This process has been very effective in welding cast iron due to modern development of flux coverings that overcome most of the welding problems. The type of deposit and to some extend the procedure for welding will vary accordingly to electrode used. Electrodes for manual. (see Fig. 3)

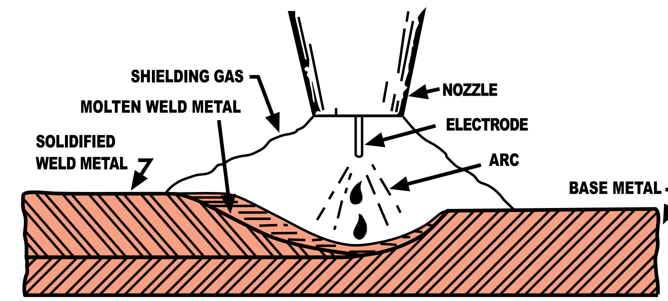


FIG. 4

The Gas-Metal Arc (MIG) process produces weld metal by fusion in an arc between the end of a continously for bare electrode and the work which progressively melts the work and the electrode through a gun. The arc is shielded by an externally supplied gas, which is usually argon, helium or carbon dioxide. It is widely used in welding gray cast iron to steel. (See Fig. 4)

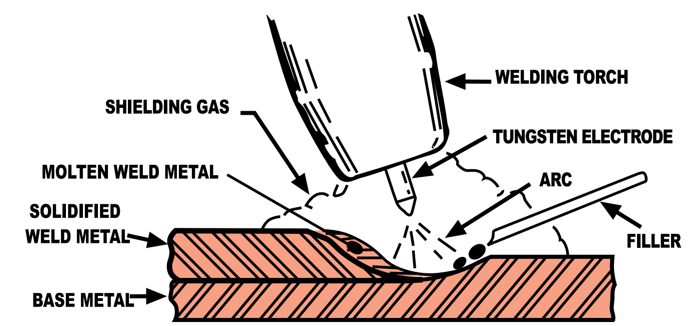


FIG. 5

In the Gas-Tungsten Arc (TIG) process the electrode is not consumed to form the weld it carries the current between the tungsten electrode and the work with virtually no change in the end of the tungsten. The filler metal is seperately fed to the arc which is shielded by argon, helium or the mixture of the two. This process is widely used in welding gray iron. Joint preparation is the same as for shielded metal-arc welding, but a higher preheat is recommended. Welds have been made using nickel iron, gray iron, and 300 series stainless steel filler metals. Unless its particulars advange is gained, gas tungsten arc welding is not used when another, less costly process is available. (See Fig. 5)

The Submerged-Arc process is particularly suitable for automatic application because it permits continous feeding of the filler wire and relatively high currents. In this process the arc is completely shielded by a layer of loose granules of flux as the diagram shows. Although submerged arc welding is acceptable in welding some malleable iron to low carbon steel it has been used to a very small extent in welding any of the cast irons. The process generally is not suited to the repair of casting defects or damage castings, because it requires undirectional operation in the flat position. Other factors that limit its applicability are lack of visibility and high heat input. (See Fig.6)

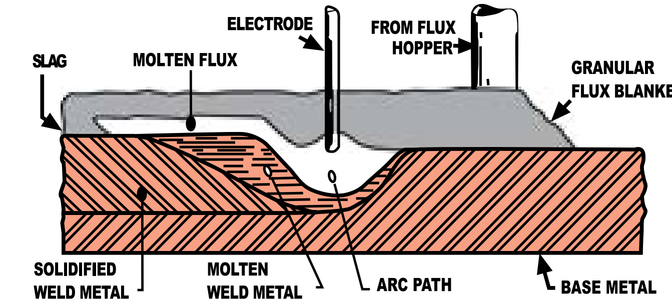


FIG. 6

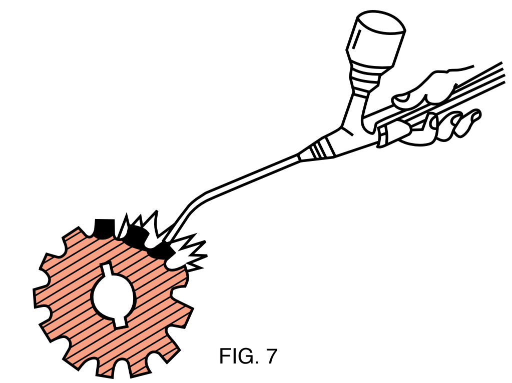
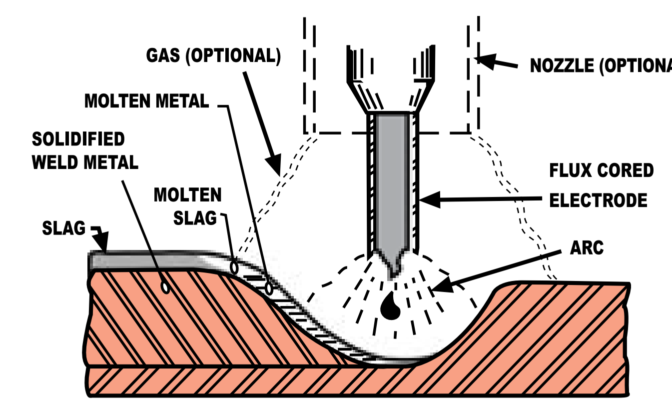


FIG. 7

Metal Spray process is spraying highly ductile metal powders with the use of a metal spray gun together with oxygen fuel gas welding. The heat of the gas melts the powders as it is sprayed on the surfaced. Metal spray welding fits into productions application requiring thin weld overlays.

This process is used in welding of cast iron where the color match is an important factor. Because of this matching feature, this process is sometimes described as cosmetic repair of cast iron. (See Fig. 7)



Flux Cored Arc Welding

FIG. 8

Flux Cored Arc welding is a process in which the heat for welding is produced by an arc between tubular consumable electrode wire and the work metal, with shielding provided by gas evolved during combustion and decomposition of a flux contained within the tubular electrode wire, or by the flux gas plus an auxiliary shielding gas. Although flux cored welding is used succesfully in many cast iron welding applications, it is however not widely used in commercial scale because most of cast iron welding is confined to welding of smaller parts not economical when flux cored welding is used. (See Fig. 8)

Problems & Solution in Welding Cast Iron

Cast Iron is an extremely versatile metal and is found as a key component in virtually every major piece of industrial and commercial equipment in use today. Its extreme fluidity in the molted states make it ideal for the pouring and manufacture of many different types of casting including the most complicated and complex designs.

Due to its brittle in nature, unusual physical and chemical properties, however cast iron has, in the past been one of the most difficult metals to arc welding. With the advent Nihonweld nickel bearings electrodes with special flux coatings, filler wires and preparations procedures, the problems connected with cast iron welding have been overcome.The nature of cast iron and why it has been so difficult to weld.

It is the unusual amount of carbon in cast iron that gives its chief characteristic and makes its so difficult to weld. The arc welding problem of cast iron is mainly three-fold.

The intense uneven heat transmitted by most conventional cast iron electrodes at their arc welding temperature, combined with resultant sporadic flow of the weld metal, causes some the carbon or graphite flakes to dissolve into the iron. Rapid cooling from the air and the cold surrounding area of the base metal then causes these carbon particles to crystallize, forming a very hard and nonmachinable structure, called martensitic, in parts of the weld deposit and weld area (transition zone) of the base metal. (Fig. 9) Nihonweld Welding products for welding cast iron all have special filler wire and special fluxes containing high percentage of sintered metal particles. This combination develops controlled exceptionally fluid and even flowing deposit at low amperage. Here you have the factors of even heat conduction, minimum temperature. Exceptional fluidity and high deposition rate-all necessary factors in avoiding a martensitic build-up and obtaining fully machinable transition zone. The resultant bead contour is thin, low and wide. (See Fig. 11)

The porous nature of cast iron permits absorption of grease, oil and contaminants which, at arc welding temperatures turn to gas. The escaping gases create porosity in the weld metal, resulting in a weak weld and increases vulnerability to stress. (Fig. 9) Here again it is the chemical-metallurgical make-up of the special coatings that overcome one of the major problems associated with the arc welding of cast iron. Emulsifying and fluxing agents within the coatings wash head of the alloying weld metal, flushing base metal contaminants and neutralizing the porosity causing effect of their gases. (See Fig. 12)

When welding the low tensile strength and brittle nature of cast iron makes it extremely prone to high stress or fracture as weld metal cools and contracts, pulling with great force against the welded surfaces of the base metal. (Fig. 10) A high degree of ductility and a balance yield strength to tensile ratio of the Nihonweld weld deposit compensates for the shrinkage factor found in the weld metal as it cools. Thus the bond between the weld metal is unaffected as contraction takes place, and no significant fracture causing strees will be found within the base metal itself. (See Fig. 13)

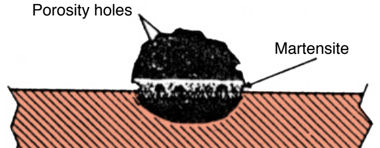


Fig. 9

Porosity holes caused by gas from contaminants appear throughout the weld bead and at the surface of the base metal, causing unbonded islands and weak weld.
Martensite (darker portion) forms a nonmachinable structure at surface of base metal.

Fig. 10

As the weld metal bonds thoroughly to the base metal, and then cools and contracts, it pulls against the brittle base metal with such force that great stress and possible fracture in the base metal results in the vicinity of the weld (arrows show direction of force.)

Fig. 11

Even heat conduction, minimum temperature, exceptional fluidity and high deposition rate, result in a thin, low, and wide bead.

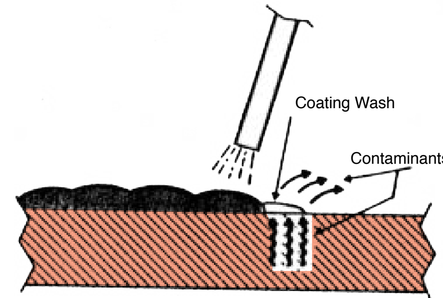


Fig. 12

Emulsifying and fluxing agents within the Dual Flow coating wash ahead of the flowing weld metal, flushing base metal contaminants and neutralizing the porosity causing effect of their gases.

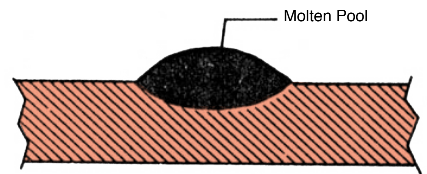


Fig. 13

The shallow molten pool and high degree of ductility (ability to strech) found in Coor-Alloy weld deposits, compensates for shrinkange, relieving stress.

Gray cast iron, due to its brittle nature, has confronted weldors with many problems; and it is only since the development of special techniques for "cold welding" that these problems have been diminished. The welding technique employed is of vital importance. It is widely accepted that the ideal way of welding cast iron includes first preheating it. This is called the preheat method. A majority of cast iron welding undertaken these is without preheating. This is possible due to the advances made in welding technique and the special electrodes available from Industrial Welding Corporation. On the following pages you will find necessary information which will enable you to solve your cast iron welding problems by using the most up to date modern welding techniques.

The Advantages of the "Cold Welding" System

At 2400 F (1315 C) nickel can hold up to 0.65% carbon in solution. When the weld freezes, carbon, which does not form a stable compound with nickel is rejected as graphite. This causes an increase in volume, lessening shrinkage stresses, and because graphite is soft, it increases the machinability of the fusion zone. Other factors necessary to obtain a machinable transition-zone are above all, an equal heat conduction, the observation of important minimum temperatures and of course slow cooling. "Cold Welding" does not imply that workpiece has to be cold; if it gradually warms up during welding. That's all right, provided that the heat does not build up more in one section than in another.

When welding thick-walled work piece it is not always possible to prevent a martensite build up. On these workpiece it is there

fore important that various layers of weld be deposited to re-heat the transition area and destroy the martensite build-up. By following the special techniques described in this section you will obtain a fully-machinable transition zone. It is unnecessary to reinforce the weld piece by studding. Knowlege gain in the oscillation technique field the investigation of fatigue resistance at dynamic stress-shows that studding is outdated.The unweld stud tends to create stresses which can result in fracture.

Preparation for "Cold Welding" of Cast Iron

There are three accepted methods of welding preparation on cast iron:
Gouging, Grinding,and Chiseling.

The fastest and the most economical method is to use gouging electrodes, such as NFG. We would recommend gouging only thick-walled parts, burnt or chemically affected cast irons. After gouging it is advisable to grind the surfaces to be welded in order to remove the hard(Martensitic) zone which has been created during the gouging process.

Preparation by grinding is very efficient particularly on larger workpiece. However, if a pressure tight weld is required, the ground surface should afterwards be filled in order to remove residue of the grindingg wheel.

Chiseling is advisable on smaller parts and especially where pressure tight welds are required. Chiseling must always be used when the first buttering layer on oily are burnt iron shows porosity. On poorer quality cast iron a repeated chiseling-off the first bead is often necessary to obtain a perfect joint.

Whatever the method of preparation, it is important that all sharp edges are removed, in other words, preparation should take the form of a single "U" and not a "V". Due to the high strength of the weld deposit, it is only essential to prepare gray-cast iron workpieces to 2/3 thickness. High strength alloyed and nodular cast irons should be veed out completely, so that full penetration of the root face can take place. Experience has proven that it is better to use a pure nickel electrode NC-100. For the first layer, enabling a better bonding to the parent metal.)See Fig. 14 & Fig. 15)

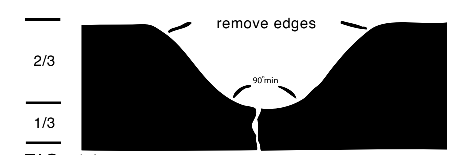


FIG. 14

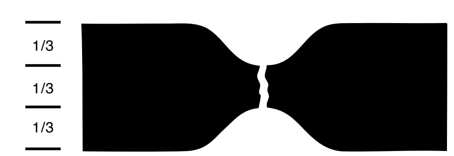


FIG. 15

Preparation If welding from both sides is possible.

There is no question that pressure tight welding is one of the most delicate problems in welding of cast iron. Industrial Welding Corporation is now able to solve most of these problems with good results. We would like to stress that the solutions to welding problems do not lie in the filler material alone, but also come from proper procedure.

An additional point which should not be underestimated is the great care needed in the preparation and welding of the workpiece. The end of any crack should stress stopped. This is done by either drilling a hole at the end of the crack or running small beads across the end of the crack and weld alternately to the right and left. This method is recommended for tying cracks in machine parts. In cases where only one end of the crack is tied, welding should commence from the inside to outside.

For pressure tight weld as well as for all deposits using pure nickel electrodes, we recommend peening of the weld seam. Buttering the flanks before joining is in any case advantageous. If the core wire of the electrode is other than pure nickel, e.g. NC-100 peening the buttering layers is not advisable. In the following pages you will find details about preparation and method application. The following basic rules should always be observed:

- On thin and middle components, prepare the crack by chiseling in tulip form as wide as possible, i.e. remove all sharp

The depth should not be greater than 50% of the wall thickness.

- Locate ends of the crack and block them by drilling stop holes or bridging runs as previously mentioned. Should the run breaks this indicate a high stress area and end of the new crack should be located and a further bridging run be applied or drill a stop hole.

Body Cracks on Thin Walled Casting

Step 1. Locate the ends of the crack and weld the small bead across the ends of the crack at right angles to the crack. (See Fig. 17)

Step 2. Using short beads, skip weld from the center towards both ends. (See Fig. 18)

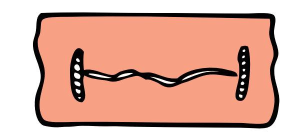


FIG. 17

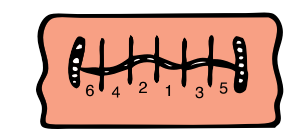


FIG. 18

Side Bead Procedure

Step 1. Use small diameter electrode to apply a thin bead to each side of the crack. (See Fig. 19)

Step 2. Use the next size larger electrode to join the two beads. (See Fig. 20)

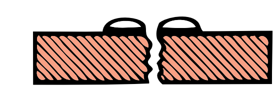


FIG. 19

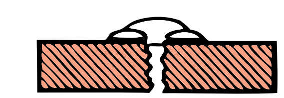


FIG. 20

Steel Plates Patch Procedure

In case of very complicated fractures, it is more often more economical to remove the broken pieces from the casting and replace them with a mild steel plate. This will satisfactorily work by closely following this points.

- As the mechanical strength of the mild steel plate is higher than that of cast iron, the thickness of the mild steel plate should not be more than 60% of the thickness of the casting to which it is joined.
- If possible the iron plates should be oval or rounded, not rectangular, so as to avoid acute angles. If for technical reasons, a rectangular plate is to be used, round the corners as much as possible.
- The plate should be fit slightly larger than the opening. The plate is then placed on sand and hit in the center with a heavy hammer to make the plate slightly concave on disk shaped. The plate is then fitted into the hole as tight as possible. Consideration should be given at this time if the plate will be buttered or not.
- Since the elongation factors of cast iron, mild steel and the pure nickel weld deposit differ, and in order to prevent a complicated uncontrollable composition of the weld, the slides of the prepared casting and the mild steel plate should be buttered uwing NC-50. If a round shaped plate is used, weld approx. 90 apart in the following manner: North, South, East, West with a short bead. If a pressure tight joint is required, peen thoroughly the buttering layer. With a rectangular shaped plate, the rounded corners are welded last of all. On thick walled castings and on components requiring high strengths, join aith NC-100 after buttering the bevelled sides with NC-50. A very good steel patch is obtained by following the simple steps practice in steel plate patch weldin procedure.

Step 1. Place patch over hole or crack and draw a line around the outside of the patch plate. (See Fig. 21)

Step 2. Remove patch plate and use a small diameter electrode to weld a bead on the outside of the lines. (see Fig. 22)

Step 3. Place patch plate back into position and weld it to the previously deposited bead. (See Fig. 23)

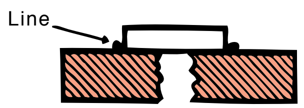


FIG. 21

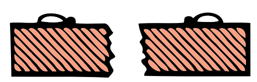
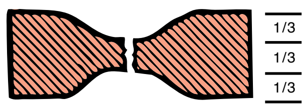


FIG. 22

FIG. 23



A double "U" is used for castings over 1/2" thickness.

Butter Pass Procedure for large, thick casting.

If the parent metal has become heavily contaminated with oil or grease, the firts buttering pass may show porosity. Chiseling of the first buttering pass is recommended in such cases. For pressure tight welding, it is important that the weld be entirely free from porosity and that the slag be completely removed by peening before additional passes are made. High strength alloyed irons, nodular iron and cast irons requiring high structural strength, should be Veed-out completely, for full penetration of the roof face.

Step 1. Use a small diameter electrode to apply a thin layer first bass over the entire area to be welded. (See Fig. 24)

Step 2. Apply remaining build-up passes with a large diameter electrode. (see Fig. 25)

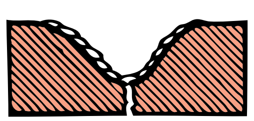


FIG. 24

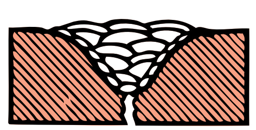


FIG. 25

Stud Procedure

This process is used fpr repairing and welding cracks of large cast iron. The studs conduct welding heat and transmit the shrinking stress to the base metal and those studs prevent the weld zone from cracks as the weld zone does not receive shrinking stress directly because of those studs.

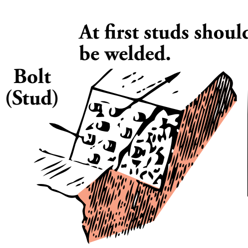


FIG. 27

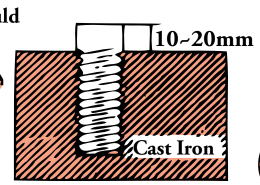


FIG. 28

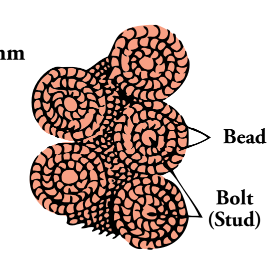


FIG. 29

Diameter of Stud (D):	Usually 6 10 it varies according to shape and size of base metal.
Weld depth of stud:	Dx1 Dx2
Length of exposed part of stud:	10-20 mm
Interval between stud:	Arrange the studs zigzag from and reduce the interval as narrow as possible.

Note for the operation:

Step 1. Weld from the circumstances of the studs.

Step 2. Lay the bead crosswise of diagonally between studs and cover the whole surface of the base metal.

Step 3. Take the care not to melt the studs together with the weld metal.

Combined Cold-Welding System

The purpose of the combined welding system is to achieve the best possible bond on all kinds of cast iron, so that the deposit does not pull away under stress; and second, to retain high tensile values, maximum elongation and a well oriented structure. Multi-layer welding of heavy sections is achieved by interlaying NC-100 and NC-50. Butter the sides of the "U". groove with NC-100 as thinly as possible and peen the first layer thoroughly. On thin-walled parts, weld shorts beads of maximum ten times the electrode diameter. Peen the beads thoroughly while still hot. Especially on pressure-tight welding it is important that the first joining layer is perfect and free from porosity. Porosity points to an inferior quality of the parent metal and above all, to the presence of oil. Should porosity be present, our recommendation is to removed first layer by chiseling. Regardless of the question of porosity it is always advisable to test the first layer with a chisel to ensure good bonding.

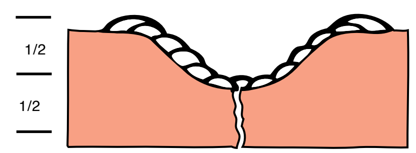


FIG. 29

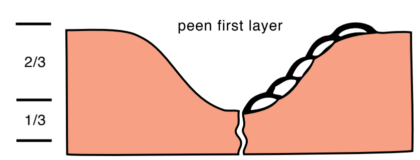


FIG. 30

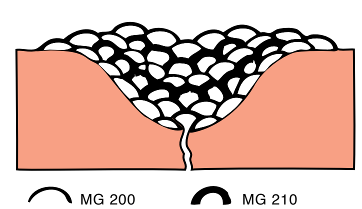


FIG. 31

Welding New Cast Iron

In order to obtain good results when filling in cavities in grey-cast iron, it is recommended that the amperage be increased by approximately 30% as compared with the normal amperage, and that the electrode be AC or DC negative (staright polarity) The penetration becomes considerably deeper, less filler material better matches the color, and slag inclusions are practically eliminated.

Welding procedures - holds electrode vertically; arc length 1/8" to 5/32". It is necessary to start electrode at the edge of the hole and to weld around once so that the weld deposits follows the contour of the cavity and the slag settles in the center. After solidification, it is easy to remove the slag and the next layer can be welded immedately. If a covering layer is welded over the edge of a filled hole, strike the arc again (after the solidification and slag removal) in the center of the deposited metal. This will help to soften the newly created transition area. Avoid weaving as this would unnecessarilly. Heat the base metal. Generally it is advisable to stop the arc by taking the electrode backwards over the weld metal and not over the parent metal. Testing is shown that multi-layer welding contributes considerably to a softening of hard transition areas even on a thick-walled castings. The cast iron transition area is heated to high temperature for a minimum time, and thus only a small amount of carbon is

brought into solution. The danger of hardening is thereby kept to a minimum. On welding subsequent layers, the transition zone is re-heated long enough to enable the transition zone (which formed through a too rapid cooling of the first layer) to re-heat and soften. Small or shallow shrinkage cavities can be welded without boring, using DC straight polarity preferably, and at increased amperage to enable a good melting of the surface and complete clearance of the inclusions. In case of moulding-sand inclusion of strong oxidation of the crack cast iron surface in fissured cracks, remove the slag completely after the first run. To get entirely smooth transition zones stop welding once or twice and continue on the solid filler material. It is important that a correct relationship between the thickness of the base material, the diameter of the electrode polarity, amperage and welding time is reached.

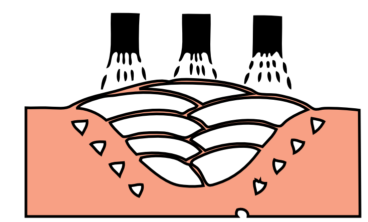


FIG. 32

Welding Oily or Burnt Cast Irons

On very oily castings, burnt or badly affected cast irons, electrodes with a ferro-nickel or iron core, with a graphite coating make a better bond. It is very important that the hardened structure in the transition zone is reduced to an absolute minimum. When using a ferro-nickel electrode or an iron core electrode, for burnt or oily castings, we do require the cast iron to melt. A hard transition zone is thereby built, which will be decomposed with the method of combined welding. In order to prevent the hardening zone on burnt or badly affected castings from becoming too large, preheat to approximately 500ºF and weld with 3/32" iron core electrode, e.g. NC-10. This first layer must be flat so that the largest part of it can be remelted when the next layer is deposited with a pure nickel (NC 100) at a higher amperage (e.g. 1/8" diameter at 100-110 amps.) With this method of introducing a pure nickel to the iron deposit, we are reducing the hardness in the transition area by annealing the transition zone and making a compatible match from the cast iron to the iron-nickel to the nickel.

Hot Welding of Cast Iron

Until a few years ago hot welding which accounts for a homogenous joint was the most widely used technique for repairing broken cast iron parts. Hot welding was principally carried out in special repair shops where the equipment and necessary skills were available.One of the most important requirement in the success of hot welding is correct equipment, necessary to obtain equal pre-heating and cooling of the workpieces and qualified filler material. Without these requirements, a repair to a complicated workpiece is very risky. NC 5 is specially developed gas rod and should be used whenever a weld deposit is required with a perfect colour match and a structure similar to the parent metal. On smaller objects, the rather troublesome oven or charcoal fire pre-heat is unnecessary. NC 5 requires only limited preheat up to a temperature of 950ºF (at this temperature, cast iron has a remarkably high elongation figure) and welding can commence on the workpiece by increasing temperature locally to a dark red. The filler material is very easy to control and, due to the high graphite activity of clean, non-po rous joining or surfacing is possible.

Can be used for repairs as well as for work on new cast iron. Even thin walled pieces (e.g. heating elements) can be welded with this alloy giving the result joint a perfect structure.

Repairing Cylinder Heads, Valve Seats and Bridge Fractures

In repairing or welding cylinder heads, valve seats and valve brisge fractures one must always examine the workpiece carefully and prepare all cracks preferably by chiseling. If grinding is used at all, the final preparation must be made by chiseling. It is important that all sharp edges are removed preferable by filling or milling, and sufficient preparation is necessary to allow multi-layer welding, use DC negative (straight polarity) or AC. Hold electrode vertical to workpiece with an arc length of 1/8" - 5/32" (3-4mm). On motor blocks welds first layer with 5/64" or 3/32 (2 or 2.5mm -14 or 12 swg). We recommend to remove only 50% of the wall thickness. Weld in short flat layers. Hammer each bead thoroughly. In case of bridge fractures, particularly deep fractures going right across the bridge, it is recommended that the VALVE SEAT is surface as well, as a stree compensation. The valve seat is surfaced with a single run without stopping. The quality of cast iron motor heads is usually inferior. The first bead is therefore inclined to show porosity shows, the first bead must be chiseled away and should subsequent first layer still show more than 2-3 pores, they must be removed by chiseling until the first run completely free or porosity, is made. The end result fully compensates this effort.

In case or re-surfacing valve seats, bear in mind that the seat should show an equal hardness and be of equal composition. It is necessary therefore to remove sufficient material from the valve seat so that three or even four layers can be free from the mixed structure of the transition zone.

On continuing welding always strike the same end. Do not run the electrode over the deposited bead. Should a final layer be deposited on the outside, strike the arc in the middle of the deposit after welding in order to reduce any hardness in the transition zone.

(12) Points in Welding Cast Iron

1. Clean and remove all grease, oil and other foreign material.
2. Select and prepare joint design best suited for type of crack and thickness of part (See joint design)
3. Parts over 1/2" in thickness may be pre-heated when maximum machinability is required.
4. Hold electrode approximately 15 off vertical, title toward the direction of the travel, use stringer beads or a slight weave.
5. Maintain an arc distance of 1/8" to 3/16" from workpiece.
6. Hold arc over molten deposited metal following the molten pool of weld metal. (Caution: Do not permit the arc to lead or get ahead of the molten pool.)
7. If metal thickness is less than 1/4" use a 1" bead. 1/4" to 1/2" bead. Over 1/2" use a 3" to 4" bead.
8. Always extinguish arc by whipping arc back over deposited metal.
9. Immediately after breaking arc, peen weld deposit LIGHTLY with ball point end of chipping hammer.
10. Always re-strike arc on previously deposited weld metal.
11. Use skip weld technique on thin or complex sharped parts.
12. Use an electrode diameter size small enough to permit at least two passes to be applied.

Fig. 33 Centrifugally cast pipe of ductile cast iron with welded flange and branches; an application for house connections of gas and water supplies as well as for intake shafts.

Fig. 34 Guide block of grey cast iron GG 25 for eccentric press. Combined welding of broken part, alternatively with NC-100 and NC-50 2.5 and 3.25 mm dias.

What is Copper?

Copper and its alloys constitute one of the major groups of commercial metals. They are widely used because of their excellent electrical and thermal conductivty, outstanding resistance to corrosion and case of fabrication, together with good strength and fatigue resistance. They are generally non-magnetic. They can be readily soldered and brazed, and many coppers and copper alloys can be welded by various gas, arc and resistance methods. Pure copper is used extensively for cables and wires, electrical contacts, and a wide variety of other parts that requires to pass electrical current. Coppers and certain brasses, bronzes and cupronickels are used extensively for automobiles, radiators, heat exchangers, home heating systems, panel for absorbing solar energy and various other applications requiring rapid conduction of heat across or along a metal section. Because of their outstanding ability to resist corrosion copper, brasses, some bronzes and cupronickels are used for pipes, valves and fittings in systems carrying portable water, process water or aqueous fluids.

In all classes of copper alloys, certain alloy composition for wrought products have counterparts among cast alloy, which enables the designer to make an initial alloy selection before deciding on the manufacturing process. Typical applications of cold worked conditions (cold worked tempers) include springs, fasteners, hardware small gears and cams. Certain types of parts-most notably plumbing fitting and valves are produced by hot forging simply because no other fabrication process can produce the required shapes and properties as economically.

Welding Processes of Copper and Copper-Base Metals

Soldering - soldering is used to join copper components in such diverse applications as plumbing, aerospace hardware, automotive radiators and printed circuits. In all cases, users can expect long, reliable performance. Copper and copper alloys are among the most engineering materials.

Brazing - brazing is strong, high quality permanent joints can be produced in copper and copper alloys by brazing. Brazed joints exhibits strength equal to or better than the strengths of the base metals, and retain joint strength and integrity at temperature from 200 to 260ºC (400 to 500ºF) and higher. Brazing is relatively easy to automate, is suitable for joining dissimilar metals and produces assemblies having good appearance. High-conductivity oxygen-free coppers and deoxidized coppers can be joined readily by furnace or torch brazing. Bag and BCup filler metals are commonly used to braze all copper and copper alloys. Flux is recommended, even in protective atmosphere, to promote good wetting.

Welding - welding copper and its alloy are readily welded, the choice of welding method being determined by the alloy, the application and the configuration of the joint. Oxy fuel-gas welding and shielded metal arc welding (SMAW) once where the preffered processes for welding copper. Gas shielded arc processes-gas metal arc welding (GMAW) and gas tungsten-arc welding (GTAW) - now have largely replaced oxy fuel-gas welding and SMAW because of the gas shielded processes produce superior welds. The primary criteria for choosing between GMAW and GTAW are thickness of the metal to be welded and amount of welding to be performed. GMAW is generally preferred for thickness greater than about 6mm (1/4 in.), GTAW for thickness less than about 2mm. (0.08 in.). For thickness between two and 6 mm., both processes will work satisfactorily. Resistance welding is also used extensively because it is readily adapted to assemble line production. It can be used for joining parts less than 3.8 mm. (0.15 in.) thick., although production of good welds in highly conductive alloys (30% LACS) requires strict control of operating procedures.

Electroplating - electroplating has been used to join copper to aluminum for electrical applications. The process is performed at room temperature which eliminates distortion, shrinkage stresses and crystallization problems associated with conventional processes that use heat and pressure. Electroplating has also been used to make vacuum tight ceramic to metal seals. In joining of dissimilar metals, formation of brittle intermetallics can be prevented by using this process.

Roll Bonding - roll bonding can be used to join copper sheet or plate to other materials, thus making layered composite, metallurgically bounded sheet or plate. Applications include cookware and coins. Roll bonding is most suitable where the joint surface is so large in area that welding or brazing would not be feasible.

Friction Welding and Explosive Bonding - friction welding and explosive bonding have not been very succesful in producing copper to copper joints. Either method can be used to join copper to other metal such as steel or brass. Joints are not very strong, and in general these processes are useful only in joining thick to thin materials.

Ultrasonic Welding - ultrasonic welding also is the most effective joining copper to other metals. Weld joints are weak, and the process is best suited for joining-thick materials to thin materials or for joining two thin materials.

Electron Beam Welding - electron beam welding is a fusion process where a concentrated high energy electron beam bombards the workpiece. Sound porosity free welds with excellent weld strength are obtained. The process is limited to copper alloys that can be joined by other fusion processes. Alloys containing lead or zinc are to be specially avoided. The process is usually carried out in a relatively hard vacuum, but equipment that allows the workpiece to be under only soft vacuum (or no vacuum at all) has been developed to make electron beam welding more flexible.

Laser welding - laser welding is chiefly an experimental process this time. The process is currently limited to materials no thicker than 0.8 mm (0.032 in.), but has high power lasers are developed this range could be expand. Because it is fusion process laser welding cannot be used for copper alloys that contanin lead or zinc.

Other welding processes - other welding processes plasma-arc welding is seldom used for copper metals. Stud welding, submerged arc welding and electroslag welding are prohibited for welding copper and its alloys.

Problems and Solution in Welding Copper, Copper-Base Metals

Despite the rapid development of news steels, special steels, and alloy steels past twenty years, industry has not lost its dependence on copper and all of the different copper-alloys, the brasses, the bronzes and of late all copper nickel alloys. Copper is sold and used in many forms and shapes; tubing, sheets, profiles and bars. It is when these shapes are joined buy means of welding brazing of soldering that manufactured items. The most common grades and alloy types can be welded are pure copper-deoxidized, aluminum bronzes, silicon bronzes, phupha bronze, brasses, copper-nickel alloy to mild steel welding.

One of the strongest joints can be achieved by means of electric arc welding. This procedure, which presented no problems in joining steels, was found to have severe obstacles when first applied to copper. After compairing th physical properties of copper and steel, the reasons were quickly discovered. The most common factors applicable to welding are:

	Melting Point ºF	Thermal Conductivity BTU/sq. ft hr./°F/in.	Coefficient of expansion ºF x 10'
Copper	1961	2680	9.8
Steel (15ºC)	2700	460	6.7
Aluminum	1220	1644	7.3

Fig. 35 A

Within the range of welding temperatures, copper has a very high affinity for oxygen and the oxygen has a tendency to get into the fusion-zone where it combines with copper to form cupro-oxides. If nothing is done to prevent them from forming, they alloy with the copper and are able to reduce the joint tensile strength by as much as 70%. The crystalline structure of copper in tne range between 650 F and 1200 F is very coarse, effecting the tensile strength in a negative way. (The tensile strength of copper at 1100 F is only at 20% of its original value). Deformation of any kind (peening, hammering, etc.) should not take place while the base metal or filler remains in this temperature range. If the copper is allowed to remain in this particular heat range for any prolonged period of time, the coarse structure will also remain after cooling, reducing the strength of the copper considerably. It seems logical then that the oxygen-acetylene method of joining copper is not the most ideal answer. Of course, it would be possible to work-hardened the heat affected zone and realize the original tensile values whether this is economical or feasible it depends on the application.

WELD WITH COMPLETE CONFIDENCE
NIHONWELD

After considering all of these previously mentioned peculiarities and many more, we developed our NCu copper arc welding electrode. Producing the core wire of the electrode presented no problems (deoxidized pure copper) but only after a special coating was developed did this electrode become a success. The deposit is free of porosity with a medium grain structure and a tensile strength similar to that of the most commercial types copper. The weldability is execellent sheet metal up to 36/6" in thickness can be welded without pre-heat. Compared to metal such as steel, the welding of copper is more difficult because of its high thermal conductivity, which rapidly dissipates the heat of electric arc. This makes preheat of the electric arc. This makes preheat a necessity in order to obtain fusion, when arc welding large or heavy sections copper. For heavier pieces of copper, preheat at 850ºF-1100ºF. This temperature range should cause no deformation of the copper providing prolonged heating is avoided. All welding should be completed as soon as possible and the copper allowed to cool in still air. The quality of the weld bead depends mainly on how long and to what extent excessive heat has been applied. In cases where electrical conductivity is of less importance, a system has been devised so that a pre-heat of 400ºF is sufficient, even on large pieces. A simple technique for welding copper is as follows:

_ Clean joint area removing all oxidized.
_ Grind or chisel to vee out joint opening 70 - 80 included angle.
_ Preheat heavy section, over 3616" thick, from 850 to 1100ºF.
_ Select electrode diameter as large as posibble. Butter joint with one layer of selected electrode. use NCu.
_ Hold arc as short as possible, using slight weave. Peen deposit immediately.

In welding of bronzes, follow the same procedure as for copper except reduce preheat temperature at 400ºF to 600ºF.

Regardless of the application, this technique remains the same Since copper and copper-base metals have a very high heat conductivity, it is necessary to allow a greater rot openings, widegroove angles, frequent tack-welding, higher preheat and interpass temperatures and higher current (higher amps when using coated electrodes). See following recomended edge and joint preparations for welding:

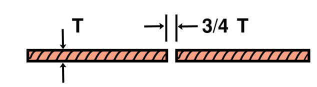


Fig. 35 B

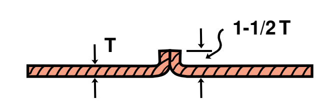


Fig. 36

Fig. 37

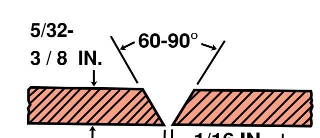


Fig. 38

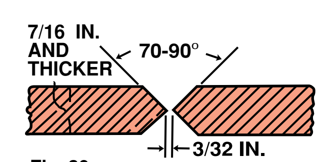


Fig. 39

(5) Arc Welding Tips for Copper and Its Base Metals.

1. Allow more space in the joint expension.
2. Tack weld more frequently.
3. Use higher pre-heats.
4. Supply higher amperages for size of electrode and part thickness.
5. Travel at a faster rate of speed as compared to mild steel welding.

(6) Points on Brazing Copper-Base Metals

1. In order to retain the heat in the base metal place workpiece on fire brick or asbestos sheet.
2. Pre-heat large section broadly. Prehaet temperature of various copper alloys as shown on Pre-heat chart 1.
3. Do not melt silver-brazing alloys by direct heat of flame, heat workpiece and melt rod with heat applied directly.
4. Use extra flux if necessary, especially on long excessive heating cycles.
5. When welding copper, regardless of method employed, it is always better to use liberal amounts of flux. (On hot surfaces use flux in powder form only.)
6 When joining a metal of high heat conductivity (i.e. broze to stainless), pre-heat the high heat conductor (bronze).

In the following pages, you will find a complete array of products which has developed to make the welders job easier. These alloys not only can be used for joining copper and copper-base metal, but also joining and overlay protection of many ferrous bse metals.

ONE SHOULD PAY PARTICULAR ATTENTION TO THE "PROCEDURE" FOR EACH PRODUCT.

What is aluminum?

The properties of aluminum that make this metal and its alloys the most economical and attractive for a wide variety of uses are appearance, light weight, fabricability, physical properties and corrosion resistance, or a combination of these. The major application for aluminum can be categorized in decreasing order of current market size, into building and construction, containers and packaging, transportation, electrical, consumer durables, machinery and equipment and other. Aluminum also is highly reflective to radiant energy-visible light, radiant heat and electromagnetic waves. It has excellent electrical and thermal conductivity which is about 50 to 60% that of copper. It is non-ferromagnetic a property of importance in the electrical and electronics industries. It has none sparkling Characteristics, which is important near imflammable or explosive materials. It is nontoxic, making it safe for use with foods and beverages. It has attractives appearance in its natural finish, which can be soft and lustrous, or bright and shiny, or if desired, it can be virtually any color or texture. Aluminum is also strong; some aluminum alloys exceed structural steel in strength. There are so many types of aluminum alloys for various commercial and industrial uses. Finally because of vast reserves, alumunim is the most abudant of all the structural metals, constituting over 8% of the earth's crust.

Welding Processes

Aluminum can be welded by a wide variety of methods. These various of methods are presented in Figure 40.

Among all these methods, gas metal-arc and gas tungsten arc welding are preferred than other arc welding processes for aluminum and aluminum alloys. These gas shielded arc welding processes result in optimum weld quality and minimum distortion, and they require no flux. As a result, difficult to reach placesa and completely inaccessible interiors of welded assembles are left free from flux residues that could be a potential source of corrosion. Futhermore, welding can be done in all positions, because there is no slag to be worked out of the weld by gravity or by pudling.

Visibility is good. The gas envelope around the arc is transparent, and the weld puddle is clean. A welder doing a hand welding. job can make a neat, sound weld because he does not have to contend with smoke and fumes and can see what he is doing. When proper techniques are used, weld joints have more than adequate strength for them many demanding applications of aluminum.

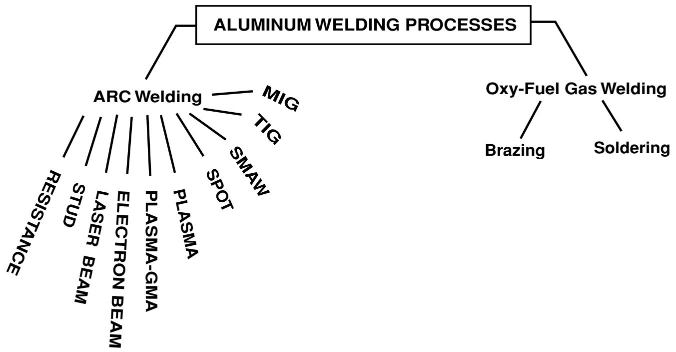


Fig. 40

Problems and Solution in Welding Aluminum and Aluminum-Base Metals

Aluminum oxide immediately forms on aluminum surfaces exposed to air. This layer of aluminum oxide increases in thickness with increasing time and temperature, and it is quite thick on heat treated aluminum. Before aluminum can be welded by fusion methods, thick oxide layers must be removed mechanically by machining filling, wire brushing scrapping or chemical cleaning. During welding, the oxide must be prevented from reforming by shielding the joint area with a non-oxidizing gas such as argon, helium or hydrogen, or chemically by use of fluxes. In some method (ultrasonic, friction. pressure and explosive welding), the oxide film is broken up and dispered mechanically during the operation.

Thermal conductivity is measured of the rate of which a material will conduct heat from one region of itself to another and is the physical property that most affects weldability. Thermal conductivity of aluminum alloy is about one-half that of copper and four times that of low carbon steel. This means that the heat must be supplied four times as fast to aluminum alloys as to steel to raise the temperature locally by the same amount. However, the high thermal conductivity of aluminum alloys help to solidify the molten weld pool of aluminum and consequently, makes out of position welding easier by reducing sag.

Specific heat is the amount of heat required to raise the temperature of a specified amount of a material one degree on a specified scale. It takes only 65 as much heat to raise the temperature of aluminum a certain amount as it does to raise the temperature of an equal volume of steel the same amount.

Coefficient of Linear Thermal expansion is a measure with a change in its temperature. The coefficient of linear thermal expansion for aluminum is twice that for steel. This means that extra care must be taken in welding aluminum to ensure that the joint space remains uniform. This may necessitate preliminary joining of parts of the assembly by tack welding prior to the main welding operation. The combination of high coefficient of thermal expansion and high thermal conductivity would cause considerable distortion of aluminum during welding were it not for the high welding speed possible.

Melting Range is the temperature range over which a solid material turns to a liquid. The melting range for aluminums alloys are considerably lower than those for copper or steel. This fact, combined with the lower volume-tric specific heats of aluminum alloys, means that the amount of heat required to reach the melting range is much lower for aluminum alloys than for copper or steel. As the temperature of the copper or steel nears the melting point there is a change in color, which indicates that melting is near. Aluminum alloys, because of their lower melting ranges, do not exhibit changes in color prior to melting, and care must be taken during welding not to melt too great an area.

Electrical conductivity has little influence on fusion welding but it is very important property for materials that are to be resistance welded. In resistance welding, resistance of the metal to the flow of welding current produces heat, which causes the portion of the metal through which the current flows approach or reach its melting points. Aluminum has higher conductivity than steel (see Fig.35A), which means that much higher currents are required to produce the same heating effect as for steel. Consequently, resistance welding machines for aluminum must have much higher output capabilities than those normally used for steel, for welding comparable sections.

Preweld cleaning of aluminum is essential for optimum weld quality. Precleaning requirements are especially stringent prior to straight-polarity direct current-gas tungsten-arc welding, because under such conditions the arc exerts no cleaning action. However, the highest-quality welds are not always needed. Where service requirements permit, many aluminum parts are welded with no preweld cleaning at all. Surface contaminants that should be remove from the base metal dirt, metal particles, oil and grease, paint, moisture and heavy oxide coatings. Another source of contamination is oxide film on the filler metal. Base metal such as 1100 and 3003 have a relatively thin oxide coating as fabricated, and the 5xxx and 6xxx series alloys generally have a thick, dark oxide coating. The thicker the oxide, the greater is diverse effect on weld metal flow and solidification and the greater and risk porosity. Any foriegn material that remains on the surface to be welded is a potential source of unsounds welds. For best results, all cleaning and oxide removal should be done immediately before welding.

Preheating in gas-shielded arc welding of aluminum alloys, preheating of parts to be welded is normally employed only when the parts is below 15 F when the mass of the parts is such that the heat is conducted away from the joint faster than the welding process can supply it. Preheating may be advantageous for gas tungsten-arc welding with alternating current of parts thicker than about 3/16" in and gas metal-arc welding with reverse-polarity direct current is limited to thin material, and preheating is not necessary to preheat thick parts when gas tungsten-arc welding using straight polarity direct current, because of the high heat input provided to the work. Preheating can also reduce production costs because the joint area will reach welding temperature faster, thus permitting higher welding speeds. Various methods can be used to preheat the entire part or assembly to be welded or only the area adjacent to the weld can be heated by use of a gas torch. In mechanized welding, local preheating (and drying) can be done by gas or tungsten-arc torches installed ahead of the welding electrode. The preheating temperatures depends on the job. Often 200ºF is sufficient to ensure adequate penetration on weld starts, without readjustment of the current as welding progresses.

Points for Better Brazing and Arc Welding of Aluminum-Aluminum-Base Metals

Since aluminum is a much better heat conductor than steel (thermal conductivity-about 3 1/2 times of the steel or iron). In order to retain heat, when brazing or arc-welding aluminum, put fire bricks or asbestos sheets under workpiece. Preheat large sections broadly. When brazing aluminum take into account that the oxide film, which forms and covers aluminum instantly, melts at 3600ºF. The underlaying aluminum melts much sooner at 1200ºF. A chemical (flux) is used to destroy the high melting oxides and to prevent formation of new oxides during the brazing operation. Without the flux, the flux, the aluminum would melt and collapse, before the oxideskin approached is melting point.

Keep workpiece at pre-heat temperature during the welding or brazing process. Remove flux residues after welding or brazing by means of brushing with warm water of flux removing solutions. When arc-welding aluminum it is well to remember that the melt-off rate of the electrode, due to the extreme temperature of the arc (5000 - 6000ºF) and low melting temperature of the aluminum core wire (1200ºF) is very high. To achieve an even arc length it is important to press the electrode slightly downward. Most welders master this technique within a very short time, often after using 2-3 electrodes.

NOTE:

The temperature of the acetylene-oxygen flame reaches the range of 3600ºF even if the flame adjustment is reduced (excess acetylene). The melting point of aluminum is 1120ºF. There is no color change when aluminum is heated to the brazing or welding temperature, therefore it is difficult to judge when the metal is near the melting point.

It is sometimes difficult to know if the part to be repaired of aluminum or magnesium since these alloys look alike. If one is in doubt, remove the oxide from the part to be repaired by using a file so as to expose the raw metal. On this area place 3 to 4 drops of NFC3 if the part is magnesium, there will be an immediate chemical reaction; if there is no reaction, then the part is aluminum and can be repaired by using one of the following superior Nihonweld products.

WELD WITH COMPLETE CONFIDENCE
NIHONWELD

SUPPLEMENTARY CONVERSION TABLES

TEMPERATURE CONVERSION TABLE

ºF	ºC	ºF	ºC	ºF	ºC	ºF	ºC	ºF	ºC
−400	−200	20	− 6.7	120	48.9	220	104.4	940	504.4
−390	−234	22	− 5.6	122	50.0		110.0	960	515.6
−380	−229	24	− 4.4	124	51.1	240	115.6	980	527
−370	−223	26	− 3.3	126	52.2	250	121.1	1000	538
−360	−218	28	− 2.2	128	53.3	160	126.7	1020	549
−350	−212	30	− 1.1	130	54.4	270	132.2	1040	560
−340	−207	32	0	132	55.6	280	137.8	1060	571
−330	−201	34	1.1	134	7	290	143.3	1089	582
−320	−196	36	2.2	136	8	300	148.9	1100	593
−310	−190	38	3.3	138	58.9	310	154.4	1120	604
−300	−184	40	4.4	140	60.0	320	160.0	1140	616
−290	−179	42	5.6	142	61.1	330	165.6	1160	627
−280	−173	44	6.7	144	62.2	340	171.1	1180	638
−270	−168	46	7.8	146	63.3	350	176.7	1200	649
−260	−162	48	8.9	148	64.4	360	182.2	1220	660
−250	−157	50	10.0	150	65.6	370	187.8	1240	671
−240	−151	52	11.1	152	66.7	380	193.3	1260	682
−230	−146	54	12.2	154	67.8	390	198.9	1280	693
−220	−140	56	13.3	156	68.9	400	204.4	1300	704
−210	−134	58	14.4	158	70.0	410	210.0	1320	716
−200	−129	60	15.6	160	70.0	420	215.6	1340	727
−190	−123	62	16.7	162	72.2	430	221.1	1360	738
−180	−118	64	17.8	164	73.3	440	226.7	1380	749
−170	−112	66	18.9	166	74.4	450	232.2	1400	760
−160	−107	68	20.0	168	75.6	460	237.8	1420	771
−150	−101	70	21.1	170	76.7	470	243.3	1440	782
−140	− 96	72	22.2	172	77.8	480	248.9	1460	793
−130	− 90	72	23.2	174	78.9	490	254.4	1480	804
−120	− 84	76	24.4	176	80.0	500	260.0	1500	816
−110	− 79	78	25.6	178	81.1	520	271.1	1520	827
−100	− 73	80	26.7	180	82.2	540	282.2	1540	838
− 90	− 68	82	27.8	182	83.3	560	293.3	1560	849
− 80	− 62	84	27.8	184	84.4	580	304.4	1580	860
− 70	− 57	86	30.0	186	85.6	600	315.6	1600	871
− 60	− 51	88	31.1	188	86.7	620	326.7	1620	882
− 50	− 45.6	90	32.2	190	87.8	640	337.8	1640	893
− 40	− 40.0	92	33.3	192	88.9	660	348.9	1660	904
− 30	− 34.4	94	34.4	194	90.9	680	360.0	1680	916
− 20	− 28.9	96	35.6	196	91.1	700	371.1	1700	927
− 10	− 23.3	98	36.7	198	92.2	720	382.2	1720	938
0	− 17.8	100	37.8	200	93.3	740	393.3	1740	949
2	− 16.7	102	38.9	202	94.4	760	404.4	1760	960
4	− 15.6	104	40.0	204	95.6	780	415.6	1780	971
6	− 14.4	106	41.1	206	06.7	800	426.7	1800	982
8	− 13.3	108	42.2	208	97.8	820	437.8	1820	993
10	− 12.2	110	43.3	210	98.9	840	448.9	1840	1004
12	− 11.1	112	44.4	212	100.0	860	460.0	1840	1016
14	− 10.0	112	44.4	214	101.1	880	471.1	1880	1027
16	− 8.9	116	46.7	216	102.2	900	482.2	1900	1038
18	− 7.8	118	47.8	218	103.3	920	493.3	1920	1049

$^{o}F = \frac{9}{5}\,^{o}C + 32$ $\quad$ $^{o}C\ [\ \frac{5}{9}\ (\,^{o}F - 32)$

LENGTH CONVERSION TABLE

in.	mil.	mm.	in.	mil.	mm.
1/64	15.625	0.39688	33/64	515.63	13.097
1/32	31.250	0.79375	17/32	531.25	13.494
3/64	46.875	1.1906	35/64	546.88	13.891
1/16	62.500	1.5875	9/16	562.50	14.288
5/64	78.125	1.9844	37/64	578.13	14.684
3/32	93.750	2.3813	19/32	593.75	15.081
7/64	109.38	2.7781	39/64	609.38	15.478
1/8	125.00	3.1750	5/8	625.00	15.875
9/64	140.63	3.5179	41/64	640.63	16.272
5/32	156.25	3.9688	21/32	656.25	16.272
11/64	171.88	4.3656	43/64	671.88	17.066
3/16	187.50	4.7625	11/16	687.50	17.463
13/64	140.63	3.5719	45/64	703.13	17.859
7/32	218.75	5.5563	23/32	718.75	18.256
15/64	234.38	5.9531	47/64	734.38	18.653
1/4	250.00	6.3500	3/4	750.00	19.050
17/64	265.63	6.7469	49/64	765.63	19.447
9/32	281.25	7.1438	25/32	781.25	19.844
19/64	296.88	7.5406	51/64	796.88	20.241
5/16	312.50	7.9375	13/16	812.50	20.638
21/64	328.13	8.3344	53/64	828.13	21.034
11/32	343.75	8.7313	27/32	843.76	21.431
23/64	359.38	9.1281	55/64	859.38	21.823
3/8	375.00	9.5250	7/8	875.00	22.225
25/64	390.63	9.9219	57/64	890.63	22.622
13/32	406.25	10.319	29/32	906.25	23.019
27/64	421.88	10.716	59/64	921.88	23.416
7/16	437.50	11.113	15/16	937.50	23.813
29/64	453.13	11.509	61/64	953.13	24.209
15/32	468.75	11.906	31/32	968.75	25.003
31/64	484.38	12.303	63/64	984.38	25.003
1/2	500.00	12.700	1	1000.00	25.400

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR CAST IRON

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)					Typical All Weld Mechanical Properties			Applications
				C	Si	Mn	Fe	Ni	T.S. N/mm² (ksi)	Elongation (%)	Hardness HV (HRC)	
LOW HYDROGEN	NC-10	Est (DFC Fe)	AC DC (+)	0.43	0.50	0.50	Bal.	-	517 (75)	32	350 - 390 (35 - 40)	Nickel free and non-machinable cast iron electrode for repair of cast iron parts where machining is unnecessary.
GRAPHITE TYPE	NC-25	Est (DFC Fe)	AC DC (+)	0.92	0.11	0.36	Bal.	-	497 (72)	22	350 - 390 (35 - 40)	Nickel free and non-machinable cast iron electrode for repair of cast iron parts where machining is unnecessary.
LIME TITANIA	NC-Fe-M	Est (DFC Fe)	AC DC (+)	0.07	0.44	0.45	Bal.	Special Element 9.20	500 (72.5)	10	230 - 260 (18 - 24) Interpass Temp. under 150ºC	Nickel free but machinable cast iron electrode for build up repair at various cast iron parts.
GRAPHITE TYPE	NC-50	ENiFe-CI (DFCNiFe)	AC DC (+)	1.18	0.70	0.49	Bal.	56.80	480 (70)	18	170 - 190 (85 - 90 HRB)	For surfacing and joining of all commercial cast iron grades, such as lamellar grey cast iron and modular cast iron & malleable cast iron.
	NC-116	ENiFe-CI (DFCNiFe)	AC DC (+)	1.18	0.70	0.49	Bal.	56.80	480 (70)	18	170 - 190 (85 - 90 HRB)	For surfacing and joining of all commercial cast iron grades, such as lamellar grey cast iron and modular cast iron & malleable cast iron.
	NICKEL CAST	ENiFe-CI (DFCNiFe)	AC DC (+)	1.20	0.64	0.45	Bal.	57.20	500 (72.5)	20	170 - 190 (85 - 90 HRB)	Welding of various type of cast iron, cast iron to steel and other ferrous and non-ferrous materials. Bimetallic core wire to prevent over-heating.
	NC-85FN	ENiFe-CI (DFCNiFe)	AC DC (+)	1.20	-	-	Bal.	54.5	586 (85)	20	170 - 190 (85 - 90 HRB)	For welding high tensile grades of nodular or ductile irons to themselves or to steel, malleable iron or cast steel.
	NC-100	ENiCI (DFCNi)	AC DC (+)	0.90	0.65	0.27	0.62	Bal.	356 (51.6)	20	140 - 160 (75 - 80 HRB)	For welding of grey and malleable cast iron, cast steel and for joining there bare metal to steel and copper alloys.
	NC-112	ENiCI (DFCNi)	AC DC (+)	0.43	0.32	0.41	1.0	Bal.	340 (49)	15	140 - 160 (75 - 80 HRB)	Non-conductive coating suited for plug welding and for applications where there is danger of coating getting in touch with work place.
	NC-8	ENiCI (DFCNi)	AC DC (+)	1.21	-	-	0.5	Bal.	480 (70)	35	140 - 160 (75 - 80 HRB)	Finest electrode for the cold welding of grey cast iron.
	NC-88H	ENiCI (DFCNi)	AC DC (+)	0.80	Cu 2.0	0.70	2.0	Bal.	480 (70)	20	140 - 160 (75 - 80 HRB)	Ideal for filling in blow holes, for resurfacing.
	NC-NiCu-B	ENiCu-B (DFC NiCu)	AC DC (+)	0.68	0.52	0.45	Cu 28.50	Bal.	168 (24)	18	140 - 160 (75 - 80 HRB)	Filling up the cavities of various cast iron.

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR BRONZE AND COPPER ALLOY

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)								Typical All Weld Mechanical Properties				Applications
				Cu	Al	Fe	Si	Sn	P	Others		Y.P. N/mm² (Ksi)	T.S. N/mm² (Ksi)	El. (%)	Hardness HB	
SPECIAL COATING	N-CuSn-A	ECuSn-A	DC (+)	Bal.	-	0.52	0.10	5.15	0.18	-	Pb 0.02 max	250 ( )	424 ( )	24	65 - 75	For welding copper and tin alloys with 6-8% Sn, DIN17662, copper-zinc alloys, copper-tin-zinc-lead alloys. Weld cladding on cast iron steel. Has good gliding properties.
	N-CuSn-C AC/DC	ECuSn-C	AC DC (+)	Bal.	-	0.16	-	7.82	-	-	-	-	387 (56)	18	56 - 70	For joining copper and copper alloys, phosphor and tin bronzes as well as copper clad plates in mechanical and plant engineering and shipbuilding. For surfacing on copper and copper alloys, phosphor and tin bronzes.
	N-CuSn-C (NPB)	ECuSn-C (D EL-CuSn 7)	DC (+)	Bal.	-	0.17	-	7.80	0.11	-	-	-	390 (57)	30	90 - 100	
	N-CuAl-A1	ECuAl-A1	DC (+)	Bal.	6.0-8.5	-	0.10 max	-	-	0.50 max	-	193 (28)	470 (8)	32	100-120	For overlaying to resist corrosion from salt water, for metal salts such as tube sheets, pickling hooks, impellers, chemical plants.
	N-CuAl-A2	ECuAl-A2	DC (+)	Bal.	8.50-11.0	0.50-5.0	1.5 max	-	-	0.50 max incl. Tin	-	240 (35)	530 (77)	27	110-120	For welding and joining many ferrous and nonferrous metals and combinations of dissimilar metals. Example: brake drums, tractor gear housings, indler pullets, impellers, gears, mixer arms, etc.
	N-CuAl-B (formerly NAB 300)	ECuAl-B	DC (+)	Bal.	11.0-12.0	2.50-5.0	1.5 max	-	-	0.50 max	-	325 (47)	615 (89)	15	165-180	For excellent bearing characteristics and is suitable for overlaying bearing surfaces subject to normal wear and shock. Resistance to "squashing out" in bearing service.
	N-CuAl-C	ECuAl-C	DC (+)	Bal.	12.0-13.0	3.0-5.0	1.0 max	-	-	0.50 max	-	320 (46)	620 (90)	4	200-210	High strength values with excellent wear resisting characteristics for bearing overlays where extreme wear and high pressures are encountered in service.
	N-CuAl-D	ECuAl-D	DC (+)	Bal.	13.0-14.0	3.0-5.0	1.0 max	-	-	0.50 max	-	370 (54)	530 (77)	1	250-260	Higher yield strength and hardness than PHIL AL BRONZE CuAl-C.
	N-CuAl-E	ECuAl-E	DC (+)	Bal.	14.0-15.0	3.0-5.0	1.0 max	-	-	0.50 max	-	475 (69)	550 (80)	0	300-310	For fabricating new or rebuilding worm ferrous dies used for forming or drawing titanium, low carbon and stainless steel.
	N-Cu (AC/DC)	ECu (Dcu)	DC (+)	98.0 min	-	-	0.50 max	1.0 max	0.15 max	0.50 max	Mn 0.50 max	-	220 (32)	32	50 - 55	For rebuilding of electrode holder and copper transformer connector.
	N-Cu 39	ECu (Dcu)	DC (+)	Bal.	-	-	0.50 max	1.0 max	0.15 max	0.50 max	Mn 0.50 max	-	200 (29)	29	50 - 55	Yields a poreless, well deoxidized crack-proof weld metal. Its corrosion resistance is equal to that of the best commercial copper grades.
	N-CuMnNiAl	ECuMnNiAl	DC (+)	Bal.	7.0-8.5	2.0-4.0	1.5 max	-	-	Ni 1.5-3.0	Mn 11.0-14.0	386 (56)	655 (95)	27	180-190	For welding cast ship propellers conforming to ML-B-21230, alloys for high resistance to corrosion and cavitation.
	N-CuNiAl	ECuNiAl	DC (+)	Bal.	8.5-9.5	3.0-6.0	1.5 max	-	-	Ni 4.0-6.0	Mn 0.5-3.50	400 (58)	680 (99)	25	180-190	For weld repairing NiBral boat propellers.
	N-CuSi	ECuSi (DCuSiB)	DC (+)	Bal.	-	0.50 max	2.4-4.0	1.5 max	-	0.50 max	Mn 1.50 max Pb 0.02 max	250 (36)	420 (61)	25	80-100	For welding of bronze impellers, hydraulic piston, overlay, bronze wear plates.

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR ALUMINUM AND SPECIAL APPLICATIONS

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)					Typical All Weld Mechanical Properties				Applications
				Al	Si				Y.P. N/mm² (Ksi)	T.S. N/mm² (Ksi)	El. (%)	I.V. ºC, J (ºF, Ft-Lbs.)	
SPECIAL COATING	N-Al4	E4043	DC (+)	95	4.0				>60 (>9.0)	>135 (>20)	>12		For welding pure aluminum and aluminum alloys castings with ≤ 7% Si content.
	N-Al12	E4047	DC (+)	85	12.0				>80 (>12)	>180 (>26)	>5		Silicon-alloyed aluminum electrode for repair welding of aluminum castings.
	Nihoncut	none	AC DC (-)										For cutting of all kinds of steel, cast iron, armor plates and non-ferrous metals.
	CUTROD	none	AC DC (-)										For arc chamfering, gouging, beveling and chanelling ferrous and non-ferrous metal.
	NFG	none	AC DC (-)										For arc chamfering, gouging, beveling and chanelling ferrous and non-ferrous metal.
	GROOVE ARC E-900	none	AC DC (-)										For arc chamfering, gouging, beveling and chanelling ferrous and non-ferrous metal.

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR NICKEL AND NICKEL ALLOYS

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)							Typical All Weld Mechanical Properties				Applications
				C	Si	Mn	Fe	Ni	Mo	Others	Y.P. N/mm² (Ksi)	T.S. N/mm² (Ksi)	El. (%)	I.V. ºC, J (ºF, Ft-Lbs.)	
SPECIAL COATING	N-Ni-1	ENi-1	DC (+)	0.02	0.62	0.34	0.40	Bal.	-	Ti 2.46 Al 0.20	331 (48)	493 (71.5)	41	-	For welding Nickel 200 & Nickel 201 and also dissimilar metals. For good corrosion resistance especially in alkalies & low free carbon weld metal.
	N-NiCu-7	ENiCu-7	DC (+)	0.01	0.60	3.23	0.70	66.55	Cu Bal.	Ti 0.65 Al 0.17	338 (49)	508 (74)	40	-	For wellding monel 400, R405 & K500 resistance to corrosion by sea water salts and reducing acids & for weld metals that meet stringent radiographic requirements.
	N-CuNi	ECuNi	DC (+)	-	0.26	1.15	0.65	30.22	Cu Bal.	-	327 (47)	425 (62)	38	-	For welding 70/30, 80/20, 90/10 copper nickel alloys. Resistance to fouling & corrosion in sea water.
	N-NiCrFe-1	ENiCrFe-1	AC DC (+)	0.04	0.45	2.81	7.78	Bal.	-	Cr 15.53 Nb&Ta 2.78	623 (90)	382 (55)	42	-196º, 88 (-132, 65)	For inconel 600, 601 & inco330. Excellent high temperature strength, metallurgical stability & oxidationresistance & can meet stringent radiographic requirements.
	N-NiCrFe-2	ENiCrFe-2	AC DC (+)	0.04	0.15	2.90	8.05	Bal.	2.24	Cr 15.90 Nb&Ta 1.86	628 (91)	399 (58)	43	-196º, 93 (-132, 69)	For incoloy 800, 800HT and inconel 600, 601 and other nickel steels. Excellent strength and oxidation resistance at high temperature and retain impact resistance at cyogenic temperatures.

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR NICKEL AND NICKEL ALLOYS

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)							Typical All Weld Mechanical Properties				Applications
				C	Si	Mn	Fe	Ni	Mo	Others	Y.P. N/mm² (Ksi)	T.S. N/mm² (Ksi)	El. (%)	I.V. ºC, J (ºF,Ft-Lbs)	
SPECIAL COATING	N-NiCrFe-3	ENiCrFe-3	DC (+)	0.04	0.49	6.89	Bal.	3.20	0.88	Cr 18.56 Nb&Ta 2.22	654 (95)	373 (54)	49	-30º,100 (-22,74)	For inconel 600, 601 & inco330. Excellent high temperature strength, metallurgical stability & oxidation resistance & can meet stringent radiographic requirements.
	N-NiCrFe-4	ENiCrFe-4	AC	0.15	0.78	2.20	8.00	Bal.	2.80	Cr 15.5	-	655 (95)	20	-	For nickel steels in cryogenic applications. Same as Nickelarc A except for AC applications to minimize magnetic or blow.
	N-NiCrFe-7	ENiCrFe-7	DC (+)	0.05	0.52	1.45	10.1	Bal.	-	Cr 29.5 Cb&Ta 1.2	-	670 (95)	44	-	Welding of inconel 690, improve resistance to stress-corrosion cracking in nuclear, pure water environments.
	N-NiCrCo Mo-1	ENiCrCoMo-1	DC (+)	0.10	0.60	1.50	4.00	Bal.	9.50	Cr 25	-	620 (90)	25	-	For inconel 617, high strength, good metallurgical stability and excellent resistant to corrosion and high temperature oxidation.
	N-NiCrMo-3	ENiCrMo-3	AC DC (+)	0.06	0.44	0.73	5.07	60.18	8.75	Nb&Ta 3.50	441 (64)	770 (112)	40	-	For inconel 625, incolloy 825 & 25.6 Mo and other Mo containing stainless steels. High strength at room or elevated temperatures & exceptional corrosion resistance including resistance to pitting, crevice corrosion & polythionicacid stress corrosion cracking.
	N-NiCrMo-4	ENiCrMo-4	AC DC (+)	0.15	0.18	0.82	5.60	Bal.	16.2	W 4.07	476 (69)	734 (106)	43	-	For welding inconel C-276 and other NiCrMo alloys. Corrosion resistance in many media and resistant to pitting crevice corrosion.
	N-NiCrMo-5	ENiCrMo-5	AC DC (+)	0.04	0.30	0.90	5.00	Bal.	17.0	Cr 16.0 W 5.0	-	100 ( )	-	210-240HB after work hardening 450HB	For impact, compassion, abrasion and heat resistance in hot work tools.
	N-NiCrMo-6	ENiCrMo-6	AC DC (+)	0.05	0.60	3.50	7.00	Bal.	7.00	Cr 13.0 Nb 1.0 W 1.2	-	650 (90)	31	-196º,55 (-321º,41)	For welding cold tough Ni steels such as X8Ni9.
	N-NiCrMo-7	ENiCrMo-7	DC (+)	0.012	0.18	0.80	2.00	Bal.	16.0	Cr 17	430 (61)	710 (103)	27	-	For welding on C-4, NiMo 16Cr16Ti and surface cladding on low alloyed steels. Exceptional resistance to contaminated mineral acids, chlorine contaminated medium, dry chlorine, sea water and brine solutions.
	N-NiCrMo-10	ENiCrMo-10	DC (+)	0.16	0.15	0.85	4.00	Bal.	13.5	Cr 21.5	-	690 (100)	25	-	For welding inconel 622 & 625, incolloy 25-6 Mo & 825 excellent dissimilar welding electrode with protection against preferrential mild metal corrosion for Mo contains steels.
	N-NiCrMo-13	ENiCrMo-13	DC (+)	0.02	0.2	0.50	1.00	Bal.	15.50	Cr 22.5	-	720 (105)	30	-	For welding component in environmental plants and plants for chemical processes with highly corrosive media. Joint welding of matching base materials as no. 2.4605 or similar matching as material no. 2.4602 NiCr21Mo14W. Joint welding of these materials with low-alloyed steel-Clading on low-alloyed steels.
	N-NiCrMo-14	ENiCrMo-14	DC (+)	0.15	0.21	0.82	35.0	Bal.	16.0	Cr 22.0	-	758 (110)	35	Hardness 95 HRB	For welding duplex, super-duplex stainless steel-austenitic stainless steel and Ni-alloys (UNS N06059 & 06022), inconel C276, 622, 625 and 686. Corrosion resistance in pollution engine & chemical, petro-chem, oil or gas and marine industries.
	N-NiMo-7	E-NiMo-7	DC (+)	0.02	0.2	0.50	1.00	Bal.	27.0	-	-	760 (110)	30	-	For welding of matching base materials, such alloy B-2 material No.2.4617 NiMo28, and surfacing of low alloyed steels. Chemical process Industry ,specially for processes involving sulphuric-, hydrochloric- and phosporic acids.

SOLID WELDING WIRE
FOR GAS TUNGSTEN ARC WELDING (GTAW) & GAS METAL ARC WELDING (GMAW)

Type of Metals/ Alloys	Brand Name		Size (mm)	Equivalent Specifications AWS (JIS)	Typical Analysis of Filler Wire						Typical All Weld Mechanical Properties				Applications
	TIG	MIG			C	Si	Mn	Cr	Ni	Others	Y.P. N/mm^2 (kg/mm^2)	T.S. N/mm^2 (kg/mm^2)	El. (%)	I.V. J (kgf-m)	
FOR CAST IRON	NT-Ni 99	NM-Ni99	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.6 0.8 0.9 1.0 1.2 1.6	ERNiCl	0.03	0.44	0.24	-	Bal.	Fe 0.01 Cu 0.02	317 (46)	482 (70)	12	-	Welding of ductile, malleable or gray cast iron to itself to dissimilar metals. Excellent for build-up of iron parts, repairing defective castings where high machinability is required.
	NT-Ni 55	NM-Ni55			0.005	0.10	0.69	0.030	55.48	Fe Bal. Cu 0.02	407 (59)	538 (78)	10	-	Welding large scale ductile cast ion, malleable cast iron or gray cast iron to themselves or to carbon and low alloy steel. Repairing thick, highly rust and weldments worn/broken parts and for salvages defective castings where higher tensile strength is required.

Type of Metals/ Alloys	Brand Name		Size (mm)	Equivalent Specifications AWS (JIS)	Typical Analysis of Filler Wire						Typical All Weld Mechanical Properties				Applications
	TIG	MIG			Al	Si	Mn	Fe	Cu		Y.P. N/mm^2 (kg/mm^2)	T.S. N/mm^2 (kg/mm^2)	El. (%)	as welded brinnel hardness	
FOR ALUMINUM ALLOYS	NT-Al 4043	NM-Al 4043	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.6 0.8 0.9 1.0 1.2 1.6	ER4043	Bal.	4.5-6.0	0.05 max	0.80 max	0.30 max		-	200 (29)	-	-	For welding 3003, 3004, 5052, 6061, 6063 and casting alloys 43, 355, 356 and 214.
	NT-Al 4047	NM-Al 4047		ER4047	Bal.	11.0-13.0	0.15 max	0.80 max	0.30 max		-	190 (27.5)	-	-	For welding 1060, 1350, 3003, 3004, 3005, 5005, 5050, 6053, 6061, 6951, 7005 and cast alloys 710.0 and 711.0. Provides good corrosion resistance.
	NT-Al 5356	NM-Al 5356		ER5356	Bal.	0.25	0.05-0.20	0.40 max	0.10 max		-	26 (3.8)	-	-	For welding 5050, 5052, 5083, 5356, 5454, 5456. Provides much better corrossion resistance to salt water.
	NT-Al 1100	NM-Al 1100		ER1100	99 min.	Fe&Si 0.95 max	0.50 max	Fe&Si 0.95 max	0.05-0.20		-	93 (13.5)	-	-	For architectural or decorative applications. For welding 1100, 3003, 3003 to 1060, to 1070, to 1080, to 1350.
FOR COPPER & BRONZE ALLOYS	NT-Cu	NM-Cu	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.6 0.8 0.9 1.0 1.2 1.6	ERCu	Cu 98 min.	0.50 max	0.50 max	Si 0.50 max	P 0.15 max	Tin 1.0 max others 0.50 max	55 (8)	200 (29)	29	54 HB	For weld deposits that are porosity free and electrically conductive. Used for copper and copper alloy based metals.
	NT-Cu Sn-A	NM-Cu Sn-A		ERCu Sn-A	Cu Bal.	-	-	0.01	P 0.10-0.35	Tin 4.0-6.0 others 0.50	-	-	-	-	For Brass and overlay welding of steel. Tin content increase wear resistance.
	NT-Cu Sn-C	NM-Cu Sn-C		ERCu Sn-C	Cu Bal.	-	P 0.03-0.35	-	0.10	Tin 7.0-9.0 others 0.50	-	-	-	-	Higher Tin than ERCuSn-A for greater hardness and higher technical/yield strength.
	NT-Cu Si-A	NM-Cu Si-A		ERCu Si-A	Cu Bal.	3.40	1.00	Sn 0.9	0.25	Zn 0.90	-	370 mpa	-	90 HB	For surfacing areas subject to corrosion. For joining copper-silicon and copper-zinc metals to themselves and to steel.

WELD WITH COMPLETE CONFIDENCE
NIHONWELD

SOLID WELDING WIRE
FOR GAS TUNGSTEN ARC WELDING (GTAW) & GAS METAL ARC WELDING (GMAW)

Type of Metal/ Alloys	Brand Name		Size (mm)	Equivalent Specifications AWS (JIS)	Typical Analysis of Filler Wire						Typical All Weld Mechanical Properties				Applications
	TIG	MIG			Cu	Si	Mn	Al	Ni		Y.P. N/mm^2 (ksi)	T.S. N/mm^2 (ksi)	El. (%)	as welded brinnel hardness	
FOR COPPER & BRONZE ALLOYS	NT-Cu Al-A1	NM-Cu Al-A1	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.8 0.9 1.0 1.2	ERCu Al-A1	Bal.	0.10 max	0.50 max	6.0-8.5	-	0.50 max	193 (28)	469 (68)	47	125HB	For bearing and wear resistance exposed to corrosive, salt or brakish water and common acids.
	NT-Cu Al-A2	NM-Cu Al-A2		ERCu Al-A2	Bal.	0.10 max	-	8.5-11.0	0.75-1.50	0.50 max	241 (35)	545 (79)	28	140HB	Excellent for joining dissimilar metals. For wear and corrosion resistance. Ex. Marine Maintenance, Piston Heads.
	NT-Cu Al-A3	NM-Cu Al-A3		ERCu Al-A3	Bal.	0.10 max	-	10.0-11.5	2.0-4.5	0.50 max	276 (40)	620 (90)	20	166HB	For a deposit of high strength and good ductility used for piston overlay and bearing surface application.
	NT-Cu NiAl	NM-Cu NiAl		ERCu NiAl	Bal.	0.10 max	0.50-3.50	8.50-9.50	4.0-5.50	Fe 3.1-5.0 others 0.50 max	407 (59)	717 (104)	23	196HB	For welding of cast and wrought nickel-aluminum-bronze. Such as ship propellers. Also for off-shore industries.
	NT-Cu MnNiAl	NM-Cu MnNiAl		ERCu NiMnAl	Bal.	Fe 2.0-4.0	11.0-14.0	7.0-8.5	1.5-3.0	0.50 max	462 (67)	758 (110)	27	217HB	For high resistance to corrosion, errosion and cavitation. Good ability to join dissimilar metals.

SOLID WELDING WIRE
FOR GAS TUNGSTEN ARC WELDING (GTAW) & GAS METAL ARC WELDING (GMAW)

Type of Metals/ Alloys	Brand Name		Size (mm)	Equivalent Specifications AWS (JIS)	Typical Analysis of Filler Wire							All Weld Mechanical Properties			Applications
	TIG	MIG			C	Si	Mn	Cr	Ni	Others	Others	T.S. N/mm² (kg/mm²)	El. (%)	I.V. J (kgf-m)	
FOR NICKEL ALLOYS	NT-Cu Ni	NM CuNi	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.6 0.8 0.9 1.0 1.2 1.6	ERCuNi	0.04 max	0.25 max	1.0 max	Cu Bal.	29.0-32.0	Ti 0.20-0.50	Fe 0.40-0.70	345 (50)	30	-	For excellent resistance to sea water corrosion. Used in marine and desalination applications.
	NT-Ni-1	NM-Ni-1		ERNi-1	0.15 max	0.75 max	1.0 max	-	93 min	Ti 2.0-3.5	Cu 0.25 max Fe 1.0 max	414 (60)	20	-	For good corrosion resistance especially alkalics. Used in dissimilar welding applications.
	NT-Ni Cr-3	NM-Ni Cr-3		ERNiCr-3	0.10 max	0.50 max	2.5-3.5	18-22.0	67.0 min	Nb 2.0-3.0	Ti 0.75 max	552 (80)	30	-	For high strength, good corrosion resistance and strength at high temperature. Also for dissimilar welding application.
	NT-Ni CrCo Mo-1	NM-Ni CrCo Mo-1		ERNiCr CoMo-1	0.07	0.50	0.50	22.0	52.0	Co 12.5	Mo 9.0	807 (117)	41	-	For high temperature strength, oxidation resistance and metalurgical stability.
	NT-Ni CrFe-5	NM-Ni CrFe-5	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.6 0.8 0.9 1.0 1.2 1.6	ERNi CrFe-5	0.08 max	0.25 max	1.0 max	14.0-17.0	70.0 min	Nb 2.5-3.0	Fe 6.0-10.0	552 (80)	30	-	For high temperature strength, oxidation resistance.
	NT-Ni CrFe-6	NM-Ni CrFe-6		ERNi CrFe-6	0.08 max	0.35 max	2.0-2.7	14.0-17.0	67.0 min	Ti 2.5-3.5	Fe 8.0 max	as welded 552 (80) annealed and aged 793 (115)	as welded 30 annealed and aged 10	-	For high strength and corrosion resistance at temperatures from cryogenic region to over 980ºC.
	NT-Ni CrMo-2	NM-Ni CrMo-2		ERNi CrMo-2	0.05-0.15	1.0 max	1.0 max	20.5 23.0	Bal.	Co 0.50-2.50 Mo 8.0-10.0	W 2.0-1.0	656 (95)	-	-	For outstanding strength and oxidation resistance at temperatures up to 1200ºC.
	NT-Ni CrMo-3	NM-Ni CrMo-3		ERNi CrMo-3	0.10 max	0.50 max	0.50 max	20.0 23.0	58.0 min	Nb 3.15-4.15 Mo 8.0-10.0	Co 1.0 max Cu 0.50 max	-	-	-	For high strength over broad temperature range and exceptional corrosion resistance including pitting and crevice corrosion.
	NT-Ni CrMo-4	NM-Ni CrMo-4	TIG Ø 1.6 2.0 2.4 3.2 4.0 Length 1000 • MIG Ø 0.6 0.8 0.9 1.0 1.2 1.6	ERNi CrMo-4	0.02 max	0.08 max	1.0 max	14.5-16.5	Bal.	Mo 15-17 Co 2.5 max	V 0.35 max W 3.0-4.5	690 (100)	-	-	For excellent corrosion resistance to many aggressive media and specially resistant pitting and crevice corrosion.
	NT-Ni CrMo-7	NM-Ni CrMo-7		ER-Ni CrMo-7	<0.01	<0.1	-	16.0	Bal.	Mo 16.0	Fe <1.5	700 (101)	30	-	For joint weldings in the chemical industry on alloys of the type materials 2.4610 NiMo16Cr16Ti UNS N06455 2.4819 NiMo16Cr15W UNS N10276
	NT-Ni CrMo-10	NM-Ni CrMo-10		ERNi CrMo-10	-	-	-	20.5	59	Mo 14.0	Fe 2.3 W 3.2	793 (115)	40	-	For welding inconel alloy 622 and other Ni-Cr-Mo corrosion resisting alloys.
	NT-Ni CrMo-13	NM-Ni CrMo-13		ER-Ni CrMo-13	<0.01	<0.1	-	22.5	Bal.	Mo 15.5	Fe <1.0	720 (102)	>35	-	For welding components in plants for chemical processes with are highly corrisive media.
	NT-Ni CrMo-18	NM-Ni CrMo-18		ER-Ni CrMo-18	<0.02	<0.5	<0.5	19-21	Bal.	Mo 11.0 W 1-2 N 0.05-0.15	Fe 14.0 Nb 0.2 P <0.02	725 (105)	>30	-	For joining and surfacing on special steels and duplex alloys, which are used in the chemical terotechnology and offshore technology.
	NT-Ni Cu-7	NM-Ni Cu-7		ER-Ni Cu-7	0.15 max	1.25 max	4.0 max	Cu Bal.	62.0-69.0	Ti 1.5-3.0	-	483 (70)	30	-	For good strength and resistance to corrosion in many media including sea water, salts and reducing acids.
	NT-Ni FeCr-1	NM-Ni FeCr-1		ER-Ni FeCr-1	0.05 max	0.50 max	1.0 max	19.5 23.5	38.0-46.0	Cu 1.5-3.0 Ti 0.60-1.20	Mo 2.50-3.80 Al 0.20 max	552 (80)	25	-	For highly corrosion resistant (particulary chemicals) deposits.
	NT-Ni FeCr-2	NM-Ni FeCr-2		ER-Ni FeCr-2	0.08 max	0.35 max	0.35 max	17.0-21.0	50-55	Al 0.20-0.80 Ti 0.65-1.15	Nb 4.75-5.5 Mo 2.80-3.30	1138 (165)	-	-	Weld metals is age hardened and has mechanical properties comparable to those of the base metals.
	NT-Ni Mo-7	NM-Ni Mo-7		ER-Ni Mo-7	<0.01	<0.1	-	-	Bal.	Mo 28.0	Fe <2.0	760 (111)	>30	-	Welding components of apparatus for chemical processes, especially in sulphuric-, chlorid-and phosphoric acid enviromentals.

SOLID WELDING WIRE
FOR GAS TUNGSTEN ARC WELDING (GTAW) & GAS METAL ARC WELDING (GMAW)

Type of Metal	Brand Name		Size (mm)	Equivalent Specifications AWS (JIS)	Typical Analysis of Filler Wire						Typical All Weld Mechanical Properties				Applications
	TIG	MIG			Al	Be	Mn	Mg	Zn	Others	Y.P. N/mm² (ksi)	T.S. N/mm² (ksi)	El. (%)	I.V. J (kgf-m)	
FOR MAGNESIUM ALLOYS	NT-AZ 61A		dia 2.4 3.2 4.0 5.0 Length 1000	ErAZ61A	5.8-7.2	0.0002-0.0008	0.15-0.5	Bal	0.40-1.5		207 (30)	303 (44)	16		For brazing & welding of magnesium sheets, plates, castinger, & extrusions.
	NT-AZ 92A			ErAZ9A	8.3-9.7	0.0002-0.0008	0.15-0.5	Bal	1.7-2.3		97 (14)	172 (25)	2		Also for brazing & welding general magnesium alloys.

Type of Metal	Brand Name		Size (mm)	Equivalent Specifications AWS (JIS)	Typical Analysis of Filler Wire						Typical All Weld Mechanical Properties				Applications
	TIG	MIG			C	O	H	N	Fe	Ti	Y.P. N/mm² (ksi)	T.S. N/mm² (ksi)	El. (%)	I.V. J (kgf-m)	
FOR TITANIUM ALLOYS	NT-Ti-1		dia 2.4 3.2 4.0 5.0 Length 1000	Er-Ti-1	0.30	0.100	0.005	0.015	0.100	Bal	172 (25) min	241 (35) min	24 min	-	For welding commercial pure titanium alloys commonly found in applications requiring high temp. resistance and resistance to chemical re-agents.
	NT-Ti-2			Er-Ti-2	0.03	0.100	0.008	0.02	0.200	Bal	345 (50)	276 (40)	20	-	Most widely used titanium alloy for industrial applications because of its good balance of strength.
	NT-Ti-3		dia 2.4 3.2 4.0 5.0 Length 1000	Er-Ti-3	0.03	0.10-0.15	0.008	0.02	0.200	Bal	448 (65)	379 (55)	18	-	For welding seawater and brakish water exchangers, chemical process hear exchange, etc.
	NT-Ti-4			Er-Ti-4	0.03	0.15-0.25	0.008	0.02	0.300	Bal	552 (80)	483 (70)	15	-	Same application as to NT-Ti-3 but with higher strength.
	NT-Ti-5			Er-Ti-5	0.05	0.180	0.015	0.03	0.300	Bal Al 5.5-6.7 V 3.8-4.5	827 (120) min	896 (130) min	10 min	-	For high fatigue strength, toughness, and are heat treatable.

OXY FUEL BRAZING FLUXES

Type of Metals/ Alloys	Brand Name	Equivalent Specifications AWS (JIS)	Unit Wt/pack	Typical Analysis of Filler Wire									Melting Point ºC (ºF)	Applications
				Ag	Cu	Zn	Cl	Ni	P	SN				
BRAZING FLUXES	NFC-1 (Copper)		0.5 Kg per JAR										635 (1175)	Brazing flux of copper, steel and stainless steel within 850-1150 deg. Celsius.
	NFC-2 (Silver)	FB3-F	0.5 Kg per JAR										540-870 (1000-1700)	Brazing flux of copper, copper alloys, steel and stainless steel within 600-850 deg. Celsius.
	NFC-3 (Aluminum Alloy)	FB1-A	0.5 Kg per JAR										550-690 (1030-1280)	Brazing flux of aluminum and aluminum alloys within 470-630 deg. Celsius.
	NFC-4 (Cast Iron)		0.5 Kg per JAR										735 (1355)	For brazing of cast iron.
	NFC-5 (stainless steel)		0.5 Kg per JAR										890 (1634)	For brazing of stainless steel. A neutral flame should be ____________ at all time.

OXY FUEL GAS FILLER ROD FOR BRAZING

Type of Metals/ Alloys	Brand Name	Equivalent Specifications AWS (JIS)	Size (mm)	Typical Chemical Composition of Filler Wire						Typical All Weld Mechanical Properties			Applications
				Cu	Sn	Fe	Ni	Si	Zn	T. S. N/mm² (ksi)	Hardness	Melting point ºC (ºF)	
FOR COPPER & BRONZE ALLOYS	NB-CuZn-A (NZB-AR) (BARE) / NB-CuZn-A FC (NZB-FC) (COATED)	RbCuZnA	1.6-4.0	57.0-61.0	0.25-1.00	-	-	-	Bal	345 (50)	70-90 HB	900 (1650)	For braze welding of copper, steel and cast iron. Melting point about 900ºC.
	NB-CuZn-B-R (BARE) / NB-CuZn-B-FC (COATED)	RbCuZn-B	1.6-4.0	56.0-60.0	0.80-1.10	0.25-1.20	0.20-0.0	0.04-0.15	Bal	386 (56)	80-110 HB	880 (1620)	For braze welding of copper, steel and cast iron. Melting point about 880ºC.
	NB-CuZn-C-R (BARE) / NB-CuZn-C-FC (COATED)	RbCuZn-C	1.6-4.0	56.0-60.0	0.80-1.10	0.25-1.20	-	0.04-0.15	Bal	386 (56)	80-110 HB	890 (1630)	Braze welding of copper, steel and cast iron. Melting point about 890ºC.
	NB-CuZn-D-R (NNB-700AR) (BARE) / NB-CuZn-D-FC (NNB-700FC) (COATED)	RbCuZn-D	1.6-4.0	46.0-50.0	-	-	9.0-11.0	0.04-0.15	Bal	414 (60)	90-110 HB	935 (1715)	For braze welding of steel, nickel and crabide alloys and for high strength. Melting point about 935ºC.
FOR CAST IRON	NB-GCR (GRAY CAST) (BARE)	ROUND SHAPE	5.0-8.0	C 3.41	Si 4.25	Mn 0.48	S 0.016	P 0.061	-	T.S. 276 (40)	hardness 200HB	working temp. 820ºC	For oxy-fuel grazing of GRAY CAST IRON.
	NB-DCR DUCTILE CAST (BARE)	HEXAGONAL SHAPE	5.0-8.0	C 3.74	Si 3.26	Mn 0.38	S 0.012	P 0.037	-	T.S. 276 (40)	hardness 200HB	working temp. 870ºC	For oxy-fuel brazing of ductile cast iron.

Type of Metals/ Alloys	Brand Name	Equivalent Specifications AWS (JIS)	Size (mm)	Typical Chemical Composition of Filler Wire						Typical All Weld Mechanical Properties			Applications
				Al	Si	Mn	Fe	Cu		T. S. N/mm² (ksi)			
FOR ALUMINUM ALLOYS	NB 4043 (BARE)	ER 4043	1.6-4.0	Bal.	4.5-6.0	0.05 max	0.80 max	0.30 max					For 3003, 3004, 5052, 6061, 6063 and casting alloys 43, 355, 356 and 214.
	NB 4047 (BARE)	ER 4047	1.6-4.0	Bal.	11.0-13.0	0.15 max	0.80 max	0.30 max					For 1060, 1350, 3003, 3004, 3005, 5005, 5050, 6053, 6061, 6951, 7005 and cast alloys 710.0 and 711.0. Provides good corrosion resistance.
	NB 5356 (BARE)	ER 5356	1.6-4.0	Bal.	0.25	0.05-0.20	0.40 max	0.10 max					For 5050, 5052, 5083, 5356, 5454, 5456. Provides much better corrosion resistance to salt water.
	NB 1100 (BARE)	ER 1100	1.6-4.0	99 min.	Fe&Si 0.95 max	0.05 max	Fe&Si 0.95 max	0.05-0.20					For architectural or decorative applications. For 1100, 3003, to 1060, to 1070, to 1080 to 1350.
	NB-Flux cored Aluminum	-	3.2mm x 32" length	-	-	-	-	-		221 (32)			Oxy fuel brazing in repairing broken or cracked aluminum castings.
	NB-Alumite	-	3.2mm x 32" length	-	-	-	-	-		269 (39)			3-in-1 for aluminum, zinc, gas brazing rod.

OXY FUEL GAS FILLER ROD FOR BRAZING

Type of Metals/ Alloys	Brand Name	Equivalent Specifications AWS (JIS)	SIZE (mm)	Typical Chemical Composition of Filler Wire						Typical All Weld Mechanical Properties			Applications
										Reference Data			
				Ag	Cu	Zn	Cd	Ni	P	Solidus ºC	Liquidus ºC	Density kg/cm³	
Copper Phosphorus Brazing Alloys	N-AgOR (bare)	BCuP-2	1.0	-	93	-	-	-	7	705	805	8.05	Used best for filleting of the alloy along the joint boundaries, reducing the flow on the work surface.
	N-Ag2R (bare)	BCuP-6	1.6	2	91	-	-	-	7	645	740	8.1	Flow is extensive; used on well fitted joints.
	N-Ag5R (bare)	BCuP-3	1.6	5	89	-	-	-	6	640	805	8.2	Used as an alternate temperature depressant.
	N-Ag15R (bare)	BCuP-5	1.6	15	80	-	-	-	5	645	770	8.4	Low soldering temperature and most versatile / most widely used among copper & alloys.
	N-Ag20R (bare)	-	1.6	20	40	25	15	-	-	605	765	8.8	Good fluidity and has a color suitably matched to brass.
Silver Alloys (Cadmium Bearing)	EZ-Ag25R (bare) / EZ-Ag25FC (flux coated)	BAg-27	1.6	25	35	27	13	-	-	605	765	8.8	With higher content of zinc and cadmium thus needs more attention during soldering.
	EZ-Ag30R (bare)	BAg-2a	1.6	30	27	23	20	-	-	610	710	9.2	A highly economic product.
	EZ-Ag35R (bare) / EZ-Ag35FC (flux coated)	BAg-2	1.6	35	26	21	18	-	-	605	700	9.2	Slightly higher soldering temperature and rapid heating.
	EZ-Ag40FC (flux coated)	-	1.6	45	15	16	24	-	-	605	620	9.4	Essentially equal to EZ-Ag50R except with 5% less silver.
	EZ-Ag45R (bare) / EZ-Ag45FC (flux coated)	BAg-1	1.6	45	15	16	24	-	-	605	620	9.4	Essentially equal to EZ-Ag50R except with 5% less silver.
	EZ-Ag50R (bare)	BAg-1a	1.6	50	15.5	16.5	18	-	-	675	635	9.5	Widely accepted for its low soldering temperature and good flow.
SILVER ALLOY (Cadmium Free)	N-Ag25R (bare) / N-Ag25FC (flux coated)	BAg-37	1.6	25	40	33	-	-	-	685	770	8.7	Lower silver; economical for brazing steel, copper, brass.
	N-Ag35R (bare) / N-Ag35FC (flux coated)	BAg-5	1.6	35	32	33	-	-	-	680	750	9.0	For productive brazing application.
	N-Ag45R (bare) / N-Ag45FC (flux coated)	BAg-5	1.6	45	30	25	-	-	-	665	745	9.2	Especially for brazing in electrical industry.
	N-Ag56R (bare)	Bag-7	1.6	56	22	17	-	-	-	620	650	9.5	To minimize steel corrosion cracking or nickel base alloys at low brazing temperature.

NIHONWELD

A-LUM-ITE

the original low-heat alloy for

SOLDERING/BRAZING ALUMINUM and WELDING ZINC ALLOYS

3 in 1 ROD

REPAIRS ALL...

Aluminum and Zinc Alloys quickly and easily.

For use with acetylene, propane, and mapp gas.

NO FLUX is necessary on accessible joints

	Joint
A-LUM-ITE is the original, fluxless, low-temperature brazing rod for aluminum. A-LUM-ITE has been used and endorsed by leading industries for over 30 years. Actual field applications have proved that joints made with A-LUM-ITE are permanent, non-corrosive, and stronger than the parent metal. A-LUM-ITE will join most aluminum alloys, zinc base alloys, pot metal, white metal. It can also be used as a general purpose, high strength solder.	Aluminum to Aluminum Aluminum to Steel Aluminum to Copper Aluminum to Stainless Steel Aluminum to Zinc Steel to Copper Steel to Steel Steel to Zinc Copper to Copper Copper to Stainless Steel Copper to Zinc Stainless Steel to Stainless Steel Stainless Steel to Zinc Zinc to Zinc

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Antique car parts

ALUMINUM WINDOWS, DOORS, FURNITURE.

Size: 1/8" x 18", 3/32" x 18", 1/4" x 18"

PHYSICAL PROPERTIES OF A-LUM-ITE

Elastic Limit - Pounds	6,600
Elastic Limit Per Sq. Inch	33,000
Tensile Strength, P.S.I.	39,000
Brinell - 500 kg. Load	100
Melting Range	715° - 735°F
MIL-R-4208	

SUPER CAST

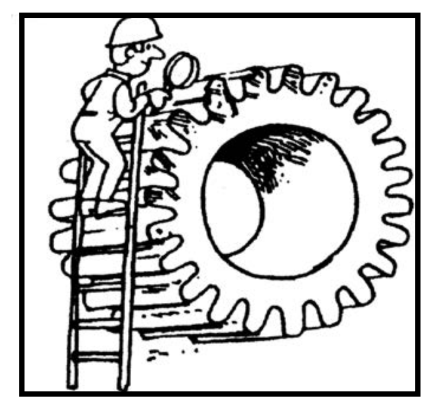
The most outstanding universal "one product" type alloy for welding.
Dissimilar combinations of steel, stainless steel, cast iron or nickel based alloy with little or no preheat required

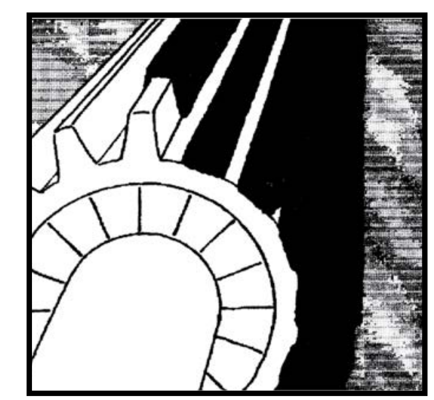
SPECIAL FEATURES:

- Universal alloyed electrode for high heat and cryogenic applications.
- Excellent high temperature strength and oxide resistance.
- Good ductility for welding massive sections where postheat treatment is required.
- Little or no preheat needed especially for massive or big dimension of work piece when pre-heating is not possible.
- Extremely tough weld metal that work hardens.
- High strength and high elongation weld metal properties.

APPLICATION:

- Ideally suited for re-building of massive gear teeth especially for the sugar cane industry wherein because of the massive size dimensions of the gear when pre-heating can be ruled out.
- For welding dissimilar combination of steel, stainless steel, cast iron and other nickel based alloy.





ALLOY OF WELD METAL DEPOSIT:
C, Mn, Si, Cr, Ni, Nb

The serviceability of a product or structure utilizing this type of information is and must be the sole responsibility of the builder/user. Many variables beyond the control of INDUSTRIAL WELDING CORPORATION affect the results obtained in applying this type of information. These variables Include, but are not limited to, welding procedure, plate chemistry and temperature, weldment design, fabrication methods and service requirements.

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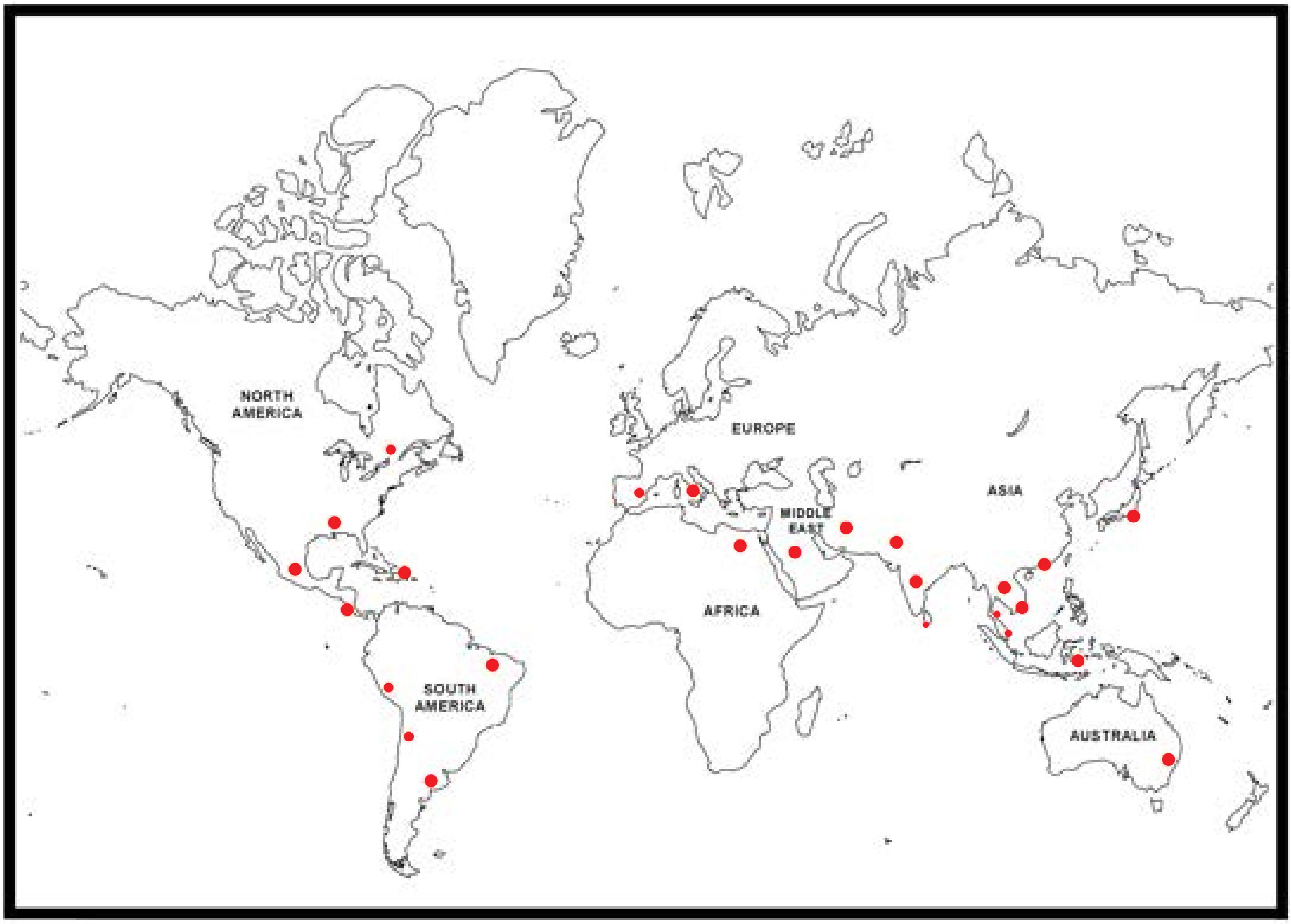

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PRINTED 03/11