WELD WITH COMPLETE CONFIDENCE

NIHONWELD

WELDING PRODUCTS

HARDSURFACING HANDBOOK

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Industrial Welding Corporation

LEADER IN WELDING TECHNOLOGY

NIHONWELD

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:

AMERICAN BUREAU OF SHIPPING
BUREAU VERITAS (FRANCE)
DET NORSKE VERITAS (NORWAY)
LLOYD'S REGISTER OF SHIPPING (UK)
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NIHONWELD HARDSURFACING HANDBOOK

This handbook is a comprehensive compilation of data about hardsurfacing. It includes definitions, welding processes, classification of hardsurfacing deposits. Among subjects covered are basic wear factors which can be controlled by hardsurfacing; major industries and applications which can be benefit economically by using **NIHONWELD** electrodes and wires, and welding systems which are used for hardsurfacing parts and equipment subject to abrasion, corrosion and heat.

The Company Behind The Products

Industrial Welding Corporation is a leader in the field of welding electrode and wire production. This leadership earned through years of intensive research and development. It has provided the industry with various types of welding materials for weld fabrication, hardsurfacing of metal components and parts so that the metals are joined better and wear longer than before.

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

We believe this handbook will explain the meaning of Hardsurfacing technology in a lay-man language.

Table of Contents **Page No.**

Hardsurfacing- Industry's Answer to Wear

What is hardsurfacing ?

The Welding Handbook of the American Welding Society defines hardsurfacing as" the deposition of filler metal on a metal surface to obtain desired properties or dimensions". The desired properties referred to the ability to resist impact, abrasion, heat, and corrosion.

The protective layer of special alloy can be deposited on new surfaces before the part is put into service, or to replace metal which has been worn or corroded away, thus restoring the original dimensions of the part.

Hard-surfacing, therefore, can be described as the process whereby an alloy material is applied to a metallic part by welding in order to form a protective surface which will resist abrasion, impact, heat, erosion, attrition, shear, compression, temperature and corrosion, or a combination of these wear factors that often reduce the service life of metal parts.

Hardsurfacing is an economical way to keep equipment on the job longer, more efficiently, with less downtime required for the repair or replacement of worn parts. The hard-surfacing will generally outlast the basic metal parts many times over, depending on the alloy used and service conditions involved in the application.

In order to select an alloy for a specific surfacing application, it is necessary to understand the types of wear normally encountered. The following are common types of wear which can have an important bearing on the efficiency and service life of metal parts and components.

Hardness not always the Criteria.

The selection of alloys to resist wear of metals is a complex subject. This brochure deals primarily with materials which are generally considered "hardsurfacing" alloys. Some are less hard than others, the criteria being oxidation or corrosion, or erosion where hardness may not correlate with wear resistance. Many stainless steels and nickel-base alloy are employed in surfacing applications.

Major Types of Wear.

Abrasion. (*see Fig.1*) The grinding, scraping and or gouging action on metal surfaces is considered to be the most common type of wear which hardsurfacing is called upon to overcome. Wear is often caused by continual exposure to the grinding action of substances such as sand, gravel, earth, or other gritty particles.

Impact. (*see Fig.2*) The pounding or battering of metal parts can cause considerable wear or result in splitting, spalling, chipping, or other breakage. Hammers, crushing equipment, dies, mandrels are typical examples of this type of wear.

Temperature. (*see Fig.3*) Operating temperatures or exposures to heat or cold should be considered for the application of hardsurfacing alloys. Rapid changes in temperature often result in thermal shock.

Corrosion. (*see Fig.4*) This type of wear is generally caused by metal coming in contact with atmosphere, moisture acids, fumes, alkalies, salts and other corrodents. Pitting cracking, and eventual destruction of the parts results. Oxidation is common form of corrosion caused by exposure to a combination of heat and air resulting in the crumbling of flaking of a metal.

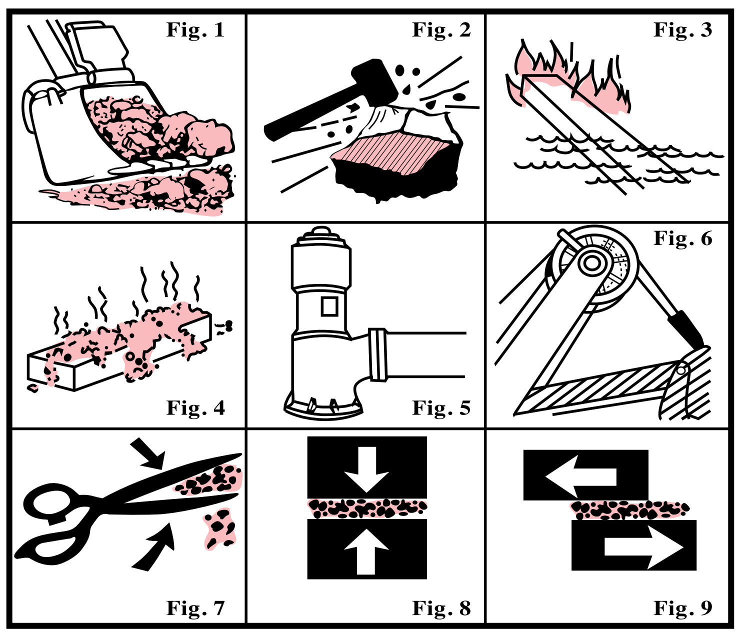
Erosion. (*see Fig. 5*) Destruction of metal by abrasive action of moving fluids, often accompanied by the impact or pressure of soil particles in the fluids is a form of erosion. Pumps, valves, and other parts of liquids or solid handling systems are subjected to erosion.

Metal - to Metal Contact.(*see Fig. 6*) Apart from friction, metal parts seizing or galling because of inadequate lubrication is another common type of wear. Bushings, sleeves, valve seats, and other components subject to frictional heat are typical examples of this type of wear.

Shear. (*see Fig.7*) Shear consists of a trimming or cleaving action rather than the rubbing action associated by attrition. Shear is usually combined with other methods. For example, single-rollcrushers employ shear together with impact and compression.

Compression. (*see Fig. 8*) As the name implies, crushing by compression is done between two surfaces, with the work being done by one or both surfaces. Jaw crushers using this method of compression are suitable for reducing extremely hard and abrasive rock. However, some jaw crushers employ attrition as well as compression and are not suitable for abrasive rock since the rubbing action accentuates the wear on crushing surfaces.

Attrition. (*see Fig. 9*) Attrition is a term applied to the reduction of materials by scrubbing it between two hard surfaces. Hammermills operate with close clearances between the hammers and the screen bars and they reduce by attrition combined with shear and impact reduction. Though attrition consumes more power and exacts heavier wear on hammers and screen bars, it is practical for crushing the less abrasive materials such as pure limestone and coal.



Significant Advantages of Hard-Surfacing.

- *Increased Part Life.* By adding the proper wear resistance where it is required, hardsurfacing prolongs the life and efficiency of parts. Depending on the alloy used and service conditions affect part, hardsurfacing will outlast unprotected surfaces by two to twenty times and often more than that.

- *Reduced Parts Inventory.* Surfaced parts help reduce stocks of new parts required for emergency and general replacements. Often a sizeable investments in stock becomes unnecessary by continued hardsurfacing of parts.

- Economical Use of Materials. One of the significant merits of hardsurfacing lies in the fact that only wear areas need to be hardsurfaced. This permits the use of a low-cost base metal in combination with the limited use of more expensive alloys. This is the concept used in what is termed a "composite" part.

- Reduced Power Consumption. Since a hard-surfaced part remains in better condition for a longer time, energy efficiency is improved, consequently resulting in saving power consumption.

- Less Equipment Downtime. Hard-surfacing keeps equipment on the job longer by reducing shutdowns due to repair or replacement of worn parts. Unnecessary downtime is averted. Productivity is maintained. Profitability is increased.

- Fewer Scrapped Parts. Hard-surfacing keeps parts in service which were generally sent to the scrap pile, for much less than the cost of replacing them. This saving can be multiplied because parts can be built up by a number of times it necessitates.

NIHONWELD Hard-Surfacing Products Help Overcome Wear.

Since only areas subjected to wear are hard-surfaced, relatively expensive metals can be used in producing parts to be surfaced. A part that has been properly hardsurfaced with the right alloy has alonger service life than an unprotected part. Choosing the alloy for hardsurfacing the working area is, therefore, very important.

A careful analysis of the conditions causing the wear will determine the type of hardsurfacing material to be used. It should be emphasized that in hardsurfacing, "hard" generally connotes durability rather than the common usage of the term. Even among the harder surfacing alloys, hardness does not always correlate with wear resistance. Since the end result desired for surfacing is added service life and longer prolonged life of the working area; it is well to keep in mind that alloy in hardness is not always a valid index of wear resistance. Selecting an alloy for the application of a hard surface can also contribute desirable toughness as an adjunct to hardness as well as corrosion resistance and other properties chosen to overcome additional wear hazards to which the parts may be subjected.

To aid in selecting the most advantageous hard surfacing material for each application, **INDUSTRIAL WELDING CORPORATION** produces highly alloyed welding filler metals to meet its customer's varied needs. These alloys provide the property advantages required to do the job and are described on pages 9 to 16. **INDUSTRIAL WELDING CORPORATION** can also design and develop hardsurfacing products according to customer's specification.

Hard-Surfacing Increases Productivity and Profitability.

Long service life with reduced downtime and minimal repairs is the goal of all users of hardsurfacing alloys. The objective is to reduce part wear as much as possible in order to extend the usable life of equipment.

Selecting the Right Welding Process for Hard-Surfacing.

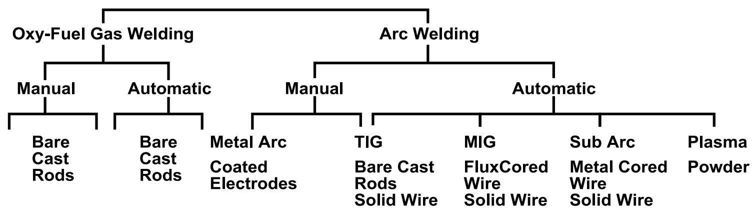
Hardsurfacing methods can be divided into two categories: Weld fusion processes and coating processes. The chief difference is in the method of application.

Weld Fusion Processes produce deposits which are metallurgically overlays on the base metal. The filler metal and the base metal are fused in the process and then resolidified to provide a continuous metallic deposit.

Coating Process. Such as applied by flame spraying, are mechanically bounded to the base metal. Some metal alloys applied coatings can be heated to their melting point in a separate operation to produce metallurgical bonding of the coating with the base metal.

This chart indicates some of the commonly used processes suitable for hard-surfacing with the different form of hard surfacing products.

Fig. 3 HARD-SURFACING WELDING PROCESSES



Each process has inherent characteristics that make it preferred for particular applications. In selecting a process, there are three important factors to consider:

- Dilution
- Deposition rate
- Deposition thickness

When choosing a particular method these other factors should also be considered:

The size and configuration of the part
- Composition and available form of the hard surfacing alloy.
- The operator's skill
- Availability of equipment
- Economics of the process

Once the process is selected based on these factors and the consideration listed, the next step is to select welding conditions to achieve the best balance between suitable bead shape and acceptable dilution, deposition rate, and deposit thickness.

Dilution is usually expressed in percent of the weld deposits which represents the fused base metal. It can be considered as the interalloying of the hard-surfacing alloy with the base metal.

A dilution level of 30 percent means that the deposit is a homogeneous alloy composed of 30 percent base metal alloy and 70 percent surfacing alloy. Excessive dilution with the base metal will reduce the alloy content of the deposit usually with a corresponding drop in hardness and wear resistance. Excessive dilution, therefore, is to be avoided.

TABLE 1. NIHONWELD HARD-SURFACING PROCESS SELECTION CHART

WELD FUSION PROCESS		Method of Application	Hard-Surfacing Alloy Form	Weld Dilution (percent)	Deposition (lbs.per hour)	Minimum Practical Deposit Thickness (in.)	Applicable Nihonweld Hardsurfacing Products	Cost of Equip-ment	Cost 0f Operation	Preheat Time	Surface of Deposit
Basic Process	Process Variations										
Combustible gas	Oxy-fuel gas	Manual	Bare cast rod	2 to 10	1 to 6	1 / 32	N-STIR N-ST6R	Low	High	Long	Smooth
		Automatic	Extra long bare cast rod	3 to 10	3 to 10	1 /32	N-STIR N-ST6R	Medium	High	Long	Smooth
Shielded metal arc	Covered electrode	Manual	Flux-coated cast rod	15 to 25	1 to 6	1 / 8	NHF- Series N- HMn N-HCrMn N-HNiMn N-HCrMo N-HMoMn	Medium	Low	Very short	Irregular
Gas shielded arc	Gas metal arc (MIG)	Semi-& Fully Automatic	Flux-cored & solid wire	15 to 25	5 to 12	1/ 8	NM-70S6 NM-70S4 NM-70S3	Medium	Very Low	Very short	Irregular
	Gas tungsten arc (TIG)	Manual	Bare cast & drawn rod	10 to 15	1 to 8	3 / 32	NT-316 NT-308	Medium	Low	Very short	Irregular
		Automatic	Extra long (6 ft.) bare cast rod	10 to 15	1 to 8	3 / 32	NT-316A NT-308A	High	Very Low	Very short	Smooth
Submerged arc	Single-wire	Automatic	Bare Solid & composite wire	15 to 35	15 to 25	1 / 8	NSW 8 NSW 14	High	Low	Very short	Smooth
Plasma arc		Automatic	Powder	5 to 30	1 to 15	1 / 32	NMP1 NMP6 NMP2 NMP7 NMP3 NMP8 NMP4 NMP9 NMP5 NMP10	High	Medium	Very short	Smooth

In hardsurfacing the composition of the deposited metal and that of the base metal are usually different and as a result, dilution or concentration of the base metal is expected. Therefore there are some cases where required properties could not be obtained.Multi-layer welding more than triple-layer is not affected by dilution or concentration but in case of single or double-layer welding this effect must be taken into consideration. The formula to obtain the composition of nth layer;

$$Cw = Cf + (P/100)n\ (Cp - Cf)$$

- Cw = Content of elements included in nth layer deposited metal (%)
- Cf = Content of elements included in the deposited metal without dilution (%)
- Cp = Content of elements included in the base metal (%)
- P = Penetration percentage
- n = Number of layers

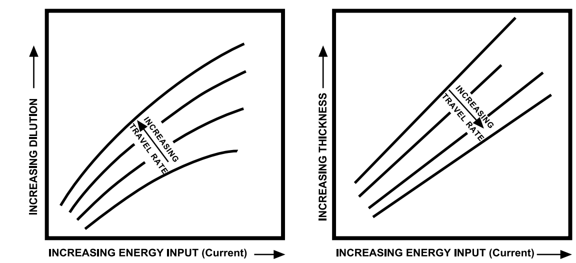


Fig. 11. Influence of travel rate and energy input on dilution and thickness of hard-surfacing deposits.

Penetration is a term related to dilution. It is the distance from the original surface to the fusion line between the weld deposit and base metal.

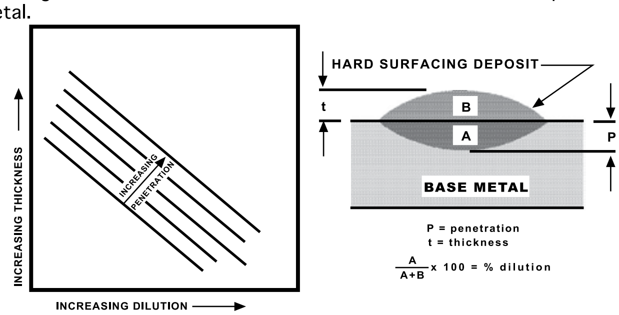


Fig. 12. The interrelationship of deposit thickness, dilution and penetration.

Welding processes in Hard Surfacing.

Weld Fusion Processes

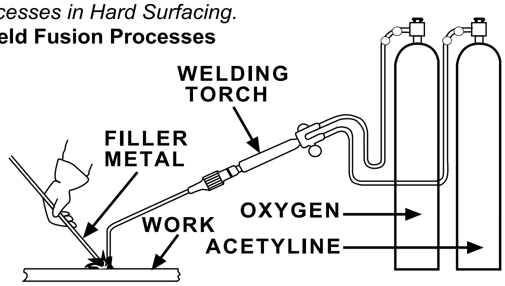


Fig. 13

The Oxy-Fuel Gas method offers many advantages in depositing smooth, precise and extremely high quality surfaces. Low base metal dilution is particularly important where filler and base metal differ considerably, as with cobalt-base filler metals applied to steels. Most grades of steel can be hard surfaced by the oxy-fuel gas method with the exception of the high manganese steel (Hadfiel) and the sulfur-and selenium containing free machining Steels. (see Fig.13)

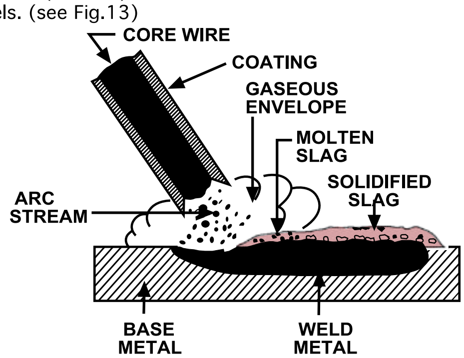


Fig. 14

The Shielded Metal-Arc welding method uses a covered electrode whose coating during arc welding decomposes to form a slag and gases which protect the weld metal. This is a widely used manual process for hardsurfing large and small parts both for restoring worn parts and for producing composite parts in new equipment. It is generally preferred over the oxy-fuel process for productivity and for low heat input where distortion may result. However, it results in greater dilution by the base metal. (*see Fig. 14*)

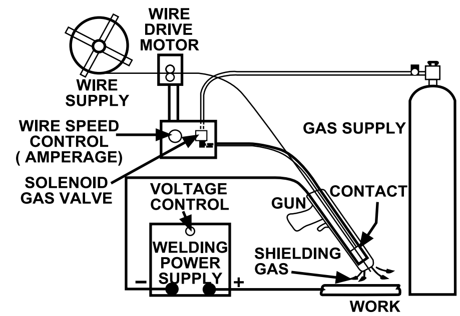


Fig. 15

The Gas Metal-Arc (MIG) Process produces weld metal by fusion in arc between the end of a constinously fed 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 for hard-surfacing is usually argon or helium, or a mixture of the two. Some hard-surfacing flux-cored wires do not require separate shielding gas. For hard-surfacing, this process can be fully automatic where the gun travels on a mechanized carriage or as more frequently the case, semi-automatic where the gun is manualy controlled. (*see Fig. 15*)

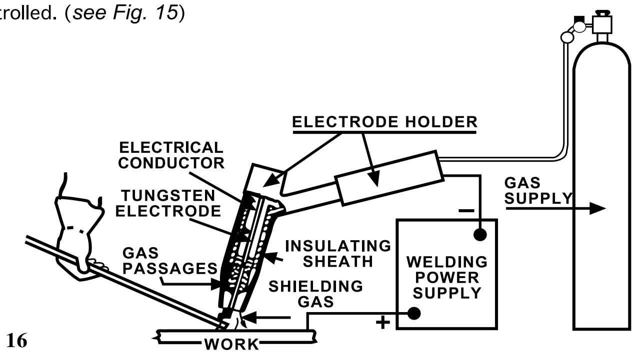
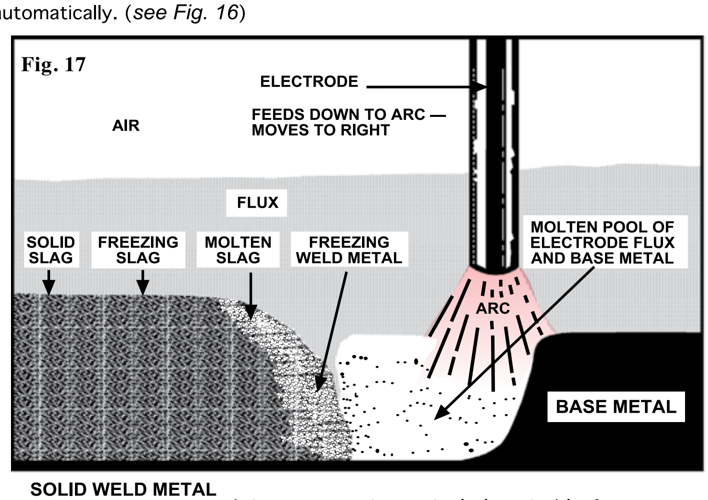


Fig. 16

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 tungsten. The filler metal is separately fed to the arc which is shielded by argon, helium or a mixture of two. In hard-surfacing, this process can be used either manually or automatically. (*see Fig. 16*)

Fig. 17



The Submerged Arc process is particularly suitable for automatic application because it permits continuous feeding of the filler wire and at relatively high currents. In this process the arc is completely shielded by a layer of loose granules of flux as the diagram shows.

The use of composite wires allows the application of highly alloyed metals in the submerged-arc process. In these metal-cored wires, the main alloy is in the sheath, with all other alloys contained in the core. A special flux particularly suitable for hardsurfacing shields the arc from contamination from the air during deposition and provides alloying ingredients to produce the desired deposits composition. (see Fig. 17)

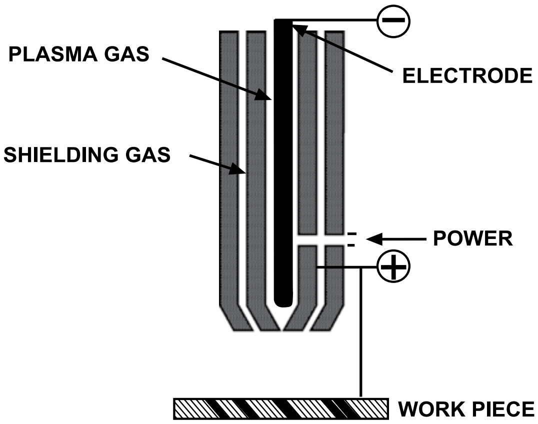
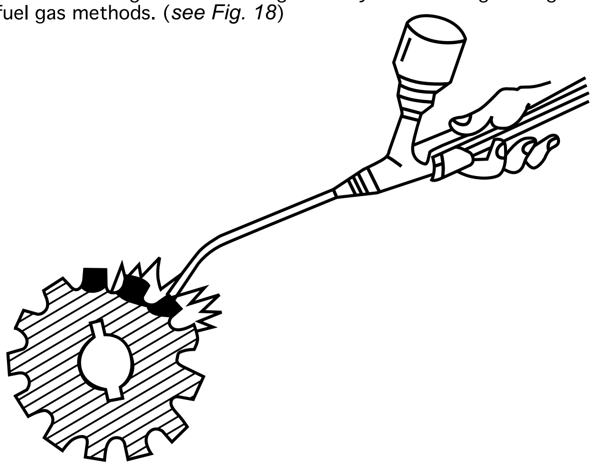


Fig. 18

Plasma-Arc weld surfacing is a true welding process (not a metal spray or coating process). To accomplish this, one employs the transferred plasma arc process shown. It is particularly suitable for highly alloyed hardsurfacing. The deposit is formed from powdered alloys which are conveyed into the arc by the gas stream. Plasma arc weld surfacing fits especially well into mechanized production applications requiring thin weld overlays, but heavy deposits can also be made at relatively fast speeds. It has high deposition rates, along with smooth deposits that reduce material usage and require less finishing. Its cost are significantly lower than gas tungsten arc and oxy-fuel gas methods. (*see Fig. 18*)



Metal Spray or Coating weld surfacing is spraying highly alloyed hardsurfacing powders with the use of a metal spray gun together with oxy-fuel gas welding. The heat of the gas melts the powders as it is sprayed on the surface forming a coating on the surface. Metal spray welding fits well into production applications requiring thin weld overlays. This process can apply difficult diffusing or non-diffusing materials to surfacing parts parts where other processes can not applied.

General Hardsurfacing Materials

Generally speaking, hardsurfacing electrodes and rods can be divided into four basic categories:

- Metal Base.
- Iron Base.
  Iron based materials are lowest in cost and provide excellent resistance to abrasion and impact.
- Nickel Base.
  Nickel based materials are more expensive and should be used where combinations of wear factors such as abrasion or impact is combined with heat, corrosion, friction or erosion.
- Cobalt Base.
  Cobalt based materials are also very expensive and should be used where combinations of wear factors such as abrasion or impact is combined with heat, corrosion, friction, impact or erosion.
- Tungsten Carbide.
  Tungsten Carbides are one of the hardest known man made materials and should be considered only when abrasion is present in its severest form.

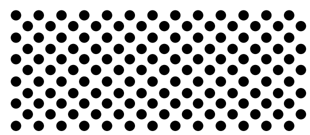
Ten Points to Consider Before Hardsurfacing

1. It is advisable to remove all worn, cracked and fatigued metal on worn parts before welding.
2. For a part that has been badly worn requiring multiple passes of weld metal to restore it to its original size, select a strong, rigid build-up alloy such as NHF-30CR, NHF-260, or N-HNiMn to provide a strong base for the final hard overlay.
3. Where two parts to be hardfaced come in contact with each other, it is recommended that two different alloys be used with approximately a 10-point difference in Rockwell hardness, or two different metal base alloys can also be used.
4. Austenitic manganese (11% to 14% manganese content) is subjected to hot-cracking at temperature over 500F and must be kept below this temperature.Manganese steel, with a manganese content of between 5% and 9%, is unstable alloy, and is highly prone to cracking. Therefore; when welding low alloy abrasion resistant wear strips to manganese parts, do not use a standard 11% to 14% manganese electrode. Dilution of the weld metal into the wear strips can reduce the manganese content to between 5% to 9% in the weld deposit. N-HMn containing 22% manganese will not dilute below an 11% manganese content and will provide a perfect solution to this problem.
5. From the chart shown below, test various hardfacing patterns to determine which can be more readily applied, and will be longest wearing, for each specific application.

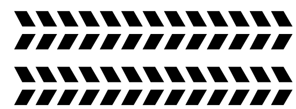
Hardfacing Patterns

Wear conditions on different parts, may vary considerably depending on the causes of wear.

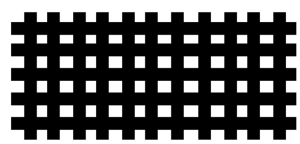
Prolonged wear life plus speed and economy can often be obtained by using one or more of the following hardfacing patterns on large parts.



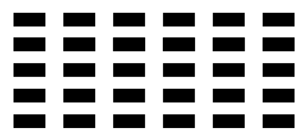
1 - DOT



2 - HERRINGBONE



3-CRISS-CROSS



4 - DASHES

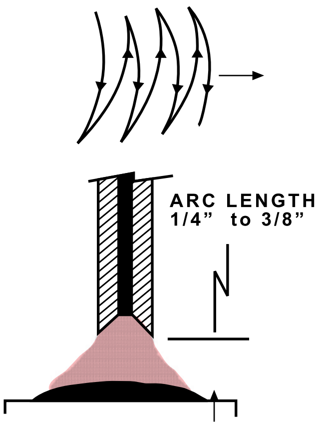
5 - STRIPES

6 - “X”

6. In depositing weld metal, apply each bead so that its edge tapers into the base metal surface. It should not be rounded due to insufficient current, and there should be no undercutting on each side of the bead due to the current being set top high.
7. When the width of the deposit required is greater than that possible with a single bead, the second bead should overlap the first by about one-third.
8. Where sound porosity-free welds are required, the first bead must be thoroughly clean by chipping and brushing to remove all scale and slag residue
9. When a second layer of hardfacing is to be applied to the inner base the thickness of the deposit, each of the beads in the second layer should cover the line of fusion between the two underlying beads. Again, the beads in the second layer should overlap each other by one-third in the same manner as the beads in the first layer are applied. Thorough cleaning is required if deposits are to be sound and porosity-free.
10. While rapid cooling of hardfacing deposits will, in many instances increase the deposit hardness, stress relief check cracking may occur. This will not affect the wear resistance or soundness of the weld deposit in many applications, but where such check relief cracks are undesirable, it is advisable to retard the cooling after welding. This can be done by cooling slowly in still air or by covering the part with an asbestos blanket, or burying it in some insulating material such as mica or dry lime.

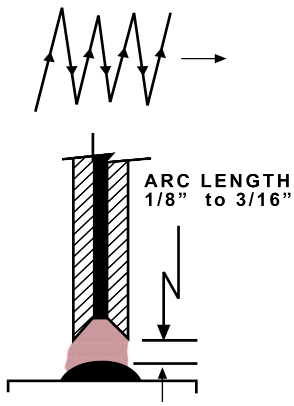
Recommended Techniques for Hardsurfacing by Arc Welding

CRESCENT WEAVE TECHNIQUE



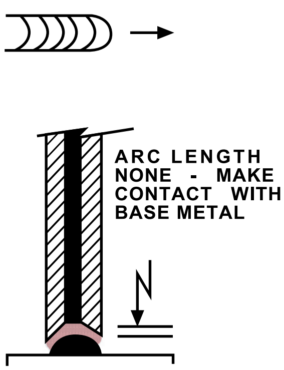
WIDE THIN OVERLAYS

OSCILLATING ZIG-ZAG WEAVE TECHNIQUE



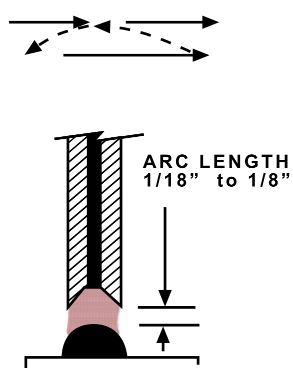
MED. WIDE -MED. THICK OVERLAYS

CONTACT OR DRAG TECHNIQUE



VERY NARROW MED THICK OVERLAYS

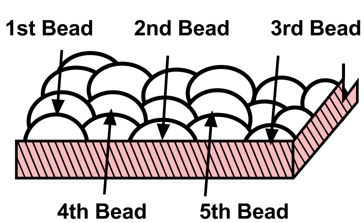
BACK AND FORTH TECHNIQUE



NARROW-VERY THICK OVERLAYS

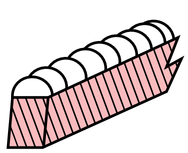
LARGE AREAS

Use oscillating zig-zag weave technique.
A/C or D/C Reverse Polarity.
Sikip weld as illustrated.



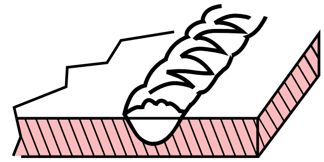
NARROW ENDS

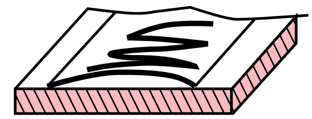
Use contact or drag technique.
A/C or D/C Reverse Polarity.



DEEP GROOVES

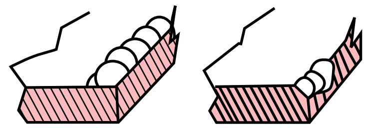
Use back and forth weave technique.
A/C or D/C Reverse Polarity.





EDGES and CORNERS

Use contact or drag technique.
A/C or D/C Reverse Polarity.



THIN METAL

Use crescent weave technique.
A/C or D/C Straight Polarity.

Hardsurfacing Welding Problems and Solution

Problems/Solutions.

Hardsurfacing demands that certain rules be observed in order to assure success. There are some common hardfacing problems which could result in poor performance or possible part failure. Some of the more serious problems are:

— Cracking
— Hard zone adjustment to weld
— Spalling
— Excessive distortion or warping
— Hardness variations
— Excessive porosity

Preheating.

On carbon steel base metal, preheating can be beneficial because it reduces the tendency to develop cracks, hard zones adjacent to welds, shrinkage stresses and distortion. The mechanics by which this is accomplished is basically the reduction of a high thermal gradient which reduces the cooling rate. Preheating should not be employed when hardfacing austenitic manganese steels.

Preheating prior to welding will:

— Eliminates the danger of crack formation.
— Reduces Hard Zones adjacent to weld.
— Reduces Distortion.
— Reduces or prevent Shrinkage Stresses.
— Enhances Dillusion of Hydrogen from steel.

The need for preheating increases as the following factors are changed:

— The larger the mass being welded.
— The lower the temperature of the pieces being welded.
— The lower atmospheric temperature.
— The smaller the weld rod in diameter.
— The greater the speed of welding.
— The higher carbon content of the steel.
— The higher the Manganese content in plain-carbon or low-alloy steels.

This does not apply to austenitic manganese steels.

— The greater alloy content in air hardening steels.
— The more air hardening capacity of the steel.
— The greater the difference in mass between the two pieces being joined.
— The more complicated the shape or section of the parts.
— The greater residual stresses resulting from hard surfacing

It is easy to determine preheating once the base metal is known. The Metal Pre-heating Chart 1 shows recommended preheat temperatures for hardfacing variety of base metal. In case when it difficult to know the type of steel to be welded, estimating the preheating temperature is possible basing on the hardness of the weld deposit required. Metals Pre-heating Chart 2 shows recommended preheating and postheating temperatures based on the maximum hardness of weld deposit required. Temperature of weld piece is usually measured by the use of temperature sticks like Tempil sticks or Thermomelt stick. However if temperature sticks are not available, temperature can be approximately measured from Heat color chart of Heated Steels.

Heat Color Chart of Heated Steels.

400 F pale straw	1050 F—blood red	1725 F—orange	
475 F deep straw	1175 F—dark cherry	1825 F—yellow	
520 F bronze	1325 F—cherry	1975 F—light yellow	
590 F full blue	1450 F—light cherry	2200 F—white	
640 F light blue	1550 F—dark salmon		
990 F black red	1650 F—salmon		

Metal Preheating Chart 1

METAL GROUP	METAL DESIGNATION	APPROXIMATE COMPOSITION - PERCENT C.	Mn.	Si	Cr.	Ni.	Mo.	Cu.		RECOM-MENDED PREHEAT	USE TEMPILSTIK* TEMPERATURE INDICATING CRAYONS
PLAIN CARBON STEELS	PLAIN CARBON STEEL	BELOW .20								UP TO 150° F	150
	PLAIN CARBON STEEL	.20-.30								150° F-300° F	150-200-250-300
	PLAIN CARBON STEEL	.30-.45								250° F-450° F	250-300-350-400-450
	PLAIN CARBON STEEL	.45-.80								450° F-750° F	450-500-600-700-750
CARBON MOLY STEELS	CARBON MOLY STEEL	.10-.20					.50			150° F-250° F	150-200-250
	CARBON MOLY STEEL	.20-.30					.50			200° F-400° F	200-250-300-350-400
MANGANESE STEELS	SILICON STRUCTURAL STEEL	.35	.80	.25						300° F-500° F	300-400-500
	MEDIUM MASNGANESE STEEL	.20-.25	1.0-1.75							300° F-500° F	300-400-500
	SAE 13330 STEEL	.30	1.75							400° F-600° F	400-500-600
	SAE 1340 STEEL	.40	1.75							500° F-800° F	500-600-700-800
	SAE 1045 STEEL	.50	1.75							600° F-900° F	600-700-800-900
	12% MANGANESE STEEL	1.25	12.0							USSUALLY NOT REQUIRED	
HIGH TENSILE STEELS	MANGANESE MOLY STEEL	.20	1.65	.20			.35			300° F-500° F	300-400-500
	JALTEN STEEL	.35 MAX	1.50	.30				.40		400° F-600° F	400-500-600
	MANTEN STEEL	.30 MAX	1.35	.30				.20		400° F-600° F	400-500-600
	ARMCO HIGH TENSILE STEEL	.12 MAX				.50 MIN	.05 MIN	..35 MIN		UP TO-200° F	200
	DOUBLE STRENGTH #1 STEEL	.12 MAX	.75			.50-1.25	.10 MIN	.50-1.50		300° F-600° F	300-400-500-600
	DOUBLE STRENGTH #1A STEEL	.30 MAX	.75			.50-1.25	.10 MIN	.50-1.50		400° F-700° F	400-500-600-700
	MAYARI R STEEL	.12 MAX	.75	.35	.2-1.0	.25-.75		.60		UP TO-300° F	200-300
	OTISCOLY STEEL	.12 MAX	1.25	.10MAX	.10 MAX			.50 MAX		200° F-400° F	200-300-400
	NAX HIGH TENSILE STEEL	.15-.25		.75	.60	.17	.15 MAX	.25 MAX	Zr. 12	UP TO-300° F	200-300
	CROMANSIL STEEL	.14 MAX	1.25	.75	.50					300° F-400° F	300-400
	A.W. DYN-EL STEEL	.11-.14						.40		UP TO-300° F	200-300
	CORTEN STEEL	.12 MAX		.25-1.0	..5-1.5	.55 MAX		.40		200° F-400° F	200-300-400
	CHROME COPPER NICKEL STEEL	.12 MAX	.75		.75	.75		.55		200° F-400° F	200-300-400
	CHROME MANGANESE STEEL	.40	.90		.40					400° F-600° F	400-500-600
	YOLOY STEEL	.05-.35	.3-1.0			1.75		1.0		200° F-600° F	200-300-400-500-600
	HI- STEEL	.12 MAX	.6	.3 MAX		.55		.9-1.25		200° F-500° F	200-300-400-500
NICKEL STEELS	21/4% NICKEL STEEL	.25				2.25				200° F-400° F	200-300-400
	31/2% NICKEL STEEL	.23				3.50				200° F-400° F	200-250-300-350-400
MOLY BEARING CHROMIUM AND NICKEL STEELS	SAE 4140 STEEL	.40			.90		.20			600° F-800° F	600-700-800
	SAE 4340 STEEL	.40			.80	1.85	.25			700° F-900° F	700-800-900
	SAE 4615 STEELL	.15				1.80	.25			400° F-600° F	400-500-600
	SAE 4820 STEEL	.20				3.50	.25			600° F-800° F	600-700-800
LOW CHROME MOLY-STEELS	11/4% Cr.-1/2% Mo.STEEL	.17 MAX			1.25		.50			250° F-400° F	250-300-350-400
	21/4% Cr.-1% Mo.STEEL	.15 MAX			2.25		1.0			300° F-500° F	300-400-500
MEDIUM CHROME MOLY STEEL	5% Cr.-1/2% Mo.STEEL	.15 MAX			5.0		.5			400° F-600° F	400-500-600
	7% Cr.-1/2% Mo.STEEL	.15 MAX			7.0		.5			400° F-600° F	400-500-600
	9% Cr.-1% Mo.STEEL	.15 MAX			9.0		.1.0			400° F-600° F	400-500-600
PLAIN HIGH CHROMIUM STEELS	11 1/2-13% Cr.TYPE 410	.15 MAX			12.0					400° F-600° F	400-500-600
	16-18% Cr.TYPE 430	.12 MAX			17.0					300° F-500° F	300-400-500
	23-27% Cr.TYPE 446	.20 MAX			25.0					300° F-500° F	300-400-500
CHROME NICKEL STAINLESS STEELS	18% Cr. 8% Ni TYPE 304	.07			18.0	8.0				USSUALLY DO NOT REQUIRE PREHEAT BUT IT MAY BE DESIRABLE TO REMOVE CHILL	200
	25-12 TYPE 309	.07			25.0	12.0					
	25-20 TYPE 310	.10			25.0	20.0					
	18-8 Cb.TYPE 347	.07			18.0	8.0			Cb.10XC		
	18-8 Mo.TYPE 316	.07			18.0	8.0	2.5				
	18-8 Mo.TYPE 317	.07			18.0	8.0	3.5				
IRONS	CAST IRON									700° F-900° F	700-800-900
	Ni. RESIST									500° F-1000° F	500-700-900-1000
NON FERROUS	NICKEL. MONEL, INCONEL							Preheat not ussually required for thin section. 300° F-400° F preheat may be desirable for thick section.			
	ALUMINUM-COPPER										

Porosity. Porosity can be prevalent in hardfacing alloys due to pick-up of gases from either the weld rod or while the deposit is molten. As molten metal cools from a liquid to a solid state, there is a large decrease in the solubility of nitrogen. This means the weld deposit must be protected from the air, (as in TIG welding) or it will absorb more nitrogen in the liquid state that it can hold when it solidifies. Therefore, when using the oxy-acetylene process it is mandatory to keep deposits moving so not allow the puddle to remain molten for a longer period of time than necessary.

There is a similar problem with hydrogen although the sources are different. Hydrogen pick-up may come from excessive moisture in the coating on electrodes or from grease, oil, rust or scale on the base metal. Protection against moisture pick-up is achieve during shipment by special packaging and also during storage by keeping the special packaged electrodes in a warm, dry atmosphere at all times.

Porosity can also be caused by the "boiling" effect of the base metal if the hardfacing alloy is not applied properly. Too much heat makes the base metal boil beyond metallurgical bond requirements thus penetrating the weld material and causing porosity.

Metal Preheating Chart 2

Maximum Hardness (Hmax)	Crack Preventive Measures
Below 200	Preheat and postheat are not needed.
200 - 250	Preheat and postheat at about 100°C are desirable, especially when welding heavy plate and high restrained steel or when it is severely cold.
250 - 325	Over 150° C preheat and 650° C stress relieving are necessary.
Over 325	Over 250° C preheat and 650° C stress relieving immediately after welding are necessary.

Hardness Conversion Table

Vickers Hardness Hv	Brinell Hardness 10m Ball 3000kg Load		Rockwell Hardness		Shore Hardness (Hs)	Tensile Strength (kg/mm) (approx.)
	Standard Ball	Tungsten carbide Ball	B scale (HRB)	C scale (HRC)		
940	-	-	-	68.0	97	-
920	-	-	-	67.5	96	-
900	-	767	-	67.0	95	-
880	-	757	-	66.4	93	-
860	-	757	-	65.9	92	-
840	-	745	-	65.3	91	-
820	-	733	-	64.7	90	-
800	-	722	-	64.0	88	-
780	710	710	-	63.5	87	-
760	-	698	-	62.6	86	-
740	-	684	-	61.8	84	-
720	-	670	-	61.0	83	-
700	-	656	-	60.1	81	-
690	-	647	-	59.7	-	-
680	-	638	-	59.2	80	-
470	-	630	-	58.8	-	227
660	-	620	-	58.3	79	224
650	-	611	-	57.8	-	220
640	-	601	-	57.3	77	217
630	-	591	-	56.8	-	213
620	-	582	-	56.3	75	210
610	-	573	-	55.7	-	206
600	-	564	-	55.2	74	203
590	-	554	-	54.7	-	199
580	-	545	-	54.1	72	196
570	-	535	-	53.6	-	192
560	-	525	-	53.0	71	189
550	505	517	-	52.3	-	185
540	496	507	-	51.7	69	182
530	488	497	-	51.1	-	178
520	480	488	-	50.5	67	175
510	473	479	- -	49.8	-	171
500	465	471	-	49.1	66	168
490	456	460	-	48.4	-	164
480	448	452	-	47.7	64	161
470	441	442	-	46.9	-	157
460	433	433	-	46.1	62	154
450	425	425	-	45.3	-	150
440	415	415	-	44.5	59	147
430	405	405	-	43.6	-	143
420	397	397	-	42.7	57	140
410	388	388	-	41.8	-	137
400	379	379	-	41.8	55	133
390	369	369	-	40.8	-	130
380	360	360	(110.0)	38.8	52	126
370	350	350	-	37.7	-	123
360	341	341	(109.0)	36.5	50	119
350	331	331	-	35.5	-	116
340	322	322	(108.0)	34.4	47	113
330	313	313	-	33.3	-	109
320	303	303	(107.0)	32.2	45	106
310	294	294	-	31.0	-	102
300	284	284	(105.5)	29.8	42	99
295	280	284	-	29.2	-	97.8
290	275	275	(104.5)	28.5	41	95.2
285	270	270	-	27.8	-	94.1
280	265	266	(103.5)	27.1	40	92.0
275	261	261	-	26.4	-	90.6
270	256	256	(102.0)	25.6	38	88.6
265	252	252	-	24.8	-	87.2
260	247	248	(101.0)	24.0	37	85.1

Vickers Hardness (Hv)	Brinell Hardness 10m Ball 3000 kg. load		Rockwell Hardness		Shore Hardness (Hs)	Tensile Strength (kg/mm2) (approx.)
	Standard Ball	Tungsten carbide Ball	B scale (HRB)	C scale (HRC)		
255	243	243	-	23.1	-	83.6
250	238	238	99.5	22.2	36	81.0
245	233	233	-	21.3	-	80.1
240	228	228	98.1	20.3	34	78.0
230	219	219	96.7	(18.0)	33	74.5
220	209	209	95.0	(15.7)	32	71.0
210	200	200	93.6	(113.4)	30	68.2
200	190	190	91.5	(11.0)	29	64.7
190	181	181	89.5	(8.5)	28	61.8
180	171	171	87.1	(6.0)	26	59.0
170	162	162	85.0	(3.0)	25	55.5
160	152	152	81.7	(0.0)	24	52.7
150	143	143	78.7	-	22	49.9
140	133	133	75.0	-	21	46.4
140	133	133	75.0	-	20	43.6
130	124	124	71.2		-	43.6
120	114	114	66.7			
110	105	105	62.3			
105	95	95	56.2			
95	90	90	52.0			
90	86	86	48.0			
85	81	81	41.0			

Temperature Conversion Table

˚F	˚C	˚F	˚C	˚F	˚C	˚F	˚C	˚F	˚C
-400	-240	20	-6.7	120	48.9	220	104.4	940	504.4
-390	-234	22	-5.6	122	50.0	230	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	260	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	56.7	290	143.3	1080	582
-320	-196	36	2.2	136	57.8	300	148.9	1100	593
-310	-190	38	3.3	138	58.9	310	154.4	1200	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	71.1	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	74	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	28.8	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	96.7	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	1860	1016
14	-10.0	114	45.4	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

$˚F = \frac{9}{5}˚C + 32$ $˚C [\frac{9}{5} (˚F - 32)$

If electrodes have been exposed to moisture pick-up, the following is suggested:
— Rebake materials for coated electrodes at temperature of 150 to 200 C\for 30 to 60 minutes before use.
— For automatic wire an increase in "stick - out" to provide automatic pre-heat of the wire maybe adequate to solve the problem.

Base Metals. The choice of base metals for hardfaced parts is often dictated by structural design or forming considerations. Weldability of such materials must be considered on an individual basis. However there are many cases where the overlay properties are of chief concern, and there is considerable latitude in base metal selection.

For most applications, carbon steel is a good selection for the base metal low and medium alloy steels can be hardfaced by all welding processes with excellent results.

Build-Up. Due to excessive wear, erosion or corrosion, build-up prior to hardfacing is desirable when more than two layers of overlays are required to restore original size. The build-up of these excessive wear areas should be done with stainless, high-nickel or low-alloy filler metals. This is necessary because of the tendency toward cracking of hardfacing alloys when applied in thickness greater than two or, at the most, three layers. This build-up with regular weld filler metal is then hardfaced with the appropriates alloy for the service. The selection of the build-up filler metal, while often not critical, is important as it provides the foudation on which the hardsurface is applied.

Cracks. In hardfacing deposits, cracks can result not only from insufficient preheat, but also from improper postweld treatment with resultant spalling and hardzones adjacent to the weld. Slow uniform cooling is usually beneficial.

Other causes for cracking include:

—Poor base metal preparation - remove all oil, grease, rust scale, Laminations, cracks or other defects.

— Base metal flaws that are not detected - for critical applications magnaflux or ultrasonic tests should be made.

— Excessive moisture - this can come about through wet or damp flux or coated electrodes exposed to humid conditions.

— Overlay too thick - usually the maximum hardfacing thickness recommended is 1/4 inch or 2 to 3 layers total.

— Improper bead sequence.

— Improper part preparation.

Excessive Distortion. In addition to preheating, peening each bead during build-up prior to overlay will help minimize distortion by relieving locked-up stresses. Bead sequence is another means of controlling distortion.

Hardness Variations. Lack of uniformity in weld deposit composition is usually the principal cause of hardness variation. This is generally due to variations in base metal dilution.

Variation in hardness due to base metal dilution is more pronounced in the first two layers. Variation in base metal dilution is due to:

— Change in travel speed. Fast stringer beads will have a higher ratio of base metal to weld metal while thick beads will have a higher ratio of weld metal to base metal.

— Variations in the degree of bead overlap will change the ratio of weld metal to base metal and result in changes in chemistry.

— Change in current. The higher the current (with the travel speed being held constant), the higher the ratio of base metal to weld metal. Change in voltage.The recovery of certain elements is affected by the arc length especially in manual electrodes. Oxidizable elements such as carbon, silicon, and chromium, may be lost. In submerged arc a greater amount of silicon, for example, may be recovered from the flux when the voltage is too high.

— Another cause of hardness variation is the thermal cycle to which the weld deposit is exposed-i.e, preheat temperature, post heat temperature, times and amount of heat applied during welding.

Impact Value Conversion Table

(Ft • 1bs- kg • m)

ft •1bs	0	1	2	3	4	5	6	7	8	9	ft •1bs
ft •1bs	kg • m	kg • m	kg • m	kg • m	kg • m	kg • m	kg • m	kg • m	kg • m	kg • m	
0	0.000	0.138	0.277	0.415	0.553	0.691	0.830	0.968	1.106	1.244	0
10	1.383	1.521	1.659	1.797	1.936	2.074	2.212	2.350	2.489	2.627	10
20	2.765	2.903	3.042	3.180	3.318	3.456	3.595	3.733	3.871	4.009	20
30	4.148	4.286	4.424	4.562	4.701	4.839	4.977	5.116	5.254	5.392	30
40	5.530	5.669	5.807	5.945	6.083	6.222	6.360	6.498	6.636	6.775	40
50	6.913	7.051	7.189	7.328	7.466	7.604	7.742	7.881	8.019	8.157	50
60	8.295	8.434	8.572	8.710	8.848	8.987	9.125	9.263	9.401	9.540	60
70	9.678	9.816	9.955	10.093	10.231	10.369	10.508	10.646	10.784	10.922	70
80	11.061	11.199	11.337	11.475	11.614	11.752	11.890	12.028	12.167	12.305	80
90	12.443	12.581	12.720	12.858	12.996	13.134	13.273	13.411	13.549	13.687	90
100	13.826	13.964	14.102	14.240	14.379	14.517	14.655	14.794	14.932	15.070	100
110	15.208	15.347	15.485	15.623	15.761	15.900	16.038	16.176	16.314	16.453	110
120	16.591	16.729	16.867	17.006	17.144	17.282	17.420	17.559	17.697	17.835	120

ft •1bs = 0.13825728 kg• m

Stress Conversion Table

1bs/in²	0.000	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000
0,000	0.000	0.703	1.406	2.109	2.812	3.515	4.218	4.291	5.625	6.328
10,000	7.031	7.734	8.437	9.140	9.843	10.546	11.249	11.952	12.655	13.358
20,000	14.061	14.764	15.468	16.171	16.874	17.577	18.280	18.983	19.686	20.389
30,000	21.092	21.795	22.498	23.201	23.904	24.607	25.311	26.014	26.717	27.420
40,000	28.123	28.826	29.529	30.232	30.935	31.638	32.341	33.044	33.747	34.450
50,000	35.154	35.857	36.560	37.263	37.966	38.669	39.372	40.075	40.778	41.481
60,000	42.184	42.887	43.590	44.293	44.996	45.700	46.403	47.106	47.809	48.512
70,000	49.215	49.918	50.621	51.324	52.027	52.730	53.433	54.136	54.839	55.543
80,000	63.276	63.979	64.682	65.386	66.089	66.792	67.495	68.198	68.901	69.604
90,000	63.276	63.979	64.682	65.386	66.089	66.792	67.495	68.198	68.901	69.604
100,000	70.307	71.010	71.713	72.416	73.119	73.822	74.525	75.228	75.932	76.635
110,000	77.338	78.041	78.744	79.447	80.150	80.853	81.556	82.259	82.962	83.665
120,000	84.368	85.071	85.774	86.478	87.181	87.884	88.587	89.290	89.993	90.696
130,000	91.399	92.102	92.805	93.508	94.211	94.914	95.618	96.321	97.024	97.727
140,000	98.430	99.133	99.836	100.539	101.242	101.945	102.648	103.351	104.054	104.757
150,000	105.460	106.164	106.867	107.570	108.273	108.976	109.679	110.382	111.085	111.788
160,000	112.491	113.194	113.897	114.600	115.303	116.007	116.710	117.413	118.116	118.819
170,000	119.522	120.225	120.928	121.631	122.334	123.037	123.740	124.443	125.146	125.850
180,000	126.553	127.256	127.959	128.662	129.365	130.771	131.474	132.177	132.88	132.880
190,000	133.583	134.286	134.989	135.693	136.396	137.099	137.802	138.505	139.208	139.911
200,000	140.614	141.317	142.020	142.723	143.426	144.426	144.129	144.832	145.535	146.942
210,000	147.645	148.348	149.051	149.754	150.457	151.160	151.863	152.566	153.269	153.972
220,000	154.675	155.378	156.082	156.785	157.488	158.191	158.894	159.597	160.300	161.003
230,000	161.706	162.409	163.112	163.815	164.518	165.221	165.925	166.628	167.331	168.034
240,000	168.737	169.440	170.143	170.846	171.549	172.252	172.955	173.658	174.361	175.064
250,000	175.768	176.471	177.174	177.877	178.580	179.283	179.986	180.689	181.932	182.095

1 bs/in²	100	200	300	400	500	600	700	800	900
kg/mm²	0.0703	0.1406	0.2106	0.3515	0.2812	0.4218	0.4921	0.5625	0.6328

1 1bs/in² = 0.000703070 kg/mm²

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	9.9212	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

(Ft • 1bs- kg • m)

Glossary of Welding Terms

Abrasion - the wearing away of a surface by repeated friction with a harder substance.

Air Hardening Steel - a steel containing sufficient carbon and other alloying elements to harden fully during cooling in air or other gaseous mediums from a temperature above its transformation range.

Alloy Steel - steel containing significant quantities of alloying elements (other than carbon and the commonly accepted amounts of manganese, silicon sulfur, and phosphorus) added to effect changes in the mechanical and physical properties.

Annealing - healing to and holding at a suitable rate, for such purposes as reducing hardness improving machineability, facilitating cold working, producing a desired microstructure or obtaining desired mechanical, physical or other properties.

Arc Blow - magnetic disturbance of the arc (when welding wiyh Dc current) which causes it to waver from its intended paths.

Arc Length - the distance from the tip of the core wire or rod to the point where the arc makes contact with the work surface.

Austenitic Steel- an alloy steel which structure is normally austenitic at room temperature.

Austenitizing - forming austenitic by heating a ferrous alloy into the transformation range (complete austenizing).

Benite - a decompositon product of austenitic consisting of an aggregate of ferrite and carbide.

Base or Parent Metal - the metal to be welded or surfaced.

Bead - a layer of weld metal passage of electrodes or rod.

Blow Holes- small and pinlike holes found on the weld metal usually by the trapped gases moisture during welding.

Brazing - joining together of metals of a filler metal with a lower melting point than the base metal. Coalescence is produced by the diffusion of the molten filler metal into the surface of the base metal at a temperature lower than the melting point of the latter(about 450 - 800°C).

Brinell Hardness Test - a test for determining the hardness of a material by forcing a hard steel or carbide ball of specified diameter into it under a specified load.

Brittleness - the quality of the material that leads to crack propogation without appreciable plastic deformation.

Buttering - depositing weld metal on the face of the point to increase weldability.

Carbide - a compound of carbon with one or more metallic elements.

Carbon Steel - steel containing carbon up to 2% and only redual quantities of other elements except those added for de-oxidation, with silicon usually limited to 0.60% and manganese to about 1.65%. Also termed plain carbon steel, ordinarili steel, and straight carbon steel.

Carburizing - introducing carbon into a solid ferrous alloy by holding above the AC, in contact with a suitable carbonaceous material.

Case Hardening - hardening a ferrous alloy so that the outer portion, or case, is made substantially harder than the inner portion, or core.

Charpy Test - a pendulum type single blow impact test in which the specimen, usually notched, is supported at both ends as simple beams and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of the pendulum is a measured of impact strength for notched toughness.

Critical Point - the temperature of pressure at which a change in crystal structure, phase of physical properties occurs, Same as transformation temperature.

Crystal - a solid composed of atoms, ions, or molecules arranged in a pattern which is repitative in three dimensions.

Cold - (or Unbeaded) Cracking- cracking in the base metal just below the fusion zone, associated with the presence of hydrogen in the arc speciaaly in welding high carbon and higher sulfur steels; occurs after weldment has cooled to room temperature. Surface of a cold crack is bright and clean while that of a hot crack is discolored.

Corrosion - wearing away of a material by chemical attack (mainly oxidation).

Deposition Efficiency - the ratio of the weight of the weld deposit to the weight of the core wire consumed, usuaaly expressed in %. Except for iron powder types (and those electrodes with high content of ferro-alloys in the coating). this value is always less than 100 because of the loss of metal by spattering, violation of metal at the arc and reaction with the slag constituents.

Deposition (or melt-down) - Rate the speed of deposition of the filler metal expressed as weigth rod consumed per unit time per ampere.

Dilatometer - an instruments for measuring expansion or contraction in a metal resulting from changes in such as temperature or allotropy.

Dragging - welding in which the electrode coating touches the surface of the base metal and movement is along straight and steady line in one direction.

Elongation in 2"- in tensile strength testing, the percentage increase in length of a 2-inch portion of the test piece at the break point; an indication of the ductility of the metal sample.

Etching - subjecting the surface of the metal to preferential to chemical or electrolytic attack in order to reveal structural details.

Filler Weld - a weld joining two surfaces approximately at right angles to each other.

Galling - developing a condition on the rubbing surface of one or both mating parts where excessive friction between high spots results in localized welding with subsequent spalling and a further roughening of the surface.

Grain - an individual crystal and a polycrystalline metal or alloy.

Hot-Cracking - occurs in a bead during welding (at above 850°C)usually located in the last to-freeze metal after the arc has passed. Sulfur and Phosphorus are the principal culprits for this type of cracking.

Impact Value - the minimum value, in work or energy units/unit cross-section, of the energy required to break a nickel sample by a sharp blow under specified conditions of temperature, speed of force, size and shape of the nick and specimen. The Charpy-V-notch value is given in ft., lbs., the cross-section of the specimen being 0.8 cm. x 0.8 cm. and the speed of force 5 meters per second. This value is the measure of the brittleness or toughness of the sample.

Interface - a surface which forms the boundary between phases or systems.

Interpass Temperature - in a multi-pass weld, the lowest temperature of a pass before the succeeding one is commenced.

Macroscopic - visible at magnifications from 1 to 10 diameters.

Matrix - the principal phase or aggregate in which another constituent is em bedded.

Microstructure - a structure of a polished and etched metal as revealed by a microscope at a magnification greater than ten diameters.

Overlap - protrusion of the weld metal above the base metal beyond the limits of fusion.

Peening - mechanical working of a metal under the blows of a hammer to induce plastic flow and relieve shrinkage stresses by the lateral expansion of metal.

Penetration of Depth of Fusion - the distance from the original surface of the base metal to the point where fusion ceases.

Porosity - the presence of fine pores or pinholes inside the weld due to entrapped gases.

Post-Heating - heat treatment after welding employed for the same reason as pre-heating.

Pre-Heating - heating work piece to specified temperatures before welding to reduce rate of cooling of the weld and decrease shrinkage stresses. Reducing the cooling rate prevents the formation of hardened brittle zones which fracture readily.

Sceleroscope Test - a hardness test where the loss in kinetic energy of a falling metal absorbed by the indentation upon impact on the metal being tested, is indicated by the height of rebound.Also called Shore Hardness Test.

Slag - the non-metallic or mineral constituents of the coating which have melted and fused at the temperatured of the arc and solidified over the weld bead.

Slag Inclusion - portions of the slag entrapped wuth in the weld metal usually caused by too low current, too short arc or insufficient puddling time.

Soldering - brazing at temperatures less than 450°C.

Spalling - the cracking and flaking of particles out of a surface.

Spatter - the metal particles expelled during welding which do not form part of the bead.

Tack Weld - a generally short weld made to hold parts of a weldment in place until final weld are made. Used for assembly purpose only.

Tempering - pre-heating a quench-hardened or normalized ferrous alloy to a temperature below the transformation range and then cooling at a rate desired.

Tensile Strength - (T.S.)- the maximum forces/unit cross-section attained when specimen is pulled till break point.

Transformation Temperature - the temperature at which a change in phase occurs.

Undercut - grooved melted into the base metal along side or sides

Weaving - welding technique in which electrode is made to oscillate from side to side.

Welding - joining of metals involving melying and fusion of the surfaces to be joined with or without a filler metal.

Weld Deposit - metal coming from the filler rod or electrode.

Weld Metal - the weld deposit plus the portion of the base metal fused with in.

Whipping - welding technique in which electrode is made to oscillate in the direction of travel.

Work Hardening - an increase in hardness and strength caused by plastic deformation and temperature lower than the recrystallization range. Also called Strain Hardening.

X-Ray Quality - when X-ray pictures of weld passes comparison with accepted standards with respect to comparison to porosity and / or other defects.

Yielded Point - (Y.P.)- the minimum force/unit cross-section required to bring about permanent deformation

Applications of Nihonweld Welding Products

AGRICULTURE

APPLICATIONS:	WELDING RODS	WIRES
Ammonia injector feet	NHF 700	
Bean knives	NHF 600	
Beet plows	NHF 700	
Brush shredder teeth	NHF 700	
Cane carding drums	NHF 700	
Cane cutter bars	NHNimn	
Cane drums finger	NHF 700	
Cane exhauster discs	NHF 600	
Cane knives	NHF 600	
Cane pison rolls	NHMn	
Cane planter	NHF 700	
Cane rake tines	NHMn	
Chain saw bars	NHFST6	
Chisel points	NHF 700	
Clearing rakes & blades	NHF 600	
Convey or fans	NHF 950	
Corn picker rolls	NHF 600	
Corn planter runners	NHF 600	
Cultivator shovels	NHF 950	
Cultivator sweeps	NHF 600	
Disc blades	NHF 950	
Grain hammers	NHF 600	
Horseshoes	NHF 950	
Krajuski cane rolls	NHCrMn	
Lister shares	NHF 600	
Mower shoes	NHF 700	
Nitrogen feet	NHF 700	
Plow shares & teeth	NHF 600	
Root cutter	NHF 700	
Shredding knives	NHF 600	
Spike tooth harrow	NHF 950	
Terracer discs	NHF 950	
Tresher cylinder teeth	NHF 600	
Tractor grouser bars	NHF 450	NSF45
Tractor rails	NHF 450	NSF45
Tractor rools, Idlers, Sprockets	NHF 450	NSF45

ALUMINUM, IRON & STEEL

APPLICATIONS:	WELDING RODS	WIRES
Agitator fingers	NHF 700	
Barrels for Wire Coller	NHF 600	
Charging Machine Rams	NHF 700	
Clamshell bucket	NHF 600	
Coke carbonscrapers (if to be forged)	NHF 600	
Coke pusher shoes	NHF 600	
Convey or gudgeons	NHF 600	
Core board arms	NHF 700	
Cutting edges blades	NHF 800	
Driving spindle wobblers	NHF 500	NSF45
Edging rolls	NHFST6	
Exhaust fan	NHF 950	
Extrusion rolls	NHFST1	
Forming rolls	NHFST6	
Furnace scrapers	NHMn	
Gagmills	NHMiMn	
Crizzly bars	NHF 700	
Hot steel handling equipment	NHFST6	
Hot shear knives	NHF 950	
Hot trimming dies	NHFST6	
Ladle trunnions	NHF 950	
Magnetic roll shaft	NHF 800	
Melting pot bars	NHFST6	
Mill guides	NHF 800	
Milling machines sprockets	NHF 300	NSF25
Mud augers, Blast furnace	NHF 950	
Mud guns, Electric rotary	NHF 950	
Mud mill paddlers	NHF 950	
Narrow gage R.R. track	NHNiMn	
Piercing mill handlers	NHFST6	
Piercing mill shoes	NHFST6	
Pinch rolls	NHF 600	
Pad on rolls-spindle grabs	NHF 600	
Pug mill paddles	NHF 700	
Pump sleeves	NHF 950	
Rail mill side guides	NHF 800	
Roll ends	NHF 300	NSF25
Rolling mill guides	NHF 800	
Roll wobblers	NHF 600	
Sand revivifier paddles	NHF 700	
Sand sliper tips	NHF 700	
Screw conveyors	NHF 950	
Sheet aluminum guides	NHFST6	
Stripper bits	NHFST6	
Soaking pit tongs	NHFST1	
Tong bits	NHFST1	
Tube closing tools	NHF 700	

ALUMINUM, IRON & STEEL (con't)

APPLICATIONS:	WELDING RODS	WIRES
Tube mill guides	NHF800	
Tap Hole augers	NHFST1	
Trimming dies	NHF950	
Water cooled pockers	NHF700	
Wearing plates	NHF700	
Wire drawing guides	NHFST6	
Wire guides	NHFST6	
Wire pitch cams	NHF600	
Wire straightening rolls	NHF950	
Wobblers	NHMn	

AUTOMOTIVE INDUSTRY

Bearing sleeves	NHFST1	
Blanking & Shearing dies	NHFST6	
Burnishing broaches	NHFST6	
Bushing	NHFST12	
Cams	NHFST6	
Dies, hot trimming	NHFST6	
Diesel engine rocker arms	NHF800	
Diesel engine valves	NHFST6	
Engine valve seats	NHFST6	
Exhaust valves	NHFST6	
Exhaust valve seats	NHFST6	
Fuel pump shaft	NHFST6	
Hot punches	NHFST6	
Lathe toolpost, tool blocks & Grinder center	NHFST1	
Locating pins & Bosses for jigs & Fixtures	NHFST6	
Machine cams & Trip dogs	NHFST6	
Metal shredder	NHMn	
Rocker arms	NHFST6	
Rotary seals & rings	NHFST1	
Tappets	NHFST6	
Valve discs	NHFST6	
Valve push rods	NHF800	
Valve rings	NHFST6	
Valve stem tips	NHFST6	
Water pumps shaft	NHF800	

BRICK and CLAY INDUSTRY

Arbors	NHF800	
Arbor plates	NHF700	
Brick dies	NHF800	
Brick extrusion dies	NHFST12	
Brick machine augers (Build up)	NHNiMn	
Brick plows	NHF700	
Bucket lips (Build up)	NHNiMn	
Bucket lips (Facing)	NHF700	
Clay feeder shoes	NHF700	
Crusher rolls (Build up)	NHNiMn	
Crusher rolls (Facing)	NHF700	
Crusher teeth (Build Up)	NHNiMn	
Crusher teeth (Facing)	NHF700	
Dipper teeth & lips (Build up)	NHFNiMn	
Dipper teeth & lips (Facing)	NHF700	
Feeder shoes	NHF600	
Mixer blades & Paddles	NHF700	
Muller plows	NHF800	
Muller tires (Build up)	NHFNiMn	
Muller tires (Facing)	NHF700	
Pug mill augers	NHF700	
Pug mill knives	NHF800	
Pug mill push shoes	NHF700	
Pug mill crusher plates	NHF700	
Refractory dies	NHF33CRS	
Screw conveyor	NHF700	
Segments-Dogs & Trips	NHF600	
Shale planer knives	NHF700	
Shredder knives	NHF950	

CEMENT INDUSTRY

Agitator bearings & Shafts	NHF450	
Air rings	NHF950	
Bag packer screw Bailey feeder sprockets	NHF500	NSF45
Barrel liners	NHF700	
Beater blades	NHF700	
Bell packers	NHF600	

CEMENT INDUSTRY (con't)

APPLICATIONS:	WELDING RODS	WIRES
Bucket conveyors	NHF700	
Bucket lips	NHF700	
Bull rings	NHF800	
Cement chutes	NHF700	
Cement drug chain	NHF950	
Cement mixers	NHF700	
Cement pump air rings	NHFST1	
Cement pump barrel liners	NHFST1	
Cement pump screws	NHFST1	
Chain links & Pins	NHF500	NSF45
Clam shell bucket lips (Build up)	NHNiMn	
Clam shell bucket lips (Facing)	NHF700	
Convey or screws	NHF950	
Crusher plates	NHF600	
Crusher plow	NHF600	
Crusher segments	NHF700	
Dipper teeth (Build up)	NHNiMn	
Dipper teeth (Facing)	NHF700	
Dipper dragline clutches	NHMn	
Disintengrator bars	NHF700	
Drag chains	NHNiMn	
Drag chains-Idlers	NHF600	
Drag chain latches & Keepers	NHF500	NSF45
Drag chain links & Pins	NHF500	NSF45
Drag chain rider block	NHF700	
Drag chain sprockets	NHF500	NSF45
Drive shaft bearings	NHF300	NSF25
Drive shaft bushings	NHF300	NSF25
Fan blades	NHF950	
Feeder screens	NHF700	
Feed spouts	NHF700	
Flapper valves (cement pump)	NHFST6	
Fuller-Kenyon pump screws	NHF950	
Grinder rings	NHF700	
Gudgeons	NHF700	
Gyratory crusher mantles (Build up)	NHNiMn	
(Facing)	NHF700	
Hammer mill hammers (Build up)	NHNiMn	
(Facing)	NHF700	
Hot clinker rolls	NHF800	
Kiln trunnions	NHMn	
Latches & keepers	NHF700	
Links	NHF600	
Mixing blades	NHF700	
Muller pandles	NHF950	
Muller plows	NHMn	
Plows	NHF800	
Plow arms	NHF600	
Primary crushes (Build up)	NHNiMn	
Pug mill knives	NHF950	
Pug mill	NHF700	
Pulverized hammers (Build up)	NHNiMn	
Pulverize	NHF700	
Raymond mills	NHF800	
Revolving spouts	NHF600	
Roll crusher teeth (Build up)	NHNiMn	
Roll housing	NHF700	
Seat pump ring	NHFST6	
Six roll mill-Beater blades	NHF700	
Six roll mill-Bull rings	NHF700	
Six roll mill-Hammers	NHF700	
Six roll mill-Plows	NHF700	
Table feed spreaders	NHF700	
Teeth	NHF700	
Three roll mill-Plows	NHF700	
Three roll mill-Plow Arms	NHF700	
Three roll mill-Rolls	NHF700	
Three roll mill-Roll Housing	NHF700	
Tube mills-Feeder Screen	NHF700	
Tube mills-Feeder Screws	NHF950	
Tuyeros	NHFST1	
Valves & valve seats	NHF600	

CONSTRUCTION MATERIAL HANDLING

Asphall mixer paddles (Build up)	NHNiMn	
(Facing)	NHF700	

CONSTRUCTION MATERIAL HANDLING (con't)

APPLICATIONS:	WELDING RODS	WIRES
Augers		
Buckets elevator	NHF700	
Buckets grab	NHF700	
Bucket lips	NHF600	
Bucket teeth	NHF600	
Bucket blades	NHF600	
Bituminous mixer blades	NHF700	
Bulldozer blades	NHF700	
Cage crushers (Build up)	NHNiMn	
Cage crushers (Facing)	NHF700	
Chutes coal	NHF700	
Chutes coke	NHF700	
Concrete mixer blades	NHF700	
Concrete mixer liners	NHF700	
Convey or coal	NHF700	
Convey or flight	NHF700	
Crane wheels	NHF300	
Crushers rolls (Build up)	NHNiMn	
Crushers roll (Facing)	NHF700	
Dipper fonts & lips	NHF700	
Ditcher teeth	NHF700	
Grader end bits	NHMn	
Gravel washer outlets pipes	NHF700	
Grauser	NHMn	
Gyratory crusher mantles	NHF700	
Hand shovels	NHF600	
Hoppers alt	NHF700	
Hoppers tipple	NHF800	
Hoppers ash	NHF700	
Hoppers brewery	NHF700	
Hoppers coal	NHF700	
Paving agitator blades	NHF700	
Paving machine paddles	NHF700	
Pitcher drive sprockets	NHF450	NSF45
Pitcher rolls	NHF450	NS
Pitcher teeth	NHF700	
Post hole diggers	NHF600	
Road grader blades	NHF700	
Road plows	NHF600	
Scrapper cutters slides	NHF700	
Scarifier teeth	NHF700	
Screens (Build up)	NHNiMn	
Screens (Facing)	NHF700	
Self loading scraper blades	NHF700	
Sheepsfoot tampers	NHF700	
Shovel boom sockets	NHF300	NSF25
Shovel carrier rollers	NHF300	NSF25
Shovel crowler pads	NHF300	NSF25
Shovel driving tumblers	NHF300	NSF25
Shovel idler wheels	NHF300	NSF25
Shovel latch bars & keepers	NHF600	
Shovel tooth	NHF700	
Skips coal	NHF600	
Skips mine	NHF600	
Skips guides	NHF600	
Snow plow shoes (Build up)	NHNiMn	
Snow plow shoes (Facing)	NHF700	
Sub grader blades	NHF700	
Tamping bars	NHF600	
Tire chains	NHF600	
Tractors grouses (Build up)	NHF300	NSF25
Tractor idlers	NHF300	NSF25
Tractor rollers	NHF300	NSF25
Tractor sprockets	NHF300	NSF25
Tractor track rails, preheat	NHNiMn	
Trencher teeth	NHF700	
Well drilling bits	NHF600	

EXCAVATING, DREDGING & QUARRYING

Ball points	NHF700	
Bucket bottoms (Build up)	NHNiMn	
Bucket bottoms (Facing)	NHF700	
Bucket lips (Build up)	NHNiMn	
Bucket lips (Facing)	NHF700	
Bucket pins	NHF600	
Chain links & pins	NHNiMn	
Crusher jaws (Build up)	NHNiMn	
Crusher jaws (Facing)	NHF700	
Dipper lips (Build up)	NHNiMn	
Dipper (Facing)	NHF700	
Dipper teeth (Build up)	NHNiMn	
Dipper teeth (Facing)	NHF700	
Ditcher teeth (if to be forged)	NHF600	
Ditcher teeth (Facing)	NHF700	
Dredge bucket points	NHF700	
Dredge fillers	NHF700	
Dredge pump cutters	NHF700	
Dredge pump shells	NHF800	
Dredge speed points	NHF450	NSF45

EXCAVATING, DREDGING & QUARRYING (con't)

APPLICATIONS:	WELDING RODS	WIRES
Dredge speed points	NHF700	
Dredge tublers	NHMn	
End bits	NHMn	
Heel plates (Build up)	NHNiMn	
Heel plates (Facing)	NHF700	
Hitch plates	NHF700	
Impellers	NHCrMn	
Latch bars	NHF600	
Pan head lips	NHF700	
Pipeline elbows	NHF950	
Pipeline valves	NHFST6	
Pipeline wyns	NHF950	
Pins clevis	NHF450	
Pump cases	NHF450	NSF45
Pump motors	NHF950	
Post hole diggers	NHF800	
Ripple bars	NHF700	
Roll crusher teeth (Build up)	NHNiMn	
Roll crusher teeth (Facing)	NHF700	
Rotary bits	NHF950	
Sand bucket lips	NHF700	
Ship rudder & associated gears	NHF700	
Spad clams	NHF700	
Suction dredge cutters	NHF700	
Suction pipe manhole pieces	NHF700	
Teeth, dragline bucket	NHF700	
Underground scraper blades	NHF700	

FOUNDRIES, FURNACES, POWER PLANTS

Ash conveyor links	NHF600	
Blast furnace bells	NHF600	
Blast furnace bell seal area	NHF700	
Blast furnace hopper seat	NHF700	
Blast furnace bell valve seat	NHF800	
Carbon scrapers	NHMn	
Clinker arms for water gas generators	NHF700	
Coal feeder screws	NHF700	
Coke & coke crushers segment	NHF700	
Coke door opener arms	NHF700	
Coke pusher shoes (Build up)	NHF300	NSF25
Coke pusher shoes (Facing)	NHF800	
Conveyor parts	NHF800	
Cyclone mill	NHF800	
Core cutters	NHF800	
Crane contact shoes	NHF800	
Drop forge dies	NHF700	
Crusher teeth	NHF700	
Crusher jaws & rolls (Build up)	NHNiMn	
Crusher jaws & rolls (Facing)	NHF700	
Exhaust fan blades	NHF950	
Flapper gates	NHF800	
Gas producer agitator tip	NHF700	
Gas producer furnace agitators fingers	NHF700	
Gas producer leveling arms	NHF700	
Gas producer pokers	NHF700	
Gas producer stirrer tip	NHF700	
Grizzly rolls	NHF700	
Hot slag shovel teeth	NHF800	
Hot steel handling equipment	NHMn	
Knocker parts	NHF800	
Mud guns	NHF700	
Muller tires (Build up)	NHNiMn	
Muller tires (Facing)	NHF700	
Mill plow on coal pulverizers	NHF700	
Mixer rotors	NHF950	
Post hole diggers	NHF800	
Power shovel idlers	NHF300	NSF25
Power shovel lips	NHF700	
Power shovel parts	NHF300	NSF25
Power shovel teeth (Build up)	NHNiMn	
Power shovel teeth (Facing)	NHF700	
Pug, mill paddles	NHF700	
Pulverizer hammers (Build up)	NHNiMn	
Pulverizer hammers (Facing)	NHF700	
Raymond mill	NHF800	
Raymond mill rolls	NHF700	
Sand plows	NHF800	

FOUNDRIES, FURNACES, POWER PLANTS (con't)

APPLICATIONS:	WELDING RODS	WIRES
Sand slinger cups	NHF800	
Screw conveyors	NHF950	
Shakeout screens	NHF300	NSF25
Shot blast machines	NHF950	
Singer anchor bolts	NHF800	
Alinger liners (wearing spot)	NHF800	
Tamping tools	NHF700	
Valves & valves seats	NHFST6	
Wet ash centrifugal pumps	NHF600	

LUMBER and PAPER INDUSTRY

Bull chains	NHNiMn	
Bulldozer end plates, tips	NHF600	
Cams	NHFST6	
Chipper chutes	NHF700	
Chipper discs	NHF700	
Chipper knives	NHF950	
Chipping machine bed plate	NHFST6	
Clutch fingers	NHFST6	
Clutch jaws	NHF300	NSF25
Convey or sprockets	NHF300	NSF25
Debarking machines	NHF950	
Dragline bucket teeth (Build up)	NHNiMn	
Dragline bucket teeth (Facing)	NHF700	
Friction clutches	NHF600	
Friction pins	NHF600	
Grader blades	NHF700	
Hog anvils	NHF700	
Hog cylinders	NHF300	NSF25
Hydraulic valves	NHFST6	
Latches	NHF300	NSF25
Log haul chains	NHNiMn	
Log haul chairs	NHNiMn	
Paper rolls	NHFST12	
Pressure bars inplaners	NHF800	
Pulverizer hammers	NHF700	
Pump sleeves	NHFST6	
Refuge chain	NHNiMn	
Salt cake hammers	NHF700	
Scarifier teeth	NHF700	
Second hooks	NHF600	
Shredder knives	NHF700	
Spiral feed rolls	NHF700	
Throat bars for hogs	NHF700	
Tractors grouser	NHF700	
Tractor idler wheels	NHF300	NSF25
Tractor rails-Preheat (Build up)	NHNiMn	
Tractor rollers	NHF300	NSF25
Tractor sprockets	NHD500	NSF45
Trip dogs	NHFST6	
Turn table rollers skidders	NHF600	

MINING INDUSTRY-COAL and METAL

Arc door (for ore chutes)	NHF600	
Augers drill	NHF700	
Augers points	NHF950	
Ball eyes	NHMn	
Ball mill scoop lips	NHF700	
Bulldozer lips	NHF700	
Bucket teeth	NHF700	
Bulldozer idlers & rollers	NHMn	
Bulldozer track rails	NHF450	NSF45
Convey or screws	NHF700	
Convey or pipes bands	NHMn	
Car coupler arms	NHF600	
Churn drill stem	NHF700	
Churn drill wrenches	NHF700	
Clutch plates	NHF300	NSF25
Classifiers	NHF700	
Classifier drag chains	NHF700	
Coal cutter bits (if to be Forged)	NHF800 NHF600	
Convey or buckets lip	NHF600	
Convey or pipe bends		
Crusher concaves	NHF600	
Crusher jaws (Build up)	NHNiMn	
Crusher jaws (Facing)	NHF700	
Crusher segment (Build up)	NHNiMn	
Crusher segment (Facing)	NHF700	
Cutter chain lugs	NHF600	
Cutter chain straps	NHF600	
Dipper carrier rollers	NHF600	
Dipper driving tumblers	NHNiMn	
Dipper idlers	NHF600	
Dipper lip	NHF700	

MINING INDUSTRY- COAL AND METAL (CON'T)

APPLICATIONS:	WELDING RODS	WIRES
Dipper tooth (Build up)	NHNiMn	
Dipper tooth (facing)	NHF700	
Dipper pads (Build up)	NHFNiMn	
Dipper pads (Facing)	NHF700	
Drag bits		
Dragline bucket pins & links	NHNiMn	
Dragline conveyor flights	NHF600	
Dragline driving tumbler	NHF500	NSF45
Dragline scapers	NHF700	
Dredge bucket lips	NHF700	
Dredge retard rings	NHF700	
Dredge screens	NHF700	
Dredge spuds	NHF600	
Drilling bits	NHF950	
Duck bills	NHF700	
Elevator bucket lips	NHF700	
Front end loader lips	NHF700	
Front end loader teeth	NHF800	
Gathering arms	NHF800	
Gathering arms, joy	NHF600	
Grizzlies	NHF700	
Gyratory crusher mantles (Build up)	NHNiMn	
(Facing)	NHF700	
Hand shovels	NHF800	
Hoe type scrapers	NHF700	
Ladle pins Latch bars and keepers	NHF700	
Matte ladles	NHF700	
Orange fuel bucket	NHF600	
Ore chutes	NHF700	
Pads joy loader	NHNiMn	
Picks	NHF600	
Pug mill knives	NHF800	
Pulverizer hammers (Build up)	NHNiMn	
(Facing)	NHF700	
Pump casings	NHF700	
Pump impellers	NHF700	
Rail cross overs Rail frogs,switches Raymond bowls ring	NHF600	
Raymond rolls	NHF450	NSF45
Road grader blades	NHF700	
Roll crusher shells	NHF700	
Screens	NHF600	
Shaker pan conveyors	NHF700	
Shovel driving tumblers	NHF500	NSF45
Shovel idler wheels	NHF300	NSF25
Shovel latch bars & keepers	NHF600	
Shovel lips (Build up)	NHNiMn	
Shovel lips (Facing)	NHF700	
Shovel pads	NHF500	
Shovel teeth (Build up)	NHNiMn	
Shovel teeth(Facing)	NHF700	
Sizing screens (punches)	NHF700	

MINING INDUSTRY- COAL AND METAL (CON'T)

APPLICATIONS:	WELDING RODS	WIRES
Skip host guides	NHF600	
Sprockets dragline	NHNiMn	
Teeth on dragline buckets (Build up)	NHNiMn	
(Facing)	NHF700	
Tractor drive sprockets	NHF500	NSF45
Tractor grouser (Build up)	NHF300	NSF45
Tractor grouser (Facing)	NHF600	
Tractor idler wheels	NHF500	NSF45
Tractor rails (Facing)	NHF500	NSF45
Tractor rollers	NHF500	NSF45
Underground scraper arm (Build up)	NHF500	NSF45
Underground scraper blades (Build up)	NHNiMn	
(Facing)	NHF800	

RAILS and RAILROAD EQUIPMENT

Brake shoe hammer	NHF300	NSF25
Cinder screw conveyors	NHF700	
Cross overs	NHNiMn	
Diesel engine locomotive rocker arms	NHF800	
Diesel engine locomotive valves	NHFST6	
Equalizer seals	NHF500	
Frogs and switches	NHNiMn	
Open heart frogs	NHNiMn	
Spreader car cutting shoes	NHF800	
Stocker screws	NHF700	
Switch Points	NHNiMn	
Tie temper bars	NHF700	

ROCK PRODUCTS

Auger points	NHF950	
Baffle plates	NHF700	
Ball eyes	NHF600	
Ball mill scoop lips	NHF600	
Clam shell bucket lips	NHF700	
Conveyor bucket lips	NHF700	
Conveyor pipe bends	NHMn	
Crusher concaves	NHF700	
Drag bits	NHF950	
Dipper carrier rollers	NHF500	NSF45
Dipper driver tumblers	NHF500	NSF45
Dipper idlers	NHF500	NSF45
Dipper lips	NHF700	
Dipper pads	NHF700	
Dipper teeth (Build up)	NHF500	NSF45
Dipper teeth (Facing)	NHF700	
Drilling bits	NHF950	
Front end loader lips	NHF700	
Front end loader teeth	NHF700	
Gyratory crusher heads	NHMn	
(Build up)	NHNiMn	

ROCK PRODUCTS (CON'T)

APPLICATIONS:	WELDING RODS	WIRES
(Facing)	NHF700	
Hammer mill (swing hammer) (Build up)	NHNiMn	
(Facing)	NHF700	
Jaw crusher plates (Build up)	NHNiMn	
Jaw crusher plates (Facing)	NHF700	
Jeffrey impact crusher (10-215)	NHMn	
Carbon bar (preheat to 300)	NHF700	
Laddle pins	NHMn	
Rail cross overs	NHF450	NSF45
Rail fog, switches	NHF450	NSF45
Rocker arms (Shaker screens)	NHMn	
Roll crusher shells	NHF450	NSF45
Sand pump casing		
Pump impeller and sand		
Pump liner plates Build up	NHNiMn	
(Facing)	NHF700	

PETROLEUM-DRILLING, REFINING

Auger and dies for chemical industry	NHFST12	
Auger and dies for energy production	NHFST12	
Auger and dies for oil	NHFST12	
Catalyst cleaner bits	NHF700	
Catalyst pipe	NHMn	
Catalytic cracking units	NHMn	
Drill bits	NHF950	
Drill collars	NHF950	
Flues	NHFST6	
Gate valves seats	NHFST6	
Gravity feed pipes	NHF950	
Hand shovels	NHF600	
Hard bonding	NHF950	
Kelly bushing	NHF300	NS25
Kellys	NHF300	NS25
Key seat wipers	NHF950	
Lift pipe	NHF950	
Oil well pump parts	NHF950	
Presure valves	NHFST6	
Pump casing	NHF700	
Pump plungers	NHF700	
Rotary rock bits	NHF950	
Rocker arms	NHF950	
Stabilizers	NHF950	
Steam and chemical valve	NHFST6	
Sucker rod couplings	NHF950	
Tool joint bonding	NHF950	
Tool joints	NHF950	
Tractor idlers	NHMn	
Tractor rails	NHMn	
Tractor rolls	NHMn	
Valve slides, catalyst	ST6	
Whipstocks, removable	NHF950	
Wiper blocks	NHF950	

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR HARDSURFACING

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)						Typical Hardness of all weld metal HRC (Hv)	Applications
				C	Si	Mn	Cr	Mo	Others		
HIGH TITANIA TYPE	NHF-260B	(DFA-260R)	AC DC (+)	0.11	0.37	0.66	2.20	-	-	20 - 27 (240 - 280)	For hardfacing of gears and wheels or for light metal to metal wear.
	NHF-300B	(DFA-300R)	AC DC (+)	0.07	0.25	0.18	0.70	1.02	-	23 - 29 (225 - 295)	For hardfacing of gears, mine rails, shovel pads, pin clutches. Rebuilding of shafts and wheel treads.
	NHF-350B	(DFA-350R)	AC DC (+)	0.11	0.26	0.84	1.88	0.51	-	30 - 35 (300 - 350)	For hardfacing and rebuilding of Tractor idler wheels, upper rollers and sprockets.
	NHF-400B	(DFA-400R)	AC DC (+)	0.17	0.38	0.56	2.90	-	-	43 - 46 (420 - 460)	Hardfacing of idlers, rollers, bulldozer, blades, sprockets and caterpillar links.
	NHF-600B	(DFA-600R)	AC DC (+)	0.65	0.52	0.43	8.78	5.03	-	54 - 58 (580 - 560)	Hardfacing of bulldozer, blades, bucket edges, dipper teeth.
	NHF-600R	(DFA-600R)	AC DC (+)	0.70	0.71	1.22	3.00	-	-	54 - 57 (580 - 650)	Hardsurfacing of augers, buckets, grouser, earth scoops.
	NHF-650B	(DFA-650R)	AC DC (+)	0.70	0.88	1.10	4.30	-	-	56 - 60 (610 - 690)	Hardfacing of augers, grousers, agricultural equipments, earth moving equipments, mixing paddles.
	NHF-700B	(DFA-700R)	AC DC (+)	0.51	0.23	0.31	5.50	5.20	-	57 - 61 (640 - 720)	Hardfacing of plow shaver, bucket teeth and lips, shovel, etc.

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW)
FOR HARDSURFACING

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)						Typical Hardness of all weld metal HRC (Hv)	Applications
				C	Si	Mn	Cr	Mo	Others		
LOW HYDROGEN TYPE	NHF-300	(DF2A-300B)	AC DC (+)	0.08	0.48	0.80	2.16	-0.84	-	23 - 27 (255 - 280)	For light intermetallic abrasion. Hardfacing of gears, shafts, wheel and rollers.
	NHF -330	(DF2A-350B)	AC DC (+)	0.24	0.64	1.43	1.46	-	-	30 - 35 (300 - 350)	Hardsurfacing of various wheels, shafts & gears.
	NHF-400	(DF2A-400B)	AC DC (+)	0.26	0.73	1.64	2.35	-	-	35 - 40 (350 - 400)	Hardsurfacing of bulldozer links, idlers, rollers & sprockets, etc.
	NHF-450	(DF2A-450B)	AC DC (+)	0.23	1.15	0.60	2.52	0.53	V 0.38	45 - 49 (450 - 500)	For intermetallic abrasion. Hardfacing rails, cast steel rollers and parts of the bulldozer.
	NHF-500	(DF2A-500B)	AC DC (+)	0.33	1.34	1.17	-	1.20	V 0.34	38 - 46 (370 - 460)	For Hardsurfacing of idlers and truck links of bulldozers.
	NHF-600	(DF2B-600B)	AC DC (+)	0.76	0.87	0.40	7.45	0.52	V 0.57	54 - 57 (580 - 630)	Hardfacing of Bulldozer blades, Tractor parts, scraper blades, shovel, Bucket lips and dipper teeth.
	NHF-650	EFe5 - B (DF5A-700B)	AC DC (+)	1.02	0.97	1.35	4.12	7.70	V 1.9 W 2.2	55 - 64 (600 - 800)	Hardfacing of high speed steel tools, milling cutters, reamer bits, twists, drills and taps.
	NHF-700	(DF3C-600B)	AC DC (+)	0.66	1.26	0.81	5.53	0.51	-	55 - 61 (600 - 720)	For scratching abrasion. Hardfacing of mixers, cutters knives, and dredgers.
SPECIAL COATING	NHF-800	(DF3C-700B)	AC DC (+)	0.91	1.88	1.32	3.87	W 2.54	B 0.52	62-64 (740-800)	Hardfacing of pumps casing and cutter knives.
SPECIAL COATING	NHF-950	(DFWA-700S)	AC DC (+)	2.78	0.29	3.22	0.10	0.12	W 47.3	60-69 (700-950)	For severe abrasion with light impact such as concrete cutter, pump impeller, water drilling dull bits.
SPECIAL COATING AUSTENITIC MANGANESE STEEL	NHF-HMn	EFeMn-B	AC DC (+)	0.88	0.33	14.2	-	-	-	as welded 87-100 HRB (180-220) work hardened 45-51 (450-530)	Hardfacing of various crusher jaws, high manganese steel rails and high manganese cast steels with work hardening properties.
	NHF-NiMn	EFeMn-A	AC DC (+)	0.85	0.34	13.90	-	-	Ni 4.05	as welded 91-95 HRB (200-220) work hardened 45-51 (450-530)	Work hardening properties. For hardfacing and underlaying of manganese steels, casting or carbon steel such as crusher jaws, bucket manganese teeth, etc.
	NHF-7200	-	AC DC (+)	0.70	0.27	13.0	4.50	0.53	Ni 4.0	as welded 95-100 HRB (220-260) work hardened 43-45 (420-450)	Work hardening properties. For hardfacing worn high Mn steel parts such as excavator pins, buckets, mill hammers, crusher jaws, cones and beaters, impeller bars, etc.
	NHF-CrMn	-	AC DC (+)	0.13	0.47	5.40	19.5	0.85	Ni 9.7	as welded 90-95 HRB (200-220) work hardened 31-33 (310-330)	Work hardening properties. For buffer layer final overlay of earth moving equipment. Suitable for buffer layering difficult repairs in restrained structures and deep cavities.
SPECIAL COATING CHROMIUM CARBIDE ELECTRODE	NHF-30CRS	(DFCrA-700B)	AC DC (+)	5.50	2.23	1.26	27.37	0.62	Nb 5.72	59-63 (670-760)	Hardfacing of pump impellers, sand blast, conveyor screw and mixer blader, etc.
	NHF-33CRS	-	AC DC (+)	5.28	2.00	0.63	22.3	5.2	W 1.22 V 1.30 Nb 5.80	63-67 (760-900)	For hardfacing of parts subjected to heavy abrasion and moderate impact as in sinter breaker plants, scraping beaker of Zinc industry, blast furnace charging equipment.
	NIDURIT-60	EFeCr-Al DIN 8555 E10-UM-60-GRZ	AC DC (+)	3.20	1.00	0.15	29.0	-	Fe Bal.	58-60 (660-700)	For hardfacing of conveyor screws, digging teeth, sand pumps and mixer blades.
	NIDURIT-61	EFeCr-Al DIN 8555 E10-UM-60-GRZ	AC DC (+)	3.50	1.00	0.14	35.0	-	Fe Bal.	58-61 (660-720)	Hardfacing electrodes to resist strong grinding abrasion combined with medium impact such as conveyor screws, scraper blades, etc.
	NIDURIT-65	EFeCr-Al DIN 8555 E10-UM-60-GRZ	AC DC (+)	4.50	1.00	0.21	23.5	6.50	Nb 5.5 W 2.2 V 1.5	64-67 (800-900)	For hardfacing on working parts in the cement and brick industry as well as in steel mills and sintering plants.
	NHF-716	-	AC DC (+)	2.65	1.50	0.14	24.0	2.00	Ni 0.80 V 0.50 W 0.17	55-60 (800-900)	For hardfacing of parts subjected to severe abrasion but moderate impact such as sand slider, conveyor screws, mixing paddles, etc.
SPECIAL COATING CHROMIUM CARBIDE ELECTRODE	NHF-43		AC DC (+)	6	-	-	23	-	Nb 7.00	60 - 63 (700 - 780)	Hardsurfacing of parts subject to very intense abrasion with moderate impact up to 450ºC such as mixer blades, screw of clay press, cement presser & palm oil presser.
	NHF-45		AC DC (+)	6	-	-	22	6	Nb 6.00 V 1.00 W 2.00	63 - 65 (780 - 830)	Hardsurfacing of parts subject to intense abrasion with moderate impact up to 600ºC such as ore disintegration toothed rolls, blast furnace charging systems.
	NHF-750	DIN 8555 E10-UM-65-G	AC DC (+)	4.4	-	-	35.5	-	-	57 - 62 (630 - 750)	For hardsurfacing for parts subject to mineral abrasion such as conveyor screws, mixer blades, concrete pump parts, etc.

COVERED ARC WELDING ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW) FOR HARDSURFACING

Type of Coating	Brand Name	Equivalent Specifications AWS (JIS)	Type of Current	Typical All Weld Deposit Analysis (%)						Typical Hardness of all weld metal HRC (Hv)	Applications
				C	SI	Mn	Cr	Mo	Others		
SPECIAL COATING COBALT BASED ALLOYS	NHF-ST-1 (flux coated)	ECoCr-C (D CoCrE)	AC DC (+)	2.15	0.47	1.03	31.25	-	W 12.72 Co Bal.	50 - 56 (520 - 620)	For corrosion and high temperature abrasion. Hardfacing of valve heads, seal rings of high pressure pump.
	NHF -ST-6 (flux coated)	ECoCr-A (D CoCrA)	AC DC (+)	0.84	0.57	0.97	30.46	-	W 4.53 Co Bal.	38 - 44 (370 - 440)	For corrosion and high temperature abrasion. Hardfacing of valve seats, forging dies, crushers and screws.
	NHF -ST-12 (flux coated)	ECoCr-B (D CoCrB)	AC DC (+)	1.43	0.56	0.98	31.62	-	W 8.67 Co Bal.	42 - 48 (410 - 490)	For corrosion and high temperature abrasion. Hardfacing sleeves of high pressure pump, cutting knives, liners.
SPECIAL COATING FOR SPECIAL APPLICATIONS	SUCROWELD		AC DC (+)	4.49	3.87	1.62	9.12	-	-	61 - 66 (720 - 860)	Special formulated of hardfacing especially for sugar mill rolls.
	AZUCAL 80		AC DC (+)	3.4	0.92	1.92	27.8	-	-	60 - 63 (700 - 770)	Special formulated for hardfacing especially for sugar mill machinery such as rolls.
	Sugarhard 90	DIN 8555 E10-UM-65-G	AC DC (+)	3.5	1.20	2.60	29	-	-	60 - 62 (700-750)	Special electrode for cladding and arching on sugar mill rolls while the mill is in operation.
SPECIAL COATING FOR SPECIAL APPLICATIONS	Rollerweld		AC DC (+)	0.42	0.36	0.39	8.85	1.22	W 10.58	55 - 58 (600 - 650)	Non-machinable hardfacing of parts subjected to metal to metal wear up to 550ºC without severe thermal shock such as cold shear blader, wire guide, twister guide, etc.
	Thermaroll -M		AC DC (+)	0.60	1.0	2.0	22.0	0.5	Ni 8.0	As needed 20-25-HRC (240 - 265) work hardened 40-45 HRC (390-450)	For machinable hardfacing of steel mill rollers or parts subject to metal to metal wear up to 500-550ºC and thermal and mechanical shock.
	Railhard		AC DC (+)	0.08	0.45	0.55	2.56	-	-	26 - 30 (270 - 300)	For surfacing of railfrogs+L51, switches, rail ends, mine rails, etc.
	Buildup		AC DC (+)	0.06	0.35	0.36	1.95	0.67	-	27 - 30 (280 - 300)	For welding and building up to worn parts such as shafts.
SPECIAL COATING FOR SPECIAL APPLICATIONS	Tractorhard	-	AC DC (+)	0.09	1.00	0.41	4.02	-	-	38 - 43 (370 - 430)	Hardfacing and building up of parts subject to impact, medium abrasion and high compressive stress such as track rollers and pads.
	Abrasohard	-	AC DC (+)	0.60	1.00	0.30	8.80	5.50	-	56 - 60 (620 - 700)	Hardfacing of parts subject to impacts and high compressive stresses such as shovel teeth, tractor parts, etc.
SPECIAL COATING FOR TOOL AND DIE WELDING	NHF-SKD-61 (NHF-70S)	(DF3C-600-B)	AC DC (+)	0.45	0.43	0.40	5.92	1.35	V 0.56	55 - 58 (600 - 650)	Air hardened electrode which is similar to alloy tool steel SKD61.
	NHF-SKD-62 (NHF-80S)	(DF3C-600-B)	AC DC (+)	0.42	0.40	0.82	5.52	2.14	W 2.24 V 0.25	57 - 59 (630 - 680)	Air hardened electrode which is similar to alloy tool steels SKD62. It is suitable for hardfacing of friction parts which might be affected by heat and soil abrasion. High speed steel for high hardness, good toughness and good crack resistant.
	NHF-HSS-7	EFe-5B (DF5A-700-B)	AC DC (+)	1.01	0.69	0.67	4.36	8.10	W 1.67 V 1.61	62 - 64 (700 - 780)	Repairing of cutter, knives, dies and crusher jaws.
	NHF-HSS690	EFe-5B DIN 8555 E4-UM-60-ST	AC DC (+)	0.90	0.81	0.52	4.60	8.10	W 2.0 V 1.2	61 - 63 (720 - 780)	For high speed steel for high wear resistant surfacings on cold and hot working steel specially for cutting edger. Heat resistant up to 550ºC.
	NHF-D236	-	AC DC (+)	0.65	1.00	0.50	14.10	0.92	V 0.21	as welded 37 (370) Hot Quench 60-63 (700-770) After Annealing 59-61 (680-720)	Special highly alloyed electrode for welding 5% Cr to 12% Cr tool steel such as D2, D3 and D6.
	NHF-73G2	DIN 8555 E3-UM-55-ST	AC DC (+)	0.35	0.55	1.35	7.10	2.55	-	55 - 58 (600 - 650)	Suited for build ups on parts subject to severe friction compression and moderate impact loads at elevated temperature. Heat resistant up to 550ºC.
	NHF-73G3	DIN 855 E3-UM-45-T	AC DC (+)	0.32	0.53	0.63	5.10	4.10	-	45 - 50 (275 - 330)	Suited for build ups on parts subject to friction compression and impact at elevated temperature such as hot gate shear, forging saddles, hammers, and forging dies. Heat resistant up to 550ºC.
SPECIAL COATING FOR TOOL AND DIE WELDING	NHF-73G4	DIN 8555 E3-UM-40-PT	AC DC (+)	0.17	0.54	0.62	6.50	3.60	-	38 - 42 (310 - 410)	Suited for hardfacing on parts and tools subject to abrasion, compression and impact at elevated temperatures, particularly for build up on rollers, die cast moulds, wobbler driver, etc. Machinable and heat resistant to 550ºC.
	NHF-WH2	DIN 8555 E3-UM-60S	AC DC (+)	0.60	0.40	0.60	0.40	0.80	V 0.25	60 - 64 (700 - 800)	For reconditioning of water hardening tool steels.
	NHF-AH2	DIN 8555 E6-UM-60S	AC DC (+)	0.85	0.40	0.22	5.50	1.60	V 0.6	60 - 63 (700 - 800)	For reconditioning of air hardening tool steels.
	NHF-OH1	DIN 8555 E2-UM-65S	AC DC (+)	0.70	0.50	1.20	1.10	1.10	V 0.1 W 0.5	62 - 65 (750 - 830)	For reconditioning of oil hardening tool steels.
SPECIAL COATING FOR TOOL AND DIE WELDING	NHF-4140	No AWS spec	AC DC (+)	0.35	0.40	0.86	0.85	0.35	-	-	For welding SAE 4140 and similar heat treatable steel. Where the weld metal must match the heat treating properties of parent metal.
	NHF-4340	No AWS spec	AC DC (+)	0.36	0.52	0.83	0.81	0.25	Ni 1.80	-	For welding of heat treatable high strength steels such as SAE 4130, 4330, 4340 and steel castings with similar hardening properties.

SUBMERGED ARC WELDING FLUXES AND WIRES FOR SUBMERGED ARC WELDING (SAW) FOR HARDFACING

Type of Fluxes	Brand Name		SIZE (mm)	Equivalent Specifications AWS (JIS)	Typical All Weld Deposit Analysis (%)						Typical Hardness of all weld metal BRINELL	Applications
	Flux	Wire			C	Si	Mn	Cr	Mo	Others		
Agglomerated Bonded Type	NSF-250	NSW-L12	2.4 3.2 4.0 4.8	N.A.	0.16	0.62	1.25	1.22	0.24		1st pass 230 2nd pass 288 3rd pass 325	Rails, rail heads, switch points, rolling-stock wheels, crane truck wheels, chain rollers, chain studs, truck supporting rollers or caterpillar tractors, machine and gear parts, etc.
	NSF-350	NSW-L12	2.4 3.2 4.0 4.8	N.A.	0.20	0.75	1.43	2.73	0.45		1st pass 335 2nd pass 428 3rd pass 450	Excavator parts, caterpillar tractors, bearing, etc.
	NSF-450	NSW-L12	2.4 3.2 4.0 4.8	N.A.	0.37	0.93	1.34	4.56	0.43		1st pass 420 2nd pass 500 3rd pass 575	Excavator parts, caterpillar tractors, bearing, etc.

SUBMERGED ARC WELDING FLUXES AND TUBULAR WIRES FOR SUBMERGED ARC WELDING (SAW) FOR HARDFACING

Type of Steel	Brand Name	Dia. (mm)	Flux	Alloy Content	Typical All Weld Deposit Analysis (%)									M.P.	Applications
					C	Mn	Si	Mo	Cr	V	Ni	W	Fe	Hard-ness	
FOR HARDFACING SUBMERGED ARC WELDING	NICOR 104	2.8 - 4.0	NSF-50	3%	0.13	2.00	0.80	0.20	1.05	-	-	-	base	30 - 35 HRC	Excellent resistance to impact. Deposits are crack-free and can be machined by high speed tools. Can be flame cut. Maximum thickness is unlimited. Ex. build-up prior to hardfacing of tractor rollers, idlers, trunnions, rolls, cable drums. Used as final oven.
	NICOR 105	2.8 - 4.0	NSF-50	8%	0.20	2.00	1.00	0.45	3.00	0.30	-	-	base	44 - 48 HRC	Very good resistance to abrasion metal to metal wear, resists cold deformation. Multiple layers up to 3 layers. Tungsten carbide tools and powerful equip. needed to machine. Difficult to flame cut. Ex. rollers, idlers, carbon steel crane wheels, mine car.
	NICOR 105B	3.2 - 4.0	NSF-50	7%	0.16	2.00	0.90	0.42	2.40	-	-	-	base	42 - 46 HRC	Very good resistance to cold deformation. Good compressive strength and impact resistance. Very good abrasion resistance in metal to metal wear. Multiple layer up to 4 layers readily machinable with carbide tools. Difficult to flame cut. Same as NICOR 105.
	NICOR 106	2.8 - 4.0	NSF-50	8%	0.08	2.00	1.10	4.80	-	-	5.25	-	base	40 - 45 HRC	Very good abrasion resistance in metal to metal wear and in hot roll applications. Tends to polish in service to reduce friction. Resists seizing and galling. Outstanding resistance to thermal shock. Not recommended for parts subject to severe mechanical shock or impact.
	NICOR 107	2.8 - 4.0	NSF-50	6%	0.20	1.60	0.65	0.35	2.70	-	-	-	base	40 - 45 HRC	Good compressive strength and excellent impact resistance. Good abrasion resistance in metal to metal wear. Machinable with carbide tools. Can be flame cut. Multiple layer up to 3/4". Ex. rollers, idlers, carbon steel crane wheels, mine car wheels, house.
	NICOR 102	3.2 - 4.0	NSF-50	11%	0.20	3.00	1.50	0.10	5.00	-	-	-	base	48 - 52 HRC	Excellent abrasion resistance. All-weld composition similar to H12 tool steel. Requires rigid, heavy duty equip. and carbide tools for machining. Difficult to flame cut. Will withstand high compressive loading. Ex. work rolls, leveler rolls, vertical edger.
	NICOR 420	3.2 - 4.0	NSF-50	15%	0.70	1.20	0.60	1.80	12.80	0.19	0.60	-	base	49 - 51 HRC	Modified 420 stainless steel. Very good abrasion resistance. Good impact resistance. Deposits polishes in service to reduce friction and minimize wear of mating part. Machinable with carbide tools. Ex. brake drums, pinch rolls, coller rolls, packing gland.
SAW FLUX (FUSED FLUX)	NSF-50	8 x 48 mesh	-	Chemical Analysis of Flux (%)											For use with NICOR line of tubular hardfacing wire.
				MnO			SiO_2			$Al_2O_3 + CaO + MgO + Fe_2O_3$					
				36 - 42			35 - 40			35 - 40					

FLUX CORE WIRES
FOR FLUX CORED ARC WELDING (FCAW)

Type of Steel/ Applications	Brand Name	SIZE (mm)	Equivalent Specifications AWS (JIS)	Shielding Gas	Type of Current	Typical All Weld Deposit Analysis (%)						Typical All Weld Mechanical Properties				Applications
						C	Si	Mn	Cr	Ni	Y.S. N/mm_2 (kg/m_2)	T.S. N/mm_2 (kg/mm_2)	El. (%)	I.V. J (kgf-m)	Hardness (HV)	
FOR HARDFACING (GAS-SHIELDED)	NFCW-250 GS	1.2-1.6	-	CO_2	DC(+)	0.07	0.50	1.59	1.3	-	-	-	-	-	260	For metal to metal wear and impact. Ex. shafts, wheels, gears and cams
	NFCW-300 GS	1.2-1.6	-	CO_2	DC(+)	0.09	0.68	1.54	1.1	-	-	-	-	-	300	For metal to metal wear. Ex. rollers, shafts and wheels.
	NFCW-350 GS	1.2-1.6	-	CO_2	DC(+)	0.12	0.45	1.37	1.3	-	Mo 0.20	-	-	-	360	For wear and abrasion. Ex. rollers, shafts, tires and idlers.
	NFCW-450 GS	1.2-1.6	-	CO_2	DC(+)	0.24	0.51	1.20	2.0	-	Mo 0.60	-	-	-	450	For wear and abrasion. Ex. rollers, idlers, screws and links.
	NFCW-600 GS	1.2-1.6	-	CO_2	DC(+)	0.25	2.18	0.36	6.5	-	Mo 0.03	-	-	-	590	For wear and abrasion. Ex. shafts, bulldozer blades and bucket lips, etc.
	NFCW-700 GS	1.2-1.6	-	CO_2	DC(+)	0.30	2.40	0.50	7.0	-	W 0.70	-	-	-	690	For wear and abrasion. Ex. rollers, conveyor screws and impellers, etc.
	NFCW-800 GS	1.2-1.6	-	CO_2	DC(+)	0.44	1.50	0.55	8.6	-	W 0.50	-	-	-	780	For wear and abrasion. Ex. impellers and buckets, etc.
FOR HARDFACING (SELF-SHIELDED OPEN ARC)	NFCW-BU-O	1.2 1.6 2.4 2.8			DC+	0.14	0.80	1.50	1.58	-	-	-	-	-	30-35 HRC 295-335 HRB	A low alloy steel for build up. Used on tractor rails, steel shafts, trunnions, gears, etc.
	NFCW-NiCrMn-O	1.6 2.4 2.8			DC+	0.75	0.80	14.5	2.5	0.50	-	-	-	-	17-20 HRC 220-235 HRB work hardens	Build-up material depositing "hardfield: type manganese steel Applications: crusher jaws and rolls, railroad sections, bucket teeth, lips and side, etc. NOT to be used on ferritic steels
	NFCW-TW-O	2.8			DC+	1.00	0.60	20.0	4.5	-	-	-	-	-	16-23 HRC 50-55 HRC work hardened	For most railroad track maintenance applications.
	NFCW-110-O	1.2 1.6 2.4 2.8			DC+	0.40	0.75	14.5	14.5	others 3% max	-	-	-	-	22-24 HRC 244-260 HRB work hardens	All purpose build up & joining wire. For building up of sections with high impact or heavy loadex. Railroad frogs, crusher rolls, hammers, etc.
	NFCW-965-O	1.2 1.6			DC+	0.50	0.80	2.50	6.0	Mo 1.6 W 1.3	-	-	-	-	52-56 HRC 490-534 HRB	High hardness up to 500ºC can be heat treated to increase hardness above Rc 60. Blast furnace balls, blooming table rolls, cable sheaves, etc. pre-heat 200ºC required for crack free welding.
	NFCW-120-O	1.2 1.6 2.4 2.8			DC+	1.00	0.60	20.0	4.5	-	-	-	-	-	16-23 HRC 50-55 HRC work hardened	High manganese alloy deposit for applications involving wear and severe impact. Deposits work harden and are non-magnetic, are machinable with carbide tools and can be flamed cut.
	NFCW-121-O	1.2 1.6 2.4 2.8			DC+	3.00	1.50	3.00	15.5	-	-	-	-	-	46-50 HRC 429-469 HRB	Used on severe impact abrasion applications. Ex. crusher parts, bucket lips, teeth, sides, conveyor, screws, augers, etc.
	NFCW-131-O	2.8			DC+	3.20	1.90	1.80	15.5	-	-	-	-	-	40-45 HRC	For parts where a low coefficient of friction and minimum cross checking is desirable. Deposits provide excellent bearing surfaces on friction type guides and cement mill gudgeons. Non-machinable deposits.

FLUX CORE WIRES
FOR FLUX CORED ARC WELDING (FCAW)

Type of Steel/ Applications	Brand Name	SIZE (mm)	Equivalent Specifications AWS (JIS)	Shielding Gas	Type of Current	Typical All Weld Deposit Analysis (%)						Typical All Weld Mechanical Properties				Applications
						C	Si	Mn	Cr	Ni	Y.S. N/mm$_2$ (kg/m$_2$)	T.S. N/mm$_2$ (kg/mm$_2$)	El. (%)	I.V. J (kgf-m)	Hardness (HV)	
FOR HARDFACING (SELF-SHIELDED OPEN ARC)	NFCW-100-O	2.8			DC+	2.10	1.80	1.30	7.0	Mo 1.6 Ti 6.0	-	-	-	-	48-60 HRC	Deposits martensitic alloy with dispersed titanium carbides. Good for resisting high stress abrasive wear. Also has good hot hardness.
	NFCW-134-O	2.8			DC+	3.20	1.90	1.80	15.5	-	-	-	-	-	42-46 HRC one pass 56-60 HRC two pass	A high chromium-iron alloy for applications subject to severe abrasion, moderate impact, and high compressive loads. Non-machinable and can be used for hot wear up to 900ºF.
	NFCW-SCr-O	2.4 2.8			DC+	0.45	0.80	1.40	6.0	Mo 1.5 W 1.5	-	-	-	-	-	Deposits H-12 tool steel composition weld. Excellent resistance to adhesive (metal-to-metal) wear. Good resistance to abrasion and impact and maintains hardness up to 1000ºF.
	NFCW-100HC-O	2.4 2.8			DC+	5.00	1.10	0.90	28.0	-	-	-	-	-	60-62 HRC 575-600 HRB	Used in cases of extreme gouging abrasion ex. Gyratory crusher cones and mantles, catalyst pipes and valves, dredge pump parts, etc. deposit should be kept to one pass unless loading is small
	NFCW-100HD-O	2.4 2.8			DC+	4.50	0.50	0.90	26.5	-	-	-	-	-	55-62 HRC	A high chromium alloy developed for high deposit rte hardfacing of large surface areas for severe abrasion. It develops a very tight cross checking pattern. Can be used for hot wear applications up to 482ºC. N0n-machinable deposits.
	NFCW-101HC-O	1.2 1.6 2.0			DC+	4.50	0.50	0.90	26.5	-	-	-	-	-	56-64 HRC	High chromium-carbon, iron based for metal to earth applications subject to severe abrasion. Non-machinable.
	NFCW-100X HC-O	2.4 2.8			DC+	5.00	1.00	0.80	22.0	Nb 6.50	-	-	-	-	62-64 HRC 600-620 HRB	A complex carbide in a tough matrix used mainly in sand and earth moving equipment.
	NFCW-S20-O	2.8			DC+	4.50	0.50	0.90	26.5	-	-	-	-	-	60-65 HRC	A very highly alloyed chromium-tungsten-moly-iron used for service involving very severe abrasion and hot wear up to 1100ºF.

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.

NOTES:

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