WALLPAPERING SHEET LINING WITH NICKEL-CHROMIUM MOLYBDENUM ALLOYS

INTRODUCTION

The practice of wallpapering, or sheet lining, of carbon steel or alloy structures such as process vessels, water boxes, ducting, chimney liners, etc., is well established with extensive experience in the chemical and process industries and more recently with Flue Gas Desulfurization, FGD, equipment.

This document is concerned with the most widely employed procedure utilizing thin, typically 1.6 mm (0.062 in.), sheet which is applied to carbon steel or alloy substrates so that the sheets overlap. See Figure 1. This procedure ensures that the seam welds which are exposed to the corrosive environment are all fillet welds made between the overlapping sheets, providing full weld integrity and performance.

This document provides guidelines for the procedures employed in wallpapering carbon steel or alloy substrates with high nickel alloys such as UNS N10276 (Alloy C-276). The practices also are applicable to a wide range of lower alloyed nickel-containing materials where appropriate.

DESIGN CONSIDERATIONS AND PLANNING

Wallpapering (sheet lining) is generally more cost effective than the use of solid high nickel alloys or nickel-alloy clad carbon steel.

Sheet Thickness and Size

The most widely used thickness is 1.6 mm (0.062 in.) although thicknesses up to 3.2 mm (0.124 in.) have been used. Welding becomes more difficult in thinner gauges and there is greater risk of mechanical damage. However, 1.6 mm (0.062 in.) thick sheet offers flexibility for ready fit-up to the substrate material in the fabricated structure.

Optimum sheet size is influenced by the geometry of the surfaces to be covered. In lining large uniform surfaces such as chimneys or stacks, wide sheets up to 2.4 m (8 ft.) may be used with considerable savings of weld metal, welding inspection and other costs. Normally 1.2 m (4 ft.) wide sheets in lengths of 2.4 m (8 ft.), 3.0 m (10 ft.), and 3.7 m (12 ft.) are used.

Layout Planning

The pre-planning of handling procedures, optimum sheet size, lining layout and detail design around supports and corners is important.

Location of fabrication

As much fabrication as is practical should be completed in a work-shop or at ground level. Whenever possible, welding should be in the flat position. Pre-fabrication of sections reduces on-site welding time.

Material handling procedures

Simple, well designed equipment, for example the

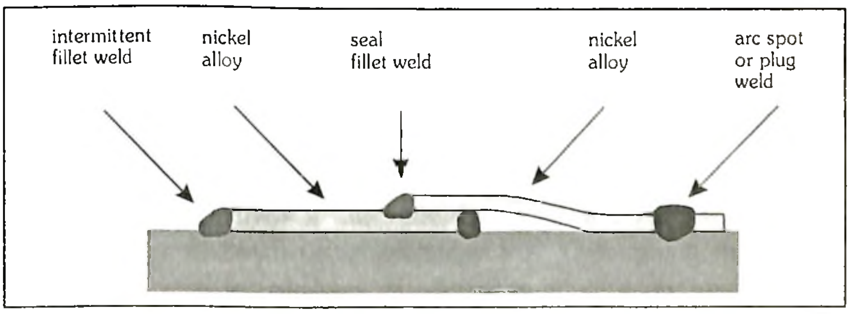


Fig. 1. Lining Technique.

"picture-frame", should be considered to safely and efficiently move sheets into place without damage.

The lining sheet should be protected against contact with carbon steel tools, clamps and other potentially contaminating surfaces. (Also see Sheet handling).

Sheet lining layout

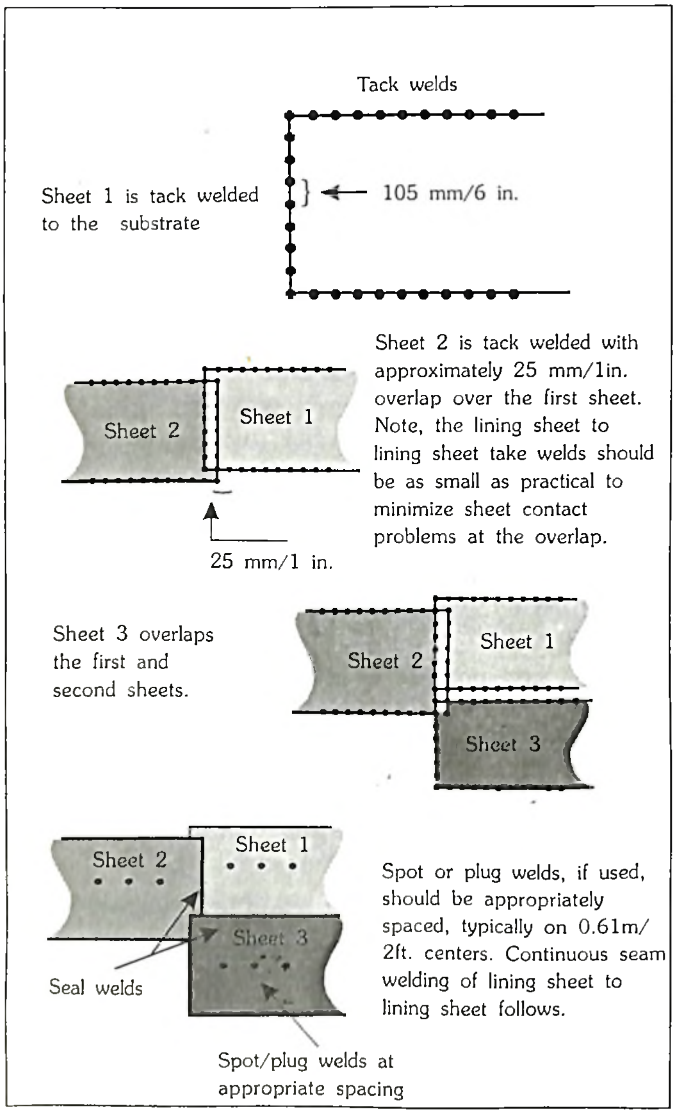


Fig. 2. Sheet lining sequence.

Plans should be developed in advance. Usually it is preferred to start lining at the top of a unit and work down. In ducts where there are roofs, sides and floors the sequence is frequently roof, sides, then the floor. Each lining sheet is completely tack welded in position and spot or plug welds are made prior to seal welding to an overlapping sheet. Continuous welds may be made attaching a sheet to the substrate, to provide means of monitoring local conditions such as the presence of a leak.

Sheets should be staggered to avoid the possibility of four corners coming together at one point. (See Figure 2).

Structural support attachments and inlets

When feasible, it is preferable to avoid internal structural supports in favor of external reinforcement. When internal supports are necessary, "windows" should be provided in the sheet lining so that the supports can be welded directly to the steel substrate rather than applying stress to the lining. Once any structural attachments are secured, the "window" area is covered, using preformed or fabricated alloy sections. Similar arrangements may be made for inlets such as pipework or manways.

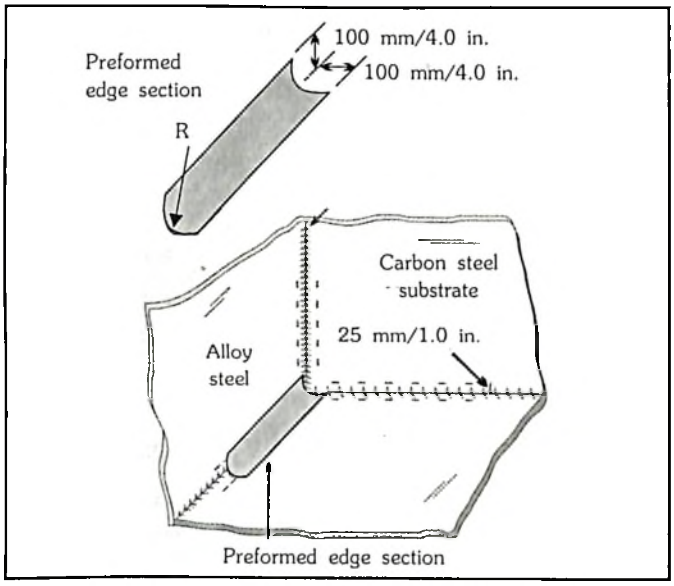


Fig. 3. Example of a preformed edge section.

Corners

It is recommended that sheets be attached to the carbon steel substrate with a gap of about 25 mm (1 in.) from a change in section, say, from horizontal to vertical planes, and in particular in corners. Suggested procedures are illustrated in Figures 3 and 4.

Small pre-fabricated sections about 100 mm x 100 mm (4 in. x 4 in.) can be employed to advantage. These facilitate seam welding, inspection are reduce the need for preparation of the fillet welds in the carbon steel substrate and avoid the need to pre-form the edges of large sheets.

PREPARATION FOR WELDING

Cleaning

The substrate surface must be cleaned and free of oxide, corrosion products, oil, grease and other foreign matter. In retrofit lining, abrasive blasting with clean abrasives, such as Garnet or Fused Alumina, is preferred for surface cleaning and removing corrosion pits. Abrasive blasting should follow the treatment of corroded areas with an alkaline solution to neutralize acidic corrosion products, followed by water washing. A rust preventative should be applied after cleaning when rerusting is likely. A number of commercial compounds and weld-through paints (primers) are available that prevent rusting and do not cause problems in welding.

Care should be taken to avoid any contamination of the nickel alloy lining sheets.

Substrate Preparation

The substrate surface should be relatively smooth and free of protrusions or depressions such as pits, to allow close contact with the lining sheet for tack and spot welding.

Grinding and/or welding and grinding should be employed as needed. As far as possible, substrate preparation should be completed prior to installation of nickel alloy sheets.

Sheet Handling

Care in handling nickel alloy sheets is necessary. Rough handling can cause mechanical damage to the relatively thin lining materials. (Also see Material handling procedures).

Cutting nickel alloy sheets

Acceptable cutting methods include:

- mechanical shearing
- plasma arc cutting with inert gas protection
- abrasive cutting or grinding with dedicated uncontaminated discs
- punching (mechanical)
- drilling

Thermal cuts should be ground back as necessary to remove dross.

Carbon/arc cutting has caused severe corrosion problems as a result of carbon pickup and the process must not be used.

Forming

The nickel alloys are generally stiffer than the austenitic stainless steels, requiring more effort for the cold forming of sections. Also, the alloys tend to work harden more readily than austenitic stainless steels so that allowance for greater "spring back" may be required.

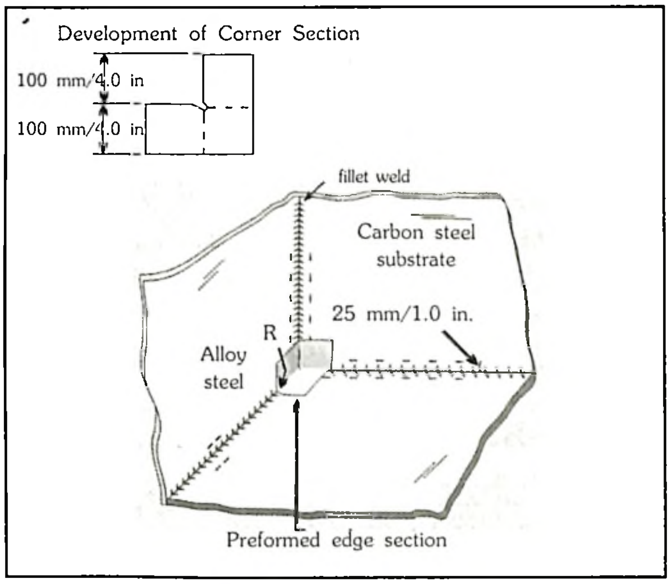


Fig. 4. Example of a preformed corner section.

The forming of simple bends on brake presses will seldom require the use of a lubricant. However, should more complex forms require the use of a lubricant, care must be taken to completely degrease the work after forming.

Care must be taken to ensure all tools are clean and free from contamination which may detrimentally influence the performance of the nickel alloy, such as iron pick-up from tools previously used for cutting and forming carbon constructional steel.

Advice should be sought of nickel alloy suppliers for specific recommendations on forming practices.

Anti-Spatter

Judicious use of anti-spatter compounds will minimize the need for post weld clean-up procedures. Care should be taken with application close to the weld joint as out-gassing of trapped compound may cause the formation of severe weld porosity.

WELDING PROCEDURES

The welding parameters cited in Tables 1 to 3 (found at the back of this paper) are for guidance purposes only, as optimum settings will vary with local conditions and characteristics of the equipment employed. The welding operators must be qualified to an agreed standard (for example, ASME Section IX) and will require specialized training.

Attachment Welding

Tack welds should be sequenced so that there is close contact between the lining and substrate. A suitable tacking procedure should be employed to avoid distortion such as "wrinkling." Tack welds may be made by Gas Metal Arc Welding (GMAW) with the pulsed arc mode as used for the seal welds (Table 1) or alternatively by TIG (GTAW) (Table 3.)

Guides for tack welds are:

Liner to substrate

These tacks provide the structural strength of the liner so they must be adequate. The tack welds should be flush with the sheet liner surface to facilitate contact by the covering sheet and avoid any necessity for grinding back.

Seal weld tacks

Close tacking is required to control distortion and burn through. Tacks should be as small as possible.

Seal Welds

Table 1 details suggested welding procedures for Gas Metal Arc Welding (GMAW) -pulsed arc mode. Seal welds are made with a single pass only.

Gas Tungsten Arc Welding (GTAW) also has been used for seal welds and repair welds. Suggested welding parameters are shown in Table 2.

Shielded Metal Arc Welding (SMAW) should not be employed unless absolutely necessary because of risk of entrapped slag and other defects.

The addition of spot or plug welds to the sheet may be required to resist stresses generated by pressure variation, vibration or thermal expansion.

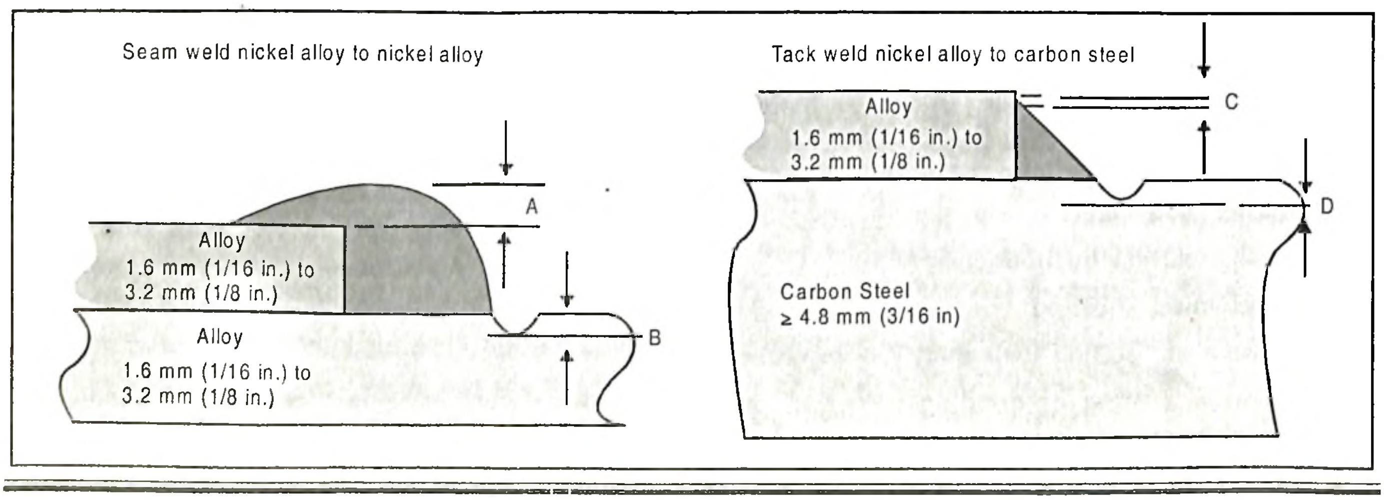
The various spot or plug welding procedures used are as follows:

Spot Welds

A spot weld, in this context, is defined as melt through of the lining sheet by the welding process without need for pre-formed holes. For suggested welding procedure see Table 3. The pre-programmed, automatic spot weld is cost-effective, fast and simple.

Plug Welds

A plug weld, in this context, is defined as the fillet welding around the periphery of a pre-cut or prepunched hole. A gap may be left in the periphery



weld to allow for the escape of hot air during the capping of the weld. The holes may be 9.5 mm (0.375 in.) to 16 mm (0.629 in.) in diameter or elongated slots 25 to 50 mm (1 to 2 in.) long.

Subsequent capping of this plug weld is necessary to prevent the risk of reduced corrosion resistance by iron dilution. The cap in matching alloy material, larger than the hole, is seal welded in place in accordance with Table 1. Care should be taken to avoid porosity due to air entrapment.

Rrepair Welding

Defects should be repaired using tungsten inert gas welding (GTAW) procedures once the area has been thoroughly cleaned and dried. Suggested welding parameters are shown in Table 2.

POST WELD CLEANING

By use of appropriate welding procedures and anti-spatter compounds, post weld cleaning should be minimal and not require anything other than detergent and water washing methods.

INSPECTION AND TESTING

All weld joints must be critically inspected for defects that might allow leakage to the backing material. Following preliminary visual inspection and repair of obvious defects (see Repair welding), weld seams and spot or plug welds must be tested for soundness using such methods as the vacuum box test (ASTM E515) or similarly effective tests such as API procedures, supplemented as necessary by dye penetrant checks in inaccessible areas.

WELD ACCEPTANCE CRITERIA

The following criteria are offered for consideration:

"A" Reinforcement of the alloy lining seal weld must be minimal to avoid the possibility of scale buildup in service which may influence corrosion resistance. Commonly accepted U.S. limitation is 4.8 mm (3/16 in.) maximum. European limitation is 0.5 of liner thickness maximum, (Term reinforcement does not imply any addition to strength of weld joint).

"B" Undercut of seal welds is a significant matter. Commonly accepted U.S. limitation is 0.25 mm (0.010 in.) maximum. European limitation is 0.1 mm (0.004 in.) maximum. Undercut is defined as a groove melted into the base metal adjacent to the toe or root of a weld and left unfilled by weld metal.

"C" As the sheet being attached to the substrate by the tack weld is to be covered by a second sheet, preferably no reinforcement is acceptable, to avoid necessity of dressing. Therefore, a tolerance of +0 - 0.4 mm (+0 - 1/64 in.) is suggested.

"D" As undercut in carbon steel is not a corrosion concern a limit of 0.25t in accordance with ANSI/AWS 09-1 is acceptable.

ANSI/AWS 09-1 - Specification for welding of sheet metal.

ANSI/AWS 01- 1 - Structural welding code -steel.

Tightest limit is 0.25 mm (0.10 in.) max in 4.8 mm (3/16 in.) to 15.88 mm (5/8 in.) thick material in primary stress members when the weld is transverse to tensile stress under any load condition. Other welds may have up to 0.79 mm (1/32 in.) undercut.

OBITUARY

Mr. M. Ismail

Mr. M. Ismail, the Past Chairman of IIW - Mumbai Branch from 1998-2000, Prominent Industrial Corporate Member, EC Member, a Council Member, aged 59 years, was a pillar of strength to IIW. His contribution to all Branches of IIW was exemplery. We, the entire Council Members express our heartfelt condolences to the bereaved family and extend our support to his family for achieving the desire of Mr. Ismail.

Table 1: Suggested Welding Procedure, Gas Metal Arc Welding (GMAW) - Pulsed Arc Mode Wallpapering -Sheet Lining (Seal welds, intermittent tack welds and plug welds)

Sheet Materials	:	UNS N10276 (Alloy C-276) or other high-nickel alloys may be used.
Filler Materials	:	Welding Wire 0.8 mm, 1 mm, or 1.2 mm Diameter AWS A5.14: ERNiCrMo-4 (Alloy C-276 filler metal) UNS N10276, 56Ni, 16Mo, 16Cr, 5Fe, 3.5W Other filler compositions are available.
Positions	:	All
Preheat	:	Not normally required, in Low temperature conditions preheat may be necessary to prevent moisture condensation in weld area.
Shielding Gas	:	75% Helium - 25% Argon Lower Helium content mixtures are being used in Europe because of reduced cost. (see note)
Electrical Characteristics	:	Polarity: DCRP (electrode positive)

	A Fixed Frequency	B Synergic Variable	Pulse
Wire Size (mm)	0.8	0.8	1.0
Wire Feed Rate (m/min)	5.5	5.0	3.0
Gas Flow (L/min)	10-15	10-15	10-15
Pulse Rate (PPS)	50	40-45	45-75
Pulse Height (V)	-	about 30	about 31
Pulse Time-on (milliseconds)	Half cycle	about 2.0	about 2.0
Mean Amps (A)	65-70	60-65	70-90
Base Amps (A)	-	20-30	20-30
Mean Volts (V)	21-22	24	20
Travel Speed	Up to 0.5 m/min for manual operation. Up to 1.5 m/min automatic with increasing arc energy		

These figures are to be used as a guide only, conditions will vary with equipment used and location (*e.g.*, shop or site)

Note : Other gas mixtures may be applicable with recent development of electronically controlled power sources, indications are that welds can be made in all positions utilizing 100% Argon. However, addition of Helium is stated to improve weld quality at lower levels of operator skills. Present work indicates that a very small addition of active gas (less than 0.5%) stabilizes the arc and aids wet-out.

Table 2: Suggested Welding Procedure for Gas Tungsten Arc Welding (GTAW), Wallpapering - Sheet Lining (Seal welds, intermittent tack welds and plug welds)

Sheet Materials	:	UNS N 10276 (Alloy C-276) or other high-nickel alloys may be used
Filler Material	:	Welding Filler 1.2-1.6 mm Dia AWSA5.14ERNiCrMo-4 (Alloy C-276 filler metal) UNSN10276, 56Ni, 16Mo, 16Cr, 5Fe, 3.5W Other filler compositions are available.
Positions	:	All
Preheat	:	In low temperature conditions preheat may be necessary to prevent moisture condensation in weld area.
Shielding Gas	:	100% Argon Use of gas lens attachment to the welding torch provides better gas protection to the weld metal.
Electrical Characteristics	:	Polarity: DCSP (electrode negative) Pointed Tungsten electrode diameter: 1.6 mm (1/16 in.) or 2.4 mm (3/32 in.) (2% Thorium preferred for longer life)
Amperage	:	40-60 amps*
Voltage	:	10-13 volts
Travel Speed	:	Manual 100-150 mm/min* Automatic 400-1000 mm/min

* Amperage and travel speed are starting guides. Depending on joint conditions, acceptable welds can be made outside indicated ranges.

Note : For guidance purposes only - conditions will vary with equipment used and location (*e.g.*, shop or site)

Table 3: Suggested Welding Procedure, Gas Metal Arc Welding (GMAW) - Pulsed Arc Mode, (Arc spot welding for plug and tack welds)

Sheet Materials	:	UNS N10276 (Alloy C-276) or other high-nickel alloys may be used.
Filler Metal	:	AWS A5, 14 ERNiCrMo - 4 (Alloy C-276 filler metal) 1.6 mm Diameter UNS N10276, 56Ni, 16Mo, 16Cr, 5Fe, 3.5W GMA spot welds may also be made in 1.6 mm thick alloy sheet with 1.2 mm Diameter wires. Other filler compositions available.
Positions	:	All
Preheat	:	In low temperature conditions preheat may be necessary to prevent moisture condensation in weld area.
Shielding Gas	:	100% Argon or Argon-Helium mixtures
Electrical Characteristics	:	Polarity : DCRP (electrode positive) Amperage : 300 amps Voltage : 28 volts Arc time : 0.5 seconds to 1.0 seconds

Note: For guidance purposes only - conditions will vary with equipment used and location. (*e.g*,, shop or site)

USE OF 312-TYPE ELECTRODES FOR REPAIR OF CAST IRON

Electrodes similar in composition to type 312 stainless steel have proven track record of successful repair in difficult-to-weld steels. There are three metallurgical keys to this success. First, there is enough alloy in the 312 so that, even with about 30 to 35% dilution from the base metal, any austenite that forms in the weld will be stable, *i.e.,* it will not transform to martensite and therefore, the weld metal will have high ductility. Second, even when welding on base metal of 1% carbon content, the chromiun content in the weld metal is high enough to provide some ferrite in the weld metal. Austenitic weld metal with a little ferrite is highly crak resistant. And third, under normal weld cooling condition, even with carbon pick up from a 1% carbon-steel base metal, most of the carbon will remain in solid solution, so the carbides do not seriously embrittle the weld metal.

The problem with welding on cast iron with 312 - type electrodes is that cast irons are much higher in carbon content than are difficult-to-weld steels. Cast iron typically contains from 2.5% to 4.5% carbon. When this carbon is diluted into the 312-type weld metal, two of the three metallurgical keys to successful welding are overcome by the high carbon. While the austenite that form will be stable, the extra carbon will prevent any ferrite from forming, making the weld metal susceptible to hot craking. In addition, the weld metal will have enough carbon in it that a lot of chromium carbides which destroys the ductility of the weld metal, will be formed. The weld metal then has lot in common with the embrittled HK 40 pipes. As result of this phenomenon weld on cast irons with 312-types electrodes tend to contain both hot cracks and cold cracks. There is no practical escape with 312- type electrodes.

The solution to successful welding of cast iron is to remove the chromium from the system entirely and add enough nickel to keep the austenite stable, even with dilution from cast iron. Then the weld metal is not a stainless steel at all. The normal electrode successfully used for welding cast iron are about 95% nickel (AWS A5.15 Class ENi-CI) or 55% nickel (AWS A5.15 Class ENiFe-CI). ❑

OBITUARY

Mrs. Reeta De

(Wife of Mr. S.K. De, Council Member, IIW)

The IIW Central Council deeply mourns on the sudden demise of Mrs. Reeta De at Kolkata on 18th December 2003, at a premature age. She was a loving lady taking active interest in IIW Matters and assembled several times among Members in IIW's social get-togethers and conquered the mind of all by her grace.

We all sincerely share the grief and sorrow of the whole "De" family is passing through and join in the condolence meeting for the departed soul & pray for the eternal peace of the departed soul.

May the Almighty give the courage and strength to Mr. S.K. De, his whole family and his tender son Sayak, to bear this loss.

Dr. M.N. Dastur

Dr. Minu Nariman Dastur, eminent metallurgist and distinguished steel manufacturers, technologist, & founder Chairman of Dasturco & M.N. Dastur & Co., has been an undisputed leader in Steel Plants Consultancy for nearly 3 decades. He was also a founder member of the Indian Institute of Welding. He and his organisation had always closely co-operated with our Institute, and he was felicitated by IIW for his immense contribution and Lifetime achievement. His demise on 5th January 2004, has been an irreparable loss to all of us at the Indian Institute of Welding and we are deeply grieved and express our heartfelt condolences to his family and pray for the eternal peace of the departed soul. ❑