

WELD WELL

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SERVICE TO THE WELDING COMMUNITY

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First CII seminar on Welding on 16th November, 2016 at Mumbai

HIGHLIGHTS

- [Welding HSLA AISI 4130](#)
- [Temper Embrittlement](#)
- [Welding Symbols](#)

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SPECTRUM



Dear Reader,

The year 2016 has come to an end and with it number of high octave announcements. The most notable was demonetisation of high value currency notes in India. The immediate impact on economy has not been very favourable its long term benefits are expected to be high. We have to wait and see. If manufacturing industry grows the welding fraternity will be benefitted.

The present edition starts with a lead article on welding of AISI 4130 steel. This HSLA group of steel has very high strength to weight ratio making it a structural steel of choice for many applications. This article also covers the selection criteria for filler metal besides welding parameters which need to be taken into consideration for a sound weld joint. It also provides some welding tips. While operating refineries we often face the problem of temper embrittlement.

The section on education throws some light on what it is, what causes it and how to measure proneness to this problem.

The technical section is the second part of Welding Symbols part II. This remains as important as ever to any welding engineer.

Last fifty years we have seen significant development in welding activities in the railways in various areas of manufacturing its hardware. The developments have been chronicled in the review section.

We have been trying our best to bring to you topics of common interest to welding fraternity through our humble efforts. We will nevertheless appreciate your feedback on our efforts. It will motivate us to do better.

Wishing you and your family a very HAPPY AND PROSPEROUS NEW YEAR 2017



Dr. S. Bhattacharya
Editor

Editorial Board: P.S. Nagnathan, Ashok Rai and Kapil Girotra

CII Conference on Welding 2016

The 1st. CII Conference on Welding, organised by CII Naoroji Godrej Centre of Manufacturing Excellence was held on November 16, in Mumbai at the Hotel Taj, Colaba, Mumbai

The theme of the conference was “Welding Innovation, Challenges & Applications in India” based on following sub-themes:

- Welding in India: Advancements and Challenges
- Future Trends – Internet of Things (IoT) Industry 4.0 and Weld Cloud in India
- Evolution of Material Sciences in the Welding sector and the challenges faced
- Skill development and Training in Welding Sector
- Safety and Non Destructive Testing for Welding in India

A survey report “Welding Industry in India” - was presented by Mr. C. Ligade, Director, BDB Projects India.

The conference considered the various key aspects related to the welding sector in India:

- The understanding of the economics of using welding related processes to enhance welding productivity
- Role and contribution of the welding sector to the Indian manufacturing process
- Need for consistency in measurement of welding productivity across establishments where welding is a critical enabling technology
- Shortage of skilled and quality manpower in the welding and associated sectors

Nearly, 200 delegates from across the Industry including our MD, Mr. CC Girotra, participated in the seminar and exhibition. Senior management of leading welding companies like ESAB, Ador Welding, Lincoln, L&T-EWAC, Kemppi, ITW etc. presented their views on the latest trends in Welding.

Some of the Key Conclusions:

- During the conference, some of the key challenges highlighted were “Lack of Welding Knowledge amongst end users”, Lack of Testing & Lack of R&D facilities”.
- Welding market in India has grown at 11% CAGR in last 5 years and is app. INR 4000 Cr now.
- Heavy Engineering, Automotive, Railways, Construction, Ship Building accounts for 70% of the consumption of welding products.

Welding of AISI 4130

INTRODUCTION

The development and use of high strength low alloy (HSLA) steels such as AISI 4130 has been driven by the need to reduce costs. The higher strength compared with a conventional carbon-manganese steel permits thinner and lighter structures to be erected. AISI/SAE 4130 alloy manufactured to MIL-T-6736, is a normalized and annealed seamless tubing possessing a tensile strength of 90,000 psi. This steel is also available in all other forms like sheets, plates, bars, rounds etc. However, this article focuses on welding of tubes only.

AISI 4130 steel belongs to “chrom-moly” group of the HSLA class of steel in AISI classification. The ‘41’ in the nomenclature indicates a low-alloy steel containing chromium and molybdenum and the ‘30’ indicates a nominal carbon content of 0.3%. Chromium (0.8 to 1.1 % by weight) and Molybdenum (0.15 – 0.25 % by weight) act as strengthening agents and the relative low carbon content enables easier welding and fabrication. Tensile strengths of up to 690MPa are achievable whilst still maintaining good weldability and high notch toughness, often better than 50J at -60°C. Applications of AISI 4130 include structural tubing, bicycle frames, tubes for transportation of pressurized gases, firearm parts, clutch and flywheel components and roll cages. Having ductility and specific strength at the same time increases the applications of AISI 4130 in the aerospace, machinery, and motor sports industries. The majority of these steels are to be found in structural applications; offshore structures, yellow goods, buildings, automobiles, shipbuilding, offshore drilling industries (popularly referred as WB36) etc. This is the desired alloy for aircraft and most race car rules that require AISI 4130 structures.

WELDING

AISI 4130 chrome-moly steel can be welded by SMAW, GMAW or GTAW process. While welding the two most important factors to be taken into account are the chemical composition of the weld metal and mechanical properties at the heat-affected zone. The low carbon content, hence low carbon equivalent indicates the low sensitivity to hydrogen cold cracking. The highest risk of cold cracking is in the weld metal, rather in HAZ. A preheat based on the weld metal composition is advisable and low hydrogen techniques must be used.

While welding using SMAW process the base metal should be preheated to 200 - 315 degree C and not

allowed to cool below that until welding is over, to prevent cracking. However, preheat is generally not needed for thinner sections, but for tubing larger than 3 mm preheat is needed for acceptable results. Low-hydrogen electrode is preferred. During GMAW, the transfer of the weld to base metal is more harsh and quicker than a GTAW weld. The ‘short arc’ transfer creates a possibility of more embrittlement along the weld. With GTAW, the base metal is heated first and already at a molten state before filler is added. GTAW welding is the process of choice. If Gas welding is used it allows greater heat input, taking the stress out of the weld.

FILLER METAL SELECTION

As with any welding application, using a low-alloy filler metal that provides the appropriate strength, ductility, toughness, and crack resistance in the final weld is critical to successful welding. However, because so many varieties of low-alloy steel are available, each with unique characteristics, there is no “one size fits all” filler metal for the job. As always, consider the mechanical and chemical properties of the specific low-alloy steel being welded and the intended service conditions of the application before you select a low-alloy filler metal.

As a rule, the HSLA steel make the material less ductile and more prone to cracking after welding. Therefore, although, matching filler can be used for applications where the weld are to be heat treated, but for other applications it is not recommended. For welding AISI 4130 (a fairly brittle alloy), a more ductile alloy filler material, which gets fused is recommended. Using a filler metal with low levels of diffusible hydrogen helps in minimizing cracking, as can implementing of proper pre-heating procedures.

The goal, when welding low-alloy steels, is to match the strength and chemistry of filler metal and base material as closely as possible. In some cases, the filler metal may actually have to exceed the base metal’s strength if the joint design indicates it is the best procedure. If a welding procedure requires two different types of low-alloy steels to be welded together, matching the filler metal to lower-strength material can provide the appropriate ductility to help prevent cracking.

Other factors that influence how to match a low-alloy filler metal to a given low-alloy steels include:

- Material thickness: Some low-alloy steels (such as

Q&T steels) lose strength at thicker dimensions, requiring a lower-strength filler metal for the job.

- Cyclical loading: A finished part that will be subject to high stress and fatigue will require a filler metal with higher toughness to protect against cracking.
- Postweld heat treatment (PWHT): If a welding procedure calls for PWHT, the filler metal must be able to maintain its mechanical properties after heating. Fillers with added molybdenum are often suitable.

In many applications, such as, motorsports applications, engineers want some degree of ductility in the weld to help absorb impacts and prevent cracking. Although there are several good filler materials, according to AWS A5.18 recommended filler is ER80S-D2, capable of producing MIG welds that approximate the strength of AISI 4130. For TIG, ER70S-2 is an acceptable alternative to ER80S-D2, although the weld strength will be slightly lower. The filler material, when diluted with the parent material, will typically under match the AISI 4130 strength. However, with the proper joint design (such as cluster or gusset, for example), the cross-sectional area and linear inches of weld can compensate for the reduced weld deposit strength

For areas requiring higher strength, such as spindles and upper and lower control arms, fabricators select ER80S-D2 filler, which produces welds with a high tensile strength and selecting ER70S-2 for filler for roll cages, chassis and other applications requiring more flexibility. While actual tensile strength of the weld will vary and depend on other factors, 4130 diluted with ER70S-2 filler is likely to produce a weld with a tensile strength in the 80,000 to 82,000 psi range. Some fabricators prefer to use austenitic stainless steel fillers to weld AISI 4130 tubing. This is acceptable provided E310 or E312 stainless steel fillers are used. Other stainless steel fillers can cause cracking. Stainless filler material is typically more expensive. The filler metals should be purchased in a hermetically sealed container and properly stored after opening to minimize the pickup of hydrogen.

WELDING PARAMETERS

Some of the guidelines to select proper welding parameters as applicable to a specific welding process are as under:

Amperage: 1 amp per 0.0254mm of wall thickness

Polarity: DC Electrode Negative

HF for arc starts only

Pulsing: Optional

Tungsten: 2% Ceriated Type

Diameter: 1.6 – 2.4 mm (smaller diameter for thinner wall)

Electrode Preparation: Pointed

Arc Length: Less than or equal to the electrode diameter

Electrode Stick-out: No further than the distance of the inside diameter of the cup being used. However using a gas lens can extend this distance

Gas Lens: Not required, but helpful if a tight joint configuration demands a longer stick out or involves multiple tubes. Keep the screen free of debris and spatter

Shielding Gas and flow: 100% Argon, 7–9 lit / min. Excessive gas creates turbulence sucking air into the weld

Pre-flow: 0.4 to 0.6 seconds

Post-flow: 10 – 15 seconds

Backing Gas: Follow applicable codes/standards, if any

Pre-heat: Not required as long as tubing is above 15 – 20 degrees C

Tack Welds: Four tacks made 90 degrees apart; tacks ideally should be longer than wide.

Joint Preparation: Tubing notcher for coping, drum sander for final fit-up, deburring for edge preparation, and final clean with acetone, lacquer thinner or similar solvent to remove oil

Joint Gap: None. Realistically, gaps smaller than 0.010 are permissible; larger gaps promote poor quality of joint

Filler Material: ER70S-2 or ER80S-D2-Filler

Diameter: 0.76 – 3.15mm.

Stress Relief: Not required on material < 3.15 mm; simply allow the weld to air-cool. Thin wall tubing normally does not require stress relief. For parts thicker than 0.120", stress-relieving is recommended and 600° C is the optimum temperature for tubing applications. An Oxy/Acetylene torch with neutral flame can be used. It should be oscillated to avoid hot spots.

TIPS FOR WELDING AISI 4130

The following provides some of the important tips for welding of this steel to get a good weld joint:

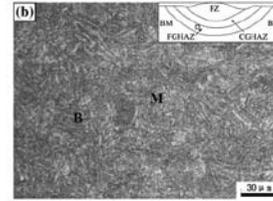
- Remove surface scale and oils with mild abrasives and acetone. Wipe to remove all oils and lubricants. All burrs should be removed with a hand scraper or de-burring tool. Better welding results are obtained with cleaner materials
- Back purging is normally not necessary, but it improves the root pass of some welds, as the weld penetration

can pick up oxygen. Purging extends the melt time. Spend the least amount of time possible by travelling as fast as possible

- Rapid quenching of the metal will create problems such as cracking and lamellar tearing. Always allow the weld to cool slowly
- The GTAW process provides sufficient heat control. To better control heat input, and to enable repositioning of the body it is recommended to employ better control over torch movement,
- Do not weld the circumference of a tube in one pass. Rather, weld it in four quarters. Weld only two of the quarters (on opposite side of the tube) then move to another joint. When the first joint cools, come back and complete the remaining sections.
- Filler rod diameter should match the thickness of the base metal.
- Use a TIG machine with high frequency starting to eliminate arc strikes. Taper off amperage slowly to avoid crater holes that will turn into cracks later on
- Most joints in aircraft, and in racing cars, are small and are of thin walled tubing which will dissipate the heat quickly, and spread the induced stresses away from the joint. Field stress relieving will help reduce this built up joint stress, but for complete structures, an oven is best
- A nearly perfect fit up of the joints must be ensured. Clean the joints bare inside and out as much as possible. Preferably use a drum sander to the inside and polish the outside. Then use acetone to strip the oils
- Weld Technique: Weld in one continuous motion, pulsing the foot control and adding filler rod to create the “stack of dimes” appearance (or use the machine’s pulsing controls). Do not stack separate puddles on top of each other, as this may lead to incomplete fusion.
- End-of-Weld Procedure: Avoid pinholes by tapering off heat input at the end of the weld and maintaining a constant distance between the tungsten and the weldment
- Weld Appearance: A good weld looks shiny and has a bluish tint. A dirty, gray-looking weld may indicate poor shielding gas coverage or excess heat
- Keep welds to within their specified size: a weld needs to be no larger than its thinnest section, which will be the “weakest link” in the chain. Larger-than-necessary welds add excess heat and waste gas, filler rod and time.

MICROSTRUCTURE

In the PWHT condition the microstructure of AISI 4130 weldment consists of tempered high strength ferrite.



JOINING AISI 4130 TO DIS-SIMILAR METAL

One of the typical applications is joining of AISI 4130 to dissimilar metal like ASTM A514 (T1). As a rule when welding HSLA (AISI 4130) to lower strength steel like T1 (A 514), the primary factor of concern is strength in the weldment. Therefore, the loading conditions dictate the filler metal strength selection not the materials being welded. Undermatched filler metals with low diffusible hydrogen levels offer least potential for cracking. AISI 4130 material has a wide range of mechanical properties that will be based on the heat treatment condition of the material. It will have a range in ultimate strength of 120 ksi to more than 225 ksi, and yield strength of 95 ksi to nearly 200 ksi. ASTM A514, depending on the grade that is being used, can have an ultimate strength of 110 ksi to 130ksi, and minimum yield strength of 100ksi. Stick electrodes such as E7018 may be acceptable given appropriate loading conditions. However, matching the lower strength of the two materials, depending on loading conditions and joint configuration also can generate an acceptable solution. In this case, it is most likely that the A514 material is the lower-strength material, and stick electrodes such as E11018 or E12018 would be acceptable to match the A514. The AISI 4130 material has significant hardenability (depth of maximum hardening) and can reach a high hardness as well due to the carbon content. A preheat and minimum inter-pass temperature of 230° to 260°C should be maintained to reduce the chances of hydrogen-assisted cracking. The maximum preheat for A514 is 95°C and, depending on the thickness of the A514, heat input must be controlled to avoid over-tempering the heat affected zone. That would produce an undesirable loss of ductility and strength. To balance the needs of both steels, a maximum preheat of 95°C should be used. The maximum heat input then will be determined by the thickness of A514 material. For example: Maximum heat input of 40 KJ/in. can be used to weld in. thick A514 for T1 and T1 Type C steels, and only 18 KJ/in. for Type A and B.

Good low hydrogen practice must be maintained when

...continued on Page 7

What is Temper Embrittlement, and How Can it be Controlled? *,**

INTRODUCTION

A major application of 2.25% Cr - 1.0% Mo steels is in the fabrication of pressure vessels to be used in oil refining operations where the materials are subjected to elevated temperatures for extended periods of time. Due to this long term exposure, a phenomenon known as temper embrittlement has a tendency to occur. Temper embrittlement refers to the decrease in notch toughness of alloy steels when heated in, or cooled slowly through, a temperature range of 400°C to 600°C. Temper embrittlement can also occur as a result of isothermal exposure to this temperature range. The occurrence of temper embrittlement can be determined by measurement of the change in the ductile to brittle transition temperature with a notched bar impact test, before and after heat treatment. In most cases, the hardness and tensile properties of the material will not show any change as a result of embrittlement, but the transition temperature can be raised by as much as 100°C for embrittling heat treatments.

CAUSES

Temper embrittlement is caused by the migration of certain elements within the material to the grain boundaries over time, causing a loss in toughness. The presence of specific impurities in the steel, which segregate to prior austenite grain boundaries during heat treatment causes the embrittlement. The main embrittling elements (in order of importance) are antimony, phosphorous, tin and arsenic. The fracture surface of a material embrittled by these elements has an intergranular appearance. P, Sb, Sn, and As migrate at high temperatures, and given sufficient concentration and time, may accumulate and weaken the grain boundaries in the weld metal, embrittling these regions. Higher manganese and silicon also increase temper embrittlement. However, these elements are necessary for good weldability.

Plain carbon steels with less than 0.5% Mn are not susceptible to temper embrittlement. However, additions of Ni, Cr and Mn will cause greater

susceptibility to temper embrittlement. Small additions of W and Mo can inhibit temper embrittlement, but this inhibition is reduced with greater additions. The original toughness of a steel which has suffered temper embrittlement can be restored by heating to above 600°C, and then cooling rapidly to below 300°C. However, the best method of avoidance is to reduce the embrittling impurities through control of raw materials and steel production.

DETERMINATION

Step cooling can reveal the susceptibility of a steel to temper embrittlement. The Charpy impact energy and transition temperature for steel after an embrittling heat treatment involving step cooling have been related to give a mathematical expression that when fulfilled ensures that the material will not suffer an unacceptable degree of temper embrittlement in service.

$$AF + 2.5(SC - AF) < 38^{\circ}C$$

where

AF = temperature at Charpy value of 54J in as welded condition

SC = temperature at Charpy value of 54J in Step cooled condition

This expression is used in the construction of pressure vessels that may operate in the embrittling temperature range, or that may pass slowly through that temperature range upon startup or shutdown. One step cooling method with hold times and temperatures is given in ASTM A387, supplementary requirements although this gives a more stringent requirement for the acceptable degree of temper embrittlement. Temper embrittlement has been also related to reheat cracking and low-ductility creep fractures.

As a means to judge the relative temper embrittlement resistance of a material, the so called J - and

*TWI Website, ** Material and Welding Blog, Saturday, September 1, 2007

X - factors were developed. In order to assess susceptibility to temper embrittlement in Cr-Mo steels, two compositional parameters are commonly employed, the Watanabe J factor and the Bruscati X factor. X - factor is also called X - bar. Note, too, that "X - factor" applies only to weld metal. For base steel, "J - factor" characterizes the temper embrittlement susceptibility, using compositional parameters Mn, Si, P, and Sn.

$$J = [(Mn + Si) x (P + Sn)] x 104$$

where the various elements are expressed in wt %. Most common specifications call for a J-factor of less than 150 but values as low as 120 have been seen. The control of these elements in the base material is critical since the Mn and Si tend to cosegregate with the P and Sn to cause the loss in toughness.

For the weld metal, the J - factor is not suitable since the rapid solidification and cooling rate of the weld beads do not allow time for the cosegregation of the Mn and Si. In fact, both Mn and Si are needed in the weld metal system; the Mn to develop the needed toughness and the Si for weldability.

Therefore, the X - factor was developed as a better means to judge the relative temper embrittlement resistance of the weld metal by incorporating the residual elements Phosphorus, Antimony, Tin and Arsenic as follows:

$$X = (10 P + 5 Sb + 4 Sn + As) / 100$$

where the elements are expressed in ppm. Typical specifications currently call for a maximum X - factor of 15 though many fabricators ask of a maximum value of 12. This calculation has proven much more effective in gauging the temper embrittlement resistance of the weld metal by controlling those elements that tend to affect the toughness the most while not considering Mn and Si due to the inherent differences in the steel and weld metal.

If J is less than or equal to 150, or if X is less than 15, the risk of temper embrittlement is considered to be low. Often this figure of J is 120 and that of X is 12. A limit in this form can be specified for procurement,

where concerns over temper embrittlement exist.

A more general expression for embrittlement in weld metals was given by Sugiyama:

$$P E = C + Mn + Mo + Cr/3 + Si/4 + 3.5 (10P + 5Sb + 4Sn + As)$$

where the various elements are expressed in wt %. The maximum value for this expression to avoid serious embrittlement depends on the welding process, but is given as 2.8 - 3.0 where coarse grained weld metal exists.

Kobelco TG- Super 304H

In the last edition of Weldwell Spectrum we covered welding of Super 304H used for fabrication of heat exchanger of USC boiler using fossil fuel. We have been informed that Kobelco also has a product, TG- Super 304H, for the purpose. TG- Super 304H has been developed for welding Super 304H, the heat exchanger tube for USC fossil-fired boilers. It provides excellent creep rupture strength, hot crack resistance and weldability. The outer bead and the root pass bead appearance of are excellent.

We regret the omission.

...Lead Article continued from Page 5

joining these steels which includes but is not limited to:

- Proper material preparation that includes removing mill scale, dirt, rust, grease or other hydrocarbon producing materials.
- Proper filler metal control that includes the use known materials that are from a new, hermetically sealed container or storage properly in a rod oven in accordance with manufacturers recommendations.
- Additionally, the materials shall be stored to minimize hydrogen pickup once opened.

CONCLUSION

AISI 4130 is finding applications in various sectors from just tube structures to airplanes to off shore industry due to its high strength to weight ration. The strength is contributed by chromium and molybdenum as the alloying element and weldability is good due to low carbon content. Though its welding is not very difficult but precautions need to be taken for a good weld joint.

Welding Symbols - The Basics* - Part 2

This is second part of the article. The first part was published in the earlier edition of this newsletter. Some more details have been explained in this part.

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DIMENSIONS AND ANGLES

Needless to say, numbers are also a big part of a welding specification. The width, depth, root opening and length of a weld, as well as the angle of any bevelling required on the base metal before welding can all be communicated succinctly above or below the reference line (Fig.6).

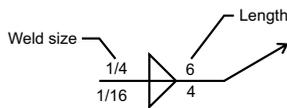


Fig.6: Showing dimensions of the weld

In most cases, the weld width (or diameter) is located to the left of the weld symbol (expressed here in inches), while its length is written to the right (the weld's width is the distance from one leg of the weld to the other). Often, no length is indicated, which means the weld should be laid down from the beginning to the end of the joint, or where there's an abrupt change in the joint on the base metal.

Dimensions written below the reference line, of course, apply to the joint on the arrow side, while dimensions written above apply to the joint on the other side. In the image above, welds are indicated for both sides of the joint.

Sometimes, a series of separate welds is specified, rather than a single long weld. This is common when thin or heat-sensitive metals are welded on, or where the joint is a really long one. In the following symbol and drawing, 3-inch intermittent fillet welds are specified (Fig.7):

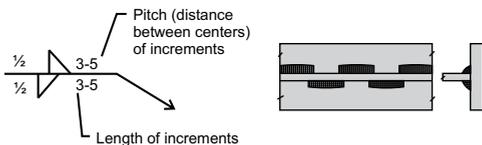


Fig.7: Intermittent fillet welds

Notice that the weld symbols on either side of the reference line above are offset, rather than mirroring each other. This

means the welds should be located at staggered spots on either side of the joint, as shown in the drawing (Fig.7). A weld symbol may also specify an angle, root opening or root face dimension (Fig.8). This is common when the base metal to be welded on is thicker (than 1/4 inch). The following example is a symbol and drawing calling for a V-groove joint:

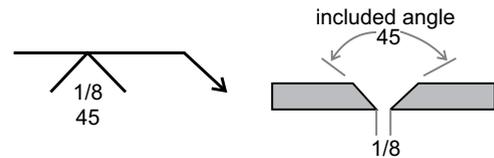


Fig.8: Showing angle, root opening or root face dimension

Here, the groove weld has dimensions written inside the symbol. The first is 1/8, which pertains to a root opening of 1/8 inch. The larger number below it signifies 45 degrees, which represents the included angle between the plates. Moving to another part of the overall welding symbol, at the intersection of the reference line and the leader line, two other symbols may be inserted, as shown below:

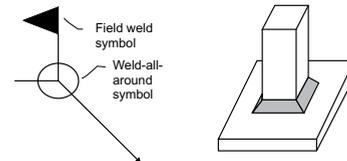


Fig.8A: Additional symbols

A flagpole indicates a field weld, which simply tells the welder to perform the work on site, rather than in the shop. The weld-all-around circle, located at the same juncture, means just that. While this symbol is often used in pipe and tubing, a non-circular structural component (as shown above right) may likewise need welding on all sides.

Here are a few other types of instructions you might see on a drawing:

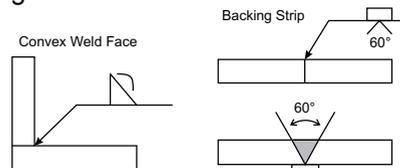


Fig.8B: Additional symbols

**Based on an article by Rosemary Regello*

A curve located above the weld symbol's face specifies that the finished weld should be flat, convex or concave. (If you see a straight line, then it's a flat weld - i.e. flush face.) As shown on the top right, a V-groove weld symbol with a box above it indicates a backing strip or bar is required for this joint. The strip or bar must be welded onto the back side of the joint before the groove weld is performed.

A backing strip or bar is sometimes confused with a "back weld" or a "backing weld". They are not the same thing as using a backing strip. A back weld is where a second weld is created on the back side of the joint after the primary groove weld is completed. Conversely, a backing weld is a weld that the welder performs first (so it serves the same function as a backing strip). A backing strip is a piece of metal welded on to the bottom of the plates to facilitate a smooth, even weld. Each of these three options are illustrated below (Fig. 9) using both the tail and the weld symbol to communicate what needs to happen.

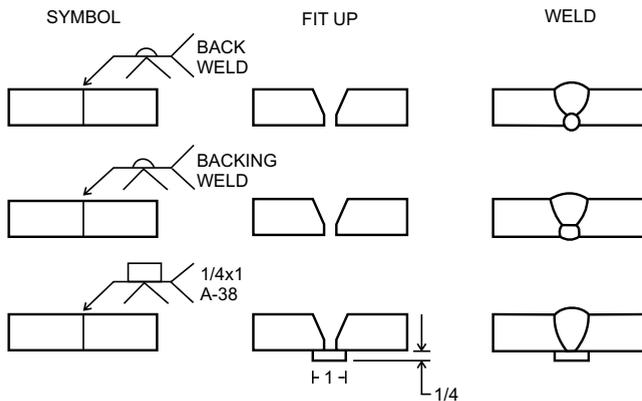


Fig. 9: Welding fit up

It can be seen that the only difference between the back and backing welds is when they're performed. The symbols look the same, so both must be specified by name. In the third symbol, the dimensions and type of steel (A-38) for the backing strip are specified.

When a welding operation involves a lot of steps and to keep the instructions clear, several reference lines may extend from the leader line at a parallel trajectory. Each line represents a separate operation and is performed in order, beginning with the line closest to the arrow, as shown below (Fig. 10):

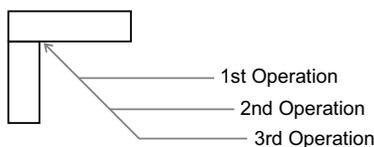


Fig.10: Welding with multi operations

As you just saw in the case of the backing strip, the forked tail of the welding symbol is used to convey details that aren't part of the normal parameters declared on the reference line. For instance, the engineer or designer might want the welder to use stick welding (i.e. SMAW), or another welding process. Or there may be other information to convey (Ref. Fig. 11):

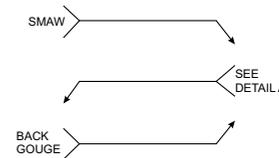


Fig. 11: Indicating other information

RULES FOR APPLYING SYMBOLS

There are some simple rules which must be applied while applying the welding symbols as follows:

1. Symbols for fillet and similar welds be shown such that the vertical position of the symbol are indicated on the left hand side of the symbol, irrespective of the orientation of the weld metal.
2. If the welds are to be made on the arrow side of the joint, the corresponding symbol should be placed either above or below the continuous reference line (Fig.)
3. If the welds are to be made on the other side of a joint, the corresponding symbol should be placed above or below the dashed reference line (Fig.)
4. If the welds are to be made on both sides of the a joint, the corresponding symbols should be placed on both sides of the reference line and the dashed line is not shown (Fig.)
5. The arrow of the symbol must point towards the joint which required welding (Fig.)
6. When only one member is to be edge prepared to make the joint, the arrow should point at the plate (Fig.)
7. Dimensions of size are indicated in mm without writing the unit mm.
8. If unequal legs of fillet are to be used, they should also be given on the left hand side.
9. If a welding is required to be made on the site or during erection or assembly, it is re
10. If a weld is to be made all around a joint, a circle should also be placed at the elbow, connecting the arrow and the reference line.(Fig.)
11. If a weld is to have a flush or flat finish, a straight line should be added above the symbol.
12. The welding process is indicated, if required, at the end of the arrow (Fig.)

Welding and its Progression in the Railways

FIRST TRAIN IN INDIA

The customary answer to this question is 3:35 pm on 16th April, 1853, when a train with 14 railway carriages and 400 guests left Bombay's Bori Bunder for Thane. That, however, was just the first commercial passenger service in India. In fact, a few other railways are known to have operated in India prior to 1853, for hauling materials. However, the use of rail transport in India can be traced back a decade and a half before this. One of them may even have been built in India, meaning the Indian locomotive building industry can trace its roots back to the dawn of railways, not just in India but in the world. The railway in question was known as the Red Hill Rail and was built in Madras by the Porto Novo Iron Company in 1836. Perhaps best known of these early pre-1853 railways is the steam locomotive, Thomason, said to have begun working there on 22nd December 1851. Later it was assembled on the spot from parts transported from Calcutta.

WELDING IN THE INDIAN RAILWAYS

The progression of welding in the Indian Railways is the story of triumph of technology. The Indian Railways have moved forward with the adoption of modern welding technologies. Introduction of welding technology has also been in pace with economic growth of the country. As a result, use of welding consumables and equipments also enhanced manifold. Different types of materials are being used for different types of coaches and wagons bringing in major changes in the type, design and fabrication technology of the wagons and coaches.

Earlier, most of the fabrication in rolling stocks such as coaches, wagons and locomotives used riveted design. However, welding process slowly became the main fabrication process with time. Chronicalisation of progression of welding in Indian Railways is difficult since many of the technologies were simultaneously developed for usage. It is thus, for the purpose of simplicity, befitting that we move on from SMAW to the latest welding technologies used in Indian Railways.

SHIELDED METAL ARC WELDING (SMAW)

Prior to the fifties welding was only used as a method of repairs. Due to various constraints – both economical and technological, SMAW process was the predominant process of welding in Indian Railways. It is interesting to note that the same rutile type of electrodes was used for all different varieties of steels. The SMAW process continues to be the predominant method for repair and maintenance of railway components even today. This process is also used extensively in the fabrication of permanent installations like platform structures, overhead traction structures, foot-over bridges and higher capacity wagons. Though SMAW was mostly used initially for the fabrication of rolling stocks, its use now is considerably reduced and only about 50% welding fabrication is undertaken with this process to take care of areas which are inaccessible to automatic or semi-automatic processes. SMAW is also used for reclamation / repair of motion components. Another area where SMAW is extensively used is in the reclamation / resurfacing of components like Medium Manganese worn out points and crossings. The bridges on the railways were steel girder bridges. Though the girders of these bridges were of riveted design, the flooring systems of these bridges were provided with welded design. SMAW process was used for welding of the flooring systems.

SUBMERGED ARC WELDING (SAW)

Along with the SMAW, submerged arc welding is also used for the fabrication of rolling stocks. This process is mainly used for fabrication of longer members. Automatic SAW is used where the joints are long and uninterrupted and semi-automatic SAW for the other locations. Initially, SMAW was used for building up of worn out flanges, but this process was not very productive. It was therefore decided to switch over to SAW method. This prompted the railways to import 3-head sub-merged automatic welding machine for improved productivity and quality of weld deposit. Based on the experiences gained with this imported 3-head submerged arc welding, indigenous multiple-head sub-merged arc welding machines have been

developed for use in the Indian Railways.

GAS TUNGSTEN ARC WELDING (GTAW)

The armature coils were originally connected with conventional soldering method. These joints were weak and frequently failed in service due to increased resistance between the two adjoining commutator segments. These joints were later made by Automatic GTAW process using a special technique. GTAW process is also used for repairing of overhead aluminium and stainless steel water tanks in coaches. The aluminium Pistons, made of forged aluminium alloy used to get damaged in service. These used to be replaced earlier by new pistons. Later, with the introduction of GTAW process in the Railways, the damaged pistons were reclaimed by GTAW process using 1.6 mm aluminium alloy wires.

GAS METAL ARC WELDING (GMAW)

Along with SMAW and SAW, GMAW process is used for the fabrication of long components like bridge girders, under frames and bogies of rolling stocks and also superstructures of carriage and wagons. Rail Coach Factory at Kapurthala uses GMAW process with solid and flux cored wires while Integral Coach Factory at Chennai uses mostly flux cored wires. GMAW process is used for rehabilitation of coaches. Almost 50 to 70% components in coaching stocks including chassis, under frame (for maintenance), head stock etc. are subjected to GMAW. Gas mixture of carbon dioxide, argon and oxygen are used for Mid Life Rehabilitation of coaches after its 12.5 years of service. Flux cored wires are used with this gas mixture. Stainless Steel is used for the construction of coaches and wagons. GMAW are used with solid wires as well as flux cored wires and gas mixtures for their fabrication. Stainless steel components are welded at some locations with dissimilar metals. Stainless Steel is also used for inside furnishing of the coaches. FCAW is used at ICF while RCF uses solid wires.

OTHER WELDING PROCESSES

Robotic welding has been started for the manufacture of coaches both at ICF, Chennai and also by the private companies. This process is also used for manufacturing of wagons and bridge girders in a

limited way. Since this is an automatic process, quality of welds is better besides improving the productivity.

The Friction welding is the only method for joining two portions of bi-metallic diesel engine valves. The quality of the joints is satisfactory and hardly any weld failure has been reported. Electrical Resistance Welding (ERW) process is used for welding of the chain links used for the Break down trains and also for joining alloy steel tool bits with the mild steel shanks. Pipes and tubes used in carriage and wagons are also welded by this method. There are three more important processes for welding of rail joints: Alumino-Thermic, Flash-Butt and Gas Pressure welding. Alumino-Thermic, commonly known as Thermit welding, is the pioneer in-situ rail welding process throughout the world. The process is simple and no expensive equipment is required.

Flash-Butt welding of rail joints is carried out regularly in workshops for joining 3,5,10 and 20 rails to form long welded rails as required. Welding is carried out mostly by an automatic electric resistance welding machine. Mobile Flash-Butt welders are also now available which are used at site in some of the divisions of Indian Railways. Gas Pressure Welding is also another method of joining of rail ends. This process is extensively used in many of the advanced countries for their high speed. Only two divisions of railways in India have used this process.

CONCLUSION

Indian Railways use almost all welding processes available today. As a result, use of welding has progressed leaps and bounds in Indian Railways and today they are the largest users of welding consumables and equipments in India.

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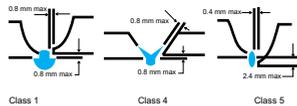
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