PROCEDURE

FOR

MAGNETIC PARTICLE EXAMINATION

OF

FERRITIC MATERIALS AND WELDED COMPONENTS

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RECORD OF REVISION

Rev.No.	Date of revision	Reason for revision
01	28 07 99	Revision in entirety
02	14 08 03	Clause 14.0,19.44,18.1and23.0 added Clause 15.1.1,21.2,21.3,22.2 and22.3 modified

1.0 SCOPE

1.1 This procedure describes the method, techniques and acceptance standards for Magnetic particle Examination of all shapes of ferromagnetic product forms in Boiler components, Boiler Auxiliaries, pressure vessels, Heat Exchangers and Structurals.

1.2 The examination shall include all Gas cut openings, attachment welds with a throat thickness over 6mm and on finished surface of welds as required by referencing code/section. The examination includes base material 13mm on each side of the welds.

2.0 REFERANCE

2.1 ASME Section V,I & VIII (Division 1 & 2) – 2002 Addenda

2.2 ASME B 31.1 (2001)

2.3 ANSI / AWS D 1.1 (2002)

3.0 EQUIPMENT

3.1 Equipments generating half-wave rectified alternating current employing prods at the end of magnetizing cables shall be used for examination by circular magnetization method.

3.2 Direct / Alternating current electromagnetic yokes shall be used to detect discontinuities that are open to the surface of the part by longitudinal magnetization method and to examine the surface where arcing is not permitted or prod method is not practicable.

4.0 EXAMINATION MEDIUM

4.1 The ferromagnetic particles used as examination medium shall be either wet or dry. Wet particles shall be non – fluorescent type.

4.2 Dry magnetic particles black, gray or red in color shall be used as examination medium for examination of welds and other product forms to provide adequate contrast with the surface being examined. The surface temperature of the part examined with dry particles shall not exceed 315°C.

4.3 Non fluorescent wet particles will be black or reddish brown in color that provide adequate contrast with the surface being examined. Wet particles shall be suspended in kerosene for application to the test surface by flowing or spraying. Suitable conditioning agents shall be added to the water to provide proper wetting and corrosion protection for the parts being examined.

4.4 The temperature of the wet particle suspension and the surface of the part being examined shall not exceed 57°C.

4.5 The bath concentration shall be determined by measuring the settling volume through the use of pear-shaped centrifuge tube. The settling volume shall be within 1.2 ml to 2.4 ml for non- fluorescent particles.

5.0 SURFACE CONDITIONING

5.1 Preparation

5.1.1 As welded, as rolled, as cast or as forged surface is generally acceptable provided the surface irregularities will not mask the indication due to discontinuities. Otherwise surface preparation by grinding or machining may be necessary. Undercuts, Overlaps or abrupt ridges and valleys in the welds and opening shall be smoothly merged with the parent metal.

5.1.2 Prior to magnetic particle examination, ensure that the surface to be examined and adjacent area within at least 25mm of the area of interest shall be dry and free of any dirt, grease, lint, scale, welding flux, spatter, oil or other extraneous matter that would interfere with the examination.

5.1.3 Cleaning may be accomplished by detergents, organic solvents, descaling solution and paint removers, sand or grit blasting method.

5.1.4 Thin nonconductive coating such as painting will not normally interfere with the formation of indications. They must be removed at all points where electrical contract is to be made for direct magenetisation.

5.2 Surface contrast Enhancement

5.2.1 When coating are applied temporarily to enhance particle contrast or if coating are left on the part being examine, it must be demonstrated that indications can be detected through the enhanced coating thickness on a test plate with machined grooves as in 16.0

5.2.2 If indications of required sensitivity could not be detected, the coating shall be removed.

6.0 METHOD OF EXAMINATION

6.1 Examination shall be made by continuous method.

6.1.1 Dry continuous magenetisation method

6.1.1.1 The magnetizing current remains on while the examination medium (Dry particle) is being applied and while the excess of the examination medium is being removed.

6.1.2 Wet continuous magenetisation method

6.1.2.1 The magnetic particle application involves bathing the surface of the part with examination medium and terminating the bath application immediately prior to cutting off the magnetizing current with two or more shots given to the part. The duration of the magnetizing current is typically on the order of ½ seconds.

7.0 TECHNIQUES

7.1 One of the following magnetization techniques shall be used.
a) Prod Technique
b) Yoke Technique

8.0 TYPE OF CURRENT FOR MAGNETISATION

8.1 Single phase half –wave rectified current (HWAC) / (HWDC) shall be employed for testing with prod techniques.

8.2 The amperage required with single – phase Half-wave rectified current shall be verified by measuring the average current during the conducting half cycle only.

8.3 For Yokes, the current shall be either AC or DC.

9.0 CALIBRATION

9.1 Ammeter of magnetizing equipment shall be calibrated as per NDT: WI:004 at least once a year, or after each time it has been subjected to major electrical repair, periodic overhaul or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

9.2 Lifting power of yokes

9.2.1 The magnetizing force of yokes shall be checked at least once a year or whenever a yoke has been damaged. If a yoke has not been in use for a year or more, a check shall be done prior to first use.

9.2.2 Each alternating current electromagnetic yoke shall have a lifting power of at least 4.5 kg and direct current / permanent magnetic yoke shall have a lifting power of 18.kg, at the maximum pole spacing that will be used or the pole distance shall be the spacings at which the yoke lifts the stipulated weight.

9.2.3 Each weight shall be weighed with a scale from a reputable manufacturer and stenciled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.

10.0. EXAMINATION

10.1 Direction of magnetization

10.1.1 At least two separate examination shall be carried out on each area. During the second examination the prods/poles are spaced so that the lines of flux are approximately perpendicular to those used during the first examination. A different technique for magnetization may also be used for the second examination

10.2 Examination Coverage

10.2.1 Examination shall be made with sufficient overlap to assure 100% coverage of testing.

11.0 PROD TECHNIQUE: (Fig. 1,2&3)

11.1 Magnetizing procedure

11.1.1 The prod electrodes are pressed firmly against the surface in the area to be examined. In order to avoid arcing a remote control switch shall be built in to the prod handles, to permit the current to be turned on after the prods have been properly positioned and to be turned off before they are removed.

11.2 Magnetising current

11.2.1 The current shall be 100 to 125 (maximum) amperes/25mm of prod spacing for sections 19mm thick or greater.

11.2.2 For sections less than 19mm thick, the current shall be 90 to 110 amperes / 25mm of prod spacing.

11.3 Prod spacing

11.3.1 Prod spacing shall not be less than 75mm nor exceed a maximum of 200mm.

11.3.2 The prod tips shall be kept clean and dressed and the contact areas of the test surface shall be free from dirt, scale, oil etc, to minimize electrical arcing. In the open circuit voltage of the magnetizing current is greater than 25 volts, Lead, steel or Aluminum rather than copper tipped prods shall be preferred to avoid copper deposits on the part being examined.

12.0 YOKE TECHNIQUE

12.1 The pole spacing shall be between 100mm to 150mm. The field indicator will be used to check the direction of the part magnetization.

13.0 APPLICATION OF DRY PARTICLES

13.1 The dry particles shall be applied in such a manner that a light uniform dust-like coating settles on the surface of the area being examined. The application technique shall be such that the particles are suspended in air and reaches the examination surface in a uniform cloud with a minimum forces, using a hand powder applicators (Squeeze bulb) or specially designed mechanical blower or by a spray nozzle.

13.1.1 Dry particles shall not be applied to a wet surface nor when there is excessive wind. The particles shall not be applied by pouring, throwing, or spreading with fingers.

13.1.2 Any excess powder shall be removed while the magnetization current is on and shall be with a gentle air stream without removing or disturbing particles attracted by a leakage field that may prove to be a relevant indication.

13.2 APPLICATION OF WET PARTICLES

13.2.1 The application of wet particles involves the bathing of the area to be examined, by spraying or flowing during the application of magnetizing current.

13.2.2 Two or more shots shall be applied, but the last shot shall be applied while the bath still remains on the area to be examined and after the particles flow has been stopped. Care shall be taken to cut off the bath application before removing the magnetic field, to prevent high-velocity particle flow that wash away or remove fine or weakly held indications.

14.0 MAGNETISING FIELD ADEQUACY AND DIRECTION

14.1 By using one or more of the following three methods, the magnetizing field adequacy and direction may be verified.

14.1.1 Pie shaped Magnetic Field Indicatior, artificial flaw shims and Hall effect Tangentisl Field probe.

15.0 LIGHTING

15.1 Visible Light Intensity

15.1.1 The examination and evaluation of indications shall be performed under minimum light intensity of 100 fc (1000 lx).

16.0 SYSTEM PERFORMANCE CHECK (Fig. 4)

16.1 For prod magnetization with HWAC, performance sensitivity shall be checked at least once in a shift before start of the examination on a test plate that contains machined grooves to different depths. The indication of a groove at 3mm depth from the surface of the test plate will indicate adequate sensitivity.

16.2 If the part is to be tested with contrast coat, the sensitivity shall be checked with the contrast coat on the surface of the test block.

16.3 For electromagnetic yokes, the adequacy or direction of the magnetizing force shall be verified by positioning the 'Magnetic Field Indicator' on the surface to be examined. The pattern in the indicator should be clearly developed on the surface of the block.

17.0 DEMAGNETISATION

17.1 No demagnetization will be done after the test except specifically required.

18.0 EVALUATION OF INDICATION

18.1 Mechanical discontinuity at the surface would be indicated by the retention of the powder or medium.

18.1.1 All the indication are not necessarily discontinuity indications since certain metallurgical discontinuities and magnetic permeability variation may produce similar unacceptable discontinuity indication. These non-relevant indications shall be reexamined by any other suitable NDT methods such as Liquid penetrant or macro etching.

18.2 Relevant indications are those which result from unacceptable mechanical discontinuities.

18.2.1 Linear indications are those indications in which length is greater than three times the width.

18.2.2 Rounded indications are circular or elliptical with the length equal to or less than three times the width.

19.0 ACCEPTANCE STANDARDS AS PER ASME (SEC I,VIII Div 1&2 and B 31.1) AND OTHERS

19.1 **Welds and Materials**

19.2 An indication of an imperfection may be larger than the imperfection that causes it: however, the size of the indication is the basis for acceptance for evaluation.

19.3 Only indications with major dimension greater than 1.6mm shall be considered relevant.

19.4 All surface to be examined, except as mentioned in 19.5, 19.6 and 19.7 shall be free of

19.4.1 Relevant linear indications.

19.4.2 Relevant rounded indication greater than 4.8mm

19.4.3 Four or more relevant rounded indications in a line separated by 1.6mm or less edge to edge.

19.4.4 Ten or more rounded indications in any 3870 mm^2 (6 $inch^2$)of surface with the major dimension of this area not to exceed 150mm with the area taken in the most unfavourable location relative to the indication being evaluated.

19.5 Cut edges and openings:

19.5.1 All surface to be examined shall be free of

(a) Cracks
(b) Laminations exceeding 25mm in length.

19.6 In welds joining nipples to drums, spheres or headers, all slag or porosity indications shall be investigated to assure that no leak – path exists.

19.7 In attachment welds of non-load carrying class, indications from crack or due to material separation are unacceptable.

20.0 ACCEPTANCE STANDARD FOR STRUCTRAL COMPONENTS AS PER AWS

20.1 The magnetic particle acceptance criteria is based on the size of the actual discontinuity and not the size of the discontinuity as indicated by the magnetic particle inspection medium. Where discontinuity cannot be visually seen (with magnitication if required) after removal of the indicating medium, evaluation shall be based on size and nature of the magnetic particle indication.

21.0 Statically loaded Non tubular connections

21.1 Cracks, Lack of Fusion, and Incomplete penetration are not acceptable.

21.2 **Undercut**-for material with thickness less than 25mm undercut shall not exceed 1.0mm, except that a maximum 2.0 mm is permitted for a accumulated length of 50mm in any 300mm. For material equal to or greater than 25.0 mm thick, undercut shall not exceed 2.0 mm for any length of weld.

21.3 **Porosity** – a complete joints penetration groove welds in butt joints transverse to the direction of computed tensile stress shall have no visible piping porosity. For all other groove welds and for fillet welds, the sum of the visible piping porosity 1.0mm or greater in diameter shall not exceed 10mm in any linear 25mm of weld and shall not exceed 20mm in any 300mm length of weld.

22.0 **Cyclically Loaded Non tubular Connections**

22.1 **Undercut** - In primary members, undercut shall be no more than 0.25mm deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall not be more than 1.0mm deep for all other cases.

22.2 **Porosity** – The frequency of piping porosity in fillet welds shall not exceed one in each 100 mm of weld length and the maximum diameter shall not exceed 2.5mm. Exception : for fillet connecting stiffeners to web, the sum of the diameter of the piping porosity shall not exceed 10mm in any linear 25mm of weld and shall not exceed 20mm in any 300 mm length of weld.

22.3 Complete joint penetrantion groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity.

22.3 **PIPING POROSITY** – (General) is elongated porosity whose major dimension lies in a direction approximately normal to the weld surface. Frequently referred to as pin holes when the porosity extends to the weld surface.

23.0 **EDGE DISCONTINUITIES IN CUT MATERIALS**

23.1.1 No crack is acceptable.

23.1.2 Mill induced discontinuity

23.1.3 Length 25mm and less- Acceptable

23.1.4 Length over 25mm and depth up to 3mm- Acceptable

23.1.5 Length over 25mm and depth between 3mm and 25mm – indications to be removed.

23.1.6 Length over 25mm and depth greater than 25mm – indications to be removed to a depth up to 25mm.

24.0 **REPAIR AND RE-EXAMINATION**

24.1 Whenever an imperfection is repaired by chipping or grinding or and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners.

24.2 After a defect is thought to have been removed and prior to making weld repairs, the area will be examined by suitable method to ensure that the defect has been removed or reduced to an acceptable size of an imperfection.

24.3 where welding is required after repair of an imperfection the area shall be cleaned and repair carried out. After repairs have been made the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners.

24.4 After repairs have been made, the repaired area shall be re-examined by methods of examination that weld originally required for the affected area.

25.0 PERSONNEL QUALIFICATION

25.1 All personnel carrying out the examination and evaluation shall be qualified to minimum Level - I as per ASNT:SNT – TC –1A.

26.0 FINAL CLEANING

26.1 When the inspection is concluded, the magnetic particles shall be removed by any suitable means, leaving the product in a dry and clean condition.

27.0 REPORT

27.1 Copies of the report in a standard format R 49-719-B or equivalent duly signed by a minimum Level - II personnel shall be issued after the test.

X - PROD POSITION 1

O - PROD. POSITION 2.

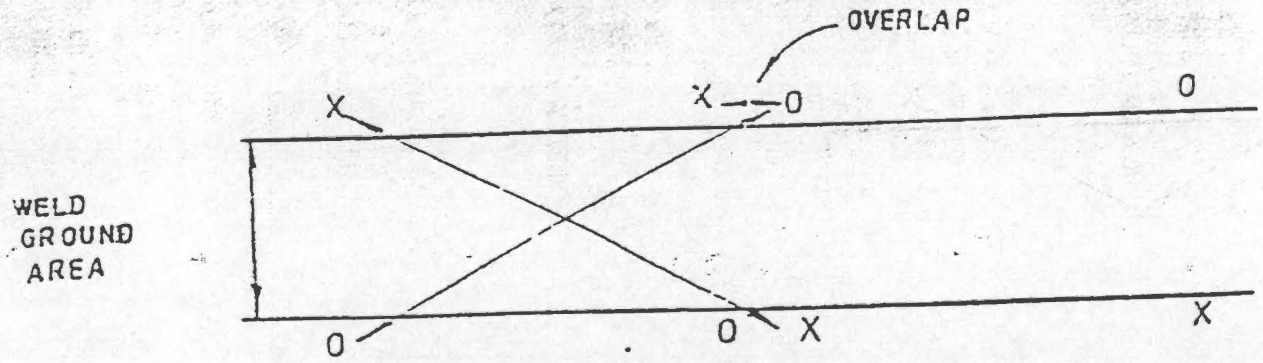


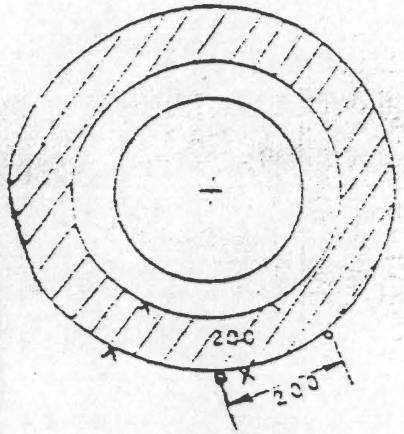
FIG. (1) TECHNIQUE FOR EXAMINATION OF LONG SEAMS & CIRCUMFERENTIAL SEAMS

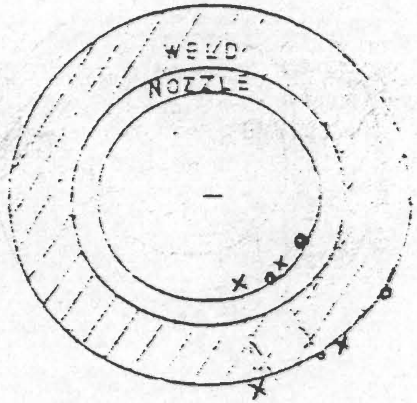
NOTE:

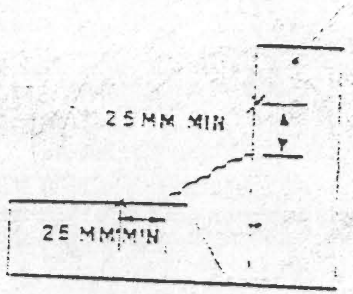
1. SUCCESSIVE SHOTS SHALL OVERLAP A MINIMUM OF 10% OR 20 MM
2. EXAMINATIONS ON O.D. AND I.D. OF THE SEAM SHALL BE CARRIED OUT IN THE SAME MANNER.
3. PRODS MUST BE PLACED ON DRUM/ VESSEL PERPENDICULAR TO PLATE SURFACE.

LONGITUDINAL INDICATIONS

TRANSVERSE INDICATIONS







O - PROD POSITION . 1

X - PROD POSITION . 2

FIG. (2) TECHNIQUE FOR EXAMINATION OF CORNER JOINTS

1. PROD LOCATION AT TOP OF WELD ALL THE WAY AROUND & AT THE BOTTOM ALL THE WAY AROUND
2. O, X - 10% OVERLAP BETWEEN SHOTS

1. PROD LOCATED AT LEAST 25MM UP ON NOZZLE & 25MM OUT ON DRUM / VESSEL
2. 10% OVERLAP (15MM) BETWEEN SHOTS

NOTE:

1. PRODS MUST BE PLACED ON DRUM / VESSEL / NOZZLE PERPENDICULAR TO PLATE SURFACE.

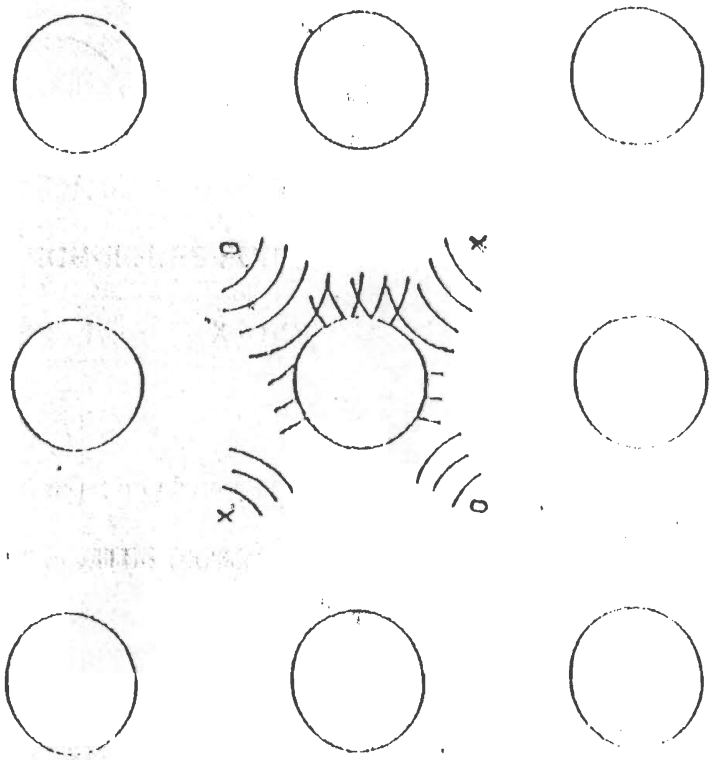


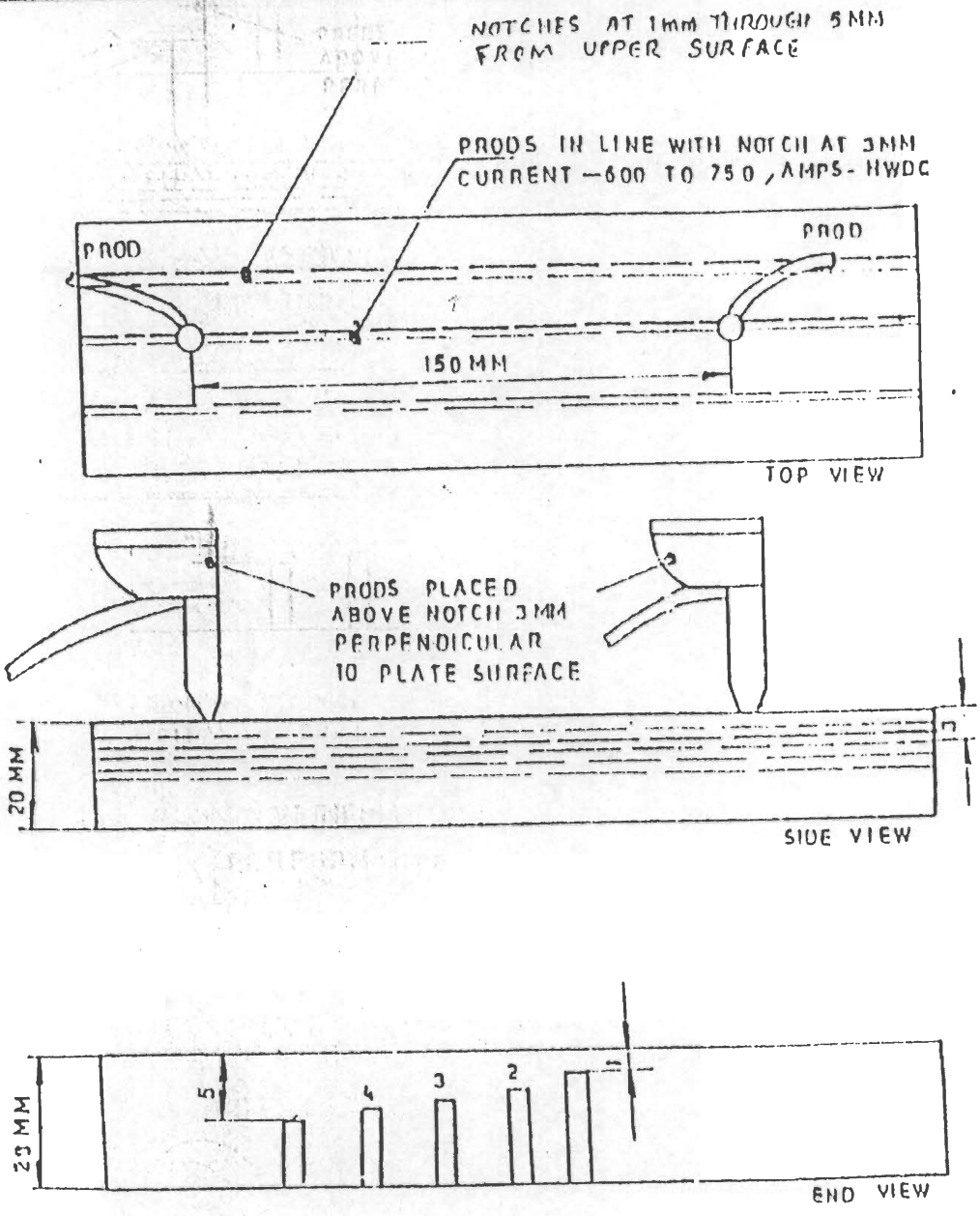
FIG (3) TECHNIQUES FOR EXAMINATION OF FILLET WELDS

0 – POSITION - 1 X -- POSITION - 2 ARC BREAK LOCATION

NOTE :

1) PRODS must be placed on drum / header perpendicular to plate surface.

2) Inspection will be 100% of weld for each shot.



PERFORMANCE CHECK - EQUIPMENT AND DRY POWDER COMBINATION PRIOR TO TEST

FIG (4) VERIFICATION OF SYSTEM PERFORMANCE FOR PROD TECHNIQUE

PROCEDURE FOR

LIQUID PENETRANT EXAMINATION

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01	28 07 99	Revision in entirety
02	14 08 03	Clause 2.1, 2.2, 2.3, 12.1.2.2, 12.1.3.1, 12.1.3.2 and 13.1.2.1 modified Clause 8.2 added

1.0 SCOPE

1.1 This procedure defines the method, techniques and acceptance standards for Liquid penetrant Examination of all shapes of ferrous and Non-ferrous product forms in Boilers, Boiler Auxiliaries, pressure vessels, Heat Exchangers and structural.

1.2 In pressure vessels the Examination shall include all welds around openings, attachment welds with a throat thickness over 6mm and on finished surfaces of welds as required by referencing code. The examination includes base material 13mm on each side of the weld.

2.0 REFERENCE

2.1 ASME Section V, I & VIII (Division 1 &2) –2002 Addenda

2.2 ASME B 31.1 / 2001

2.3 ANSI / AWS D 1.1 / D1.1M: 2002

3.0 EQUIPMENT

3.1 The term 'penetrant materials' as used in the procedure is intended to include all liquid penetrants, solvents (penetrant removers) or cleaning agents, developers etc used for 'Liquid penetrant Examination'.

3.2 Penetrant used shall be of solvent removable type and have a color contrast, which can be seen, readily in daylight or under normal interior illumination.

3.3 The cleaner used for the surface cleaning shall be an organic chemical such as Acetone or Trichloro Ethylene.

3.4 Developer shall be of non–aqueous suspendible type. When the developer dries, it shall form a white coating of fine powder on the part.

3.5 The Chemicals used for the examination of austenitic stainless steel or nickel base alloys shall be analysed for sulphur and total halogens. The residual amount of total sulphur and chlorine content shall not exceed 1% by weight.

4.0 SURFACE PREPARATION

4.1 In general satisfactory results may be obtained when the surface is as welded, as rolled, as forged or as cast condition. When the surface irregularities might mask the indications of unacceptable discontinuities, the surface shall be prepared by grinding or machining or any other suitable method.

4.2 The surface to be examined and all adjacent areas within at least 25mm shall be dry and free of any dirt, grease, lint, scale, welding flux, weld spatter, rust, paint, oil or any other extraneous matter that could obscure surface openings or otherwise interfere with the examination by preventing the penetration.

4.3 Shot blasting may close discontinuities at the surface and should not be used before conducting penetrant examination. If the component is shot blasted, the surface is to be etched before conducting penetrant examination.

4.4 Prior to the application of the penetrant, the surface is recleaned with typical industrial cleaning agents such as Acetone.

5.0 DRYING AFTER PREPARATION

5.1 After cleaning, drying of the surface shall be accomplished by normal evaporation and ensure that the cleaning solution has evaporated. The minimum time required for the cleaner to dry from the surface is 20 to 30 seconds depending on the position.

6.0 TECHNIQUES

6.1 Color contrast (visible) penetrant shall be used with solvent removable penetrant process.

6.1.1 The temperature of the penetrant and the surface of the part shall not be below 10°C and not above 52°C throughout the examination period. Local heating or cooling is permitted provided the part temperature remains in the range of 10°C to 52°C during the examination.

6.2 TECHNIQUE RESTRICTIONS

6.2.1 Intermixing of penetrant materials from different families or different manufacturers is not permitted.

7.0 EXAMINATION

7.1 Penetrant Application

7.1.1 The penetrant shall be applied by brushing, spraying or dipping after the surface is dried. For spraying a handpump or an aerosol spray cans will be used.

7.2 Penetration time

7.2.1 The penetrant shall be allowed to remain wet on the part for a minimum period for 10 minutes. (dwell time).

7.2.2 If the penetrant has completely dried up during the dwell time, then the surface shall be recleaned and reexamined.

7.3 REMOVAL OF EXCESS PENETRANT

7.3.1 After the required dwell time has elapsed, the excess penetrant remaining on the surface shall be removed by wiping with a lint free cloth, repeating the operation until most traces of penetrant have been removed. Final left out penetrant shall be remove by wiping with a clean cloth moistened with the solvent. Excessive application of the cleaner shall be avoided to prevent the possibility of removing the penetrant from discontinuities causing a decrease in the sensitivity of the test. FLUSHING THE MATERIAL SURFACE WITH THE SOLVENT FOLLOWING THE APPLICATION OF PENETRANT AND PRIOR TO DEVELOPING IS PROHIBITED.

7.3.2 Drying after excess penetrant removal.

7.3.2.1 After the removal of excess penetrant the surface shall be dried by normal evaporation. The minimum time required for the surface to get dried by normal evaporation is 20 seconds.

7.4 DEVELOPING

7.4.1 The developer shall be applied by spraying to provide uniform coating as soon as possible to the dry surface after the removal of excess penetrant. Insufficient coating thickness may not draw penetrant out of discontinuities. Excessive coating thickness may mask indications.

7.4.2 WET DEVELOPER APPLICATION

7.4.2.1 Prior to applying suspension type wet developer to the surface the developer must be thoroughly agitated too ensure adequate dispersion of suspended particles. The developer shall be applied by spraying using spray pump or aerosol spray can. The developer shall be applied over the surface in such a manner to assure complete coverage of the part with a thin, uniform film of developer. Drying of developer shall be by normal evaporation.

7.4.3 DEVELOPMENT TIME

7.4.3.1 The surface shall be closely observed during the application of the developer to monitor the behavior of the indication, which tends to bleed-out. Developing time for final interpretation begins as soon as a wet developer coating is dry. The minimum developing time shall be 7 minutes.

8.0 INTERPRETATION

8.1 Final interpretation shall be made with in 7 to 60 minutes after the wet developer coating is dry. If the bleed - out does not alter the examination results longer periods are permitted.

8.2 The surface shall be examined in increments if the surface to be examined is large enough to complete the inspection within the prescribed time.

8.3 A minimum light intensity of 50 foot candle (500 lux) is required to ensure adequate sensitivity during the examination and evaluation of indications, which can be achieved by a hand lamp or torch light positioning at a distance of 300mm.

9.0 EVALUATION

9.1 Flaws at the surface will be indicated by bleed out of the penetrant. However localized surface irregularities such as machining marks or other surface conditions may produce false indications. Broad areas of pigmentation which would mask indications are not acceptable and such areas shall be cleaned and reexamined.

9.2 Welds made to ASME Boiler and pressure vessel code

9.2.1 An indication of an imperfection may be large than the imperfection that causes it: however, the size of the indication is the basis for acceptance evaluation.

9.2.2 Relevant indications area those which result from mechanical discontinuities (imperfection).

9.2.3 Only indications with major dimension greater than 1.6mm shall be considered relevant.

9.2.4 Any indication which is believed to be non-relevant shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is evaluated by other non - destructive testing and proved to be non - relevant.

9.2.5 Linear indications are those indications in which the length is more than three times the width.

9.2.6 Rounded indications are those which are circular or elliptical with the length equal to or less than three times the width.

9.2.7 Any questionable or doubtful indications shall be reexamined to determine whether they are relevant, or not.

10.0 ACCEPTANCE STANDARD (as per ASME Sec I and VIII Div 1&2)

10.1 Cut edges and openings

10.1.1 All surfaces to be examined shall be free of

(a) Cracks

(b) Non laminar discontinuities (having length not parallel to the material surface).

(c) Laminations exceeding 25mm in length.

(d) Laminations under 25mm in length and adjacent to each other within 25mm shall be considered as one defect.

10.2 Welds and Materials

10.2.1 All surfaces to be examined shall be free of

a) Relevant linear indications.

b) Relevant rounded indications greater than 4.8mm.

c) All relevant indications shall be investigated to assure that no leak-path exists in welds joining nipples to drums, dished – ends and headers.

10.2.2 Four or more relevant rounded indications in a line separated by 1.6mm or less edge to edge.

10.2.3 Ten or more rounded indication in any 3870mm² (6 inch^2) of surface with the major dimension of this area not exceed 150 mm with the area taken in the most unfavorable location relative to the indication being evaluated.

10.2.4 In attachment welds of non-load carrying class, indications from cracks or due to material separation are unacceptable.

11.0 WELDS MADE TO STRUCTURAL WELDING CODE ANSI / AWS D 1.1

11.1 For statically and cyclically loaded non-tubular connections made to AWS code the acceptance of any discontinuity shall be based upon a visual examination of the discontinuity after the removal of developer medium and evaluated for its nature and size. Where the discontinuity cannot be seen after removal of the developer medium either directly or using magnifying glass evaluation shall be based on the size and nature of liquid penetrant indication.

12.0 ACCEPTANCE STANDARD (AS PER AWS)

12.1 Statically loaded non-tubular connections.

12.1.1 Indications from cracks, lack of penetration and lack of fusion are not acceptable.

12.1.2 Porosity.

12.1.2.1 Complete joint penetration groove welds in butt joints transverse to the computed tensile stress shall have no visible piping porosity.

12.1.2.2 For all other groove welds and for fillet welds, the sum of the visible piping porosity of 1.0 mm or greater in diameter shall not exceed 10 mm in any linear 25 mm of weld and shall not exceed 20 mm in any 300 mm length of weld.

12.1.3 Undercut

12.1.3.1 For material less than 25 mm thick, undercut shall not exceed 1.0 mm except that a maximum 2.0 mm is permitted for an accumulated length of 50 mm in any 300 mm

12.1.3.2 For material equal to or greater than 25 mm thick undercut shall not exceed 2.0 mm for any length of weld.

13.0 Cyclically loaded non-tubular connections.

13.1 Indications from Cracks, Lack of penetration and lack of fusion are not acceptable in any welds.

13.1.2 Porosity

13.1.2.1 Complete joint penetration groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the frequency of piping porosity shall not exceed one in 100mm of length and the maximum diameter shall not exceed 2.5 mm.

13.1.2.2 The Frequency of piping porosity in fillet welds shall not exceed one in each 100mm of weld length and the maximum diameter shall not exceed 2.5mm. EXCEPTION for fillet welds connecting stiffeners to web, the sum of the diameter of piping porosity shall not exceed 10mm in any linear 25mm of weld and shall not exceed 20mm in any 300mm length of weld.

13.1.3 Undercut.

13.1.3.1 In primary members, undercut shall not be more than 0.25mm deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall not be more than 1mm deep for all other cases.

14.0 REPAIR AND RE-EXAMINATION

14.1 Whenever an imperfection is repaired by chipping or grinding the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners.

14.2 After a defect is thought to have been removed and where welding is required after repair, the area shall be examined for removal of defects, area cleaned and repair carried out. The repaired area shall be blended into the surrounding surface as in 14.1 and re-examined by the liquid penetrant or any other NDT methods originally required for the affected area.

15.0 PERSONAL QUALIFICATION

15.1 Wherever penetrant examination is required by the referencing code, the same shall be conducted and evaluated by a personnel qualified to minimum, Level – I as per ASNT SNT-TC-1A.

16.0 POST CLEANING

16.1 After the examination and evaluation is completed all penetrant testing material shall be removed from the surface, so that it will not interfere with the subsequent processing or service requirements.

17.0 REPORTING

17.1 Where penetrant test is mandatory, a copy of the report signed by personnel certified to minimum Level II will be issued in the format R49-720B or equivalent, after the completion of the examination.

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BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPPALLI 620 014 INDIA

QUALITY CONTROL PROCEDURE FOR MANUFACTURE OF NON PRESSURE PARTS

QCP:002 / 02

Prepared by Quality Assurance	G S N Murthy	

Reviewed by	Signature	
Engineering	Structures	Fuel Firing
O P & C		
Manufacturing	Shops	Ancillary Development
Quality Assurance		
Quality Control	RM Area	O L I

Revision No.	Date	Approved by	Signature
00	01/04/93	SM / QA	-sd-
01	01/01/95	SM / QA	-sd-
02	**24/04/04**	**SDGM /QA**	

RECORD OF REVISIONS

Rev No...	Clause No	Details of revision
00	--	This document consolidates all the general requirements and technical disciplines covered in the various previous
01	--	All amendments issued has been regularized and editorial correction made for better clarity. Scope of machining added in this document.
02		**Shaded clauses are Revised /added**

1.0 SCOPE

1.1 This procedure details out the process control and quality requirements for manufacture of Non Pressure Parts.

2.0 REFERENCE DOCUMENTS

2.1 AWS D.1.1, D1.6, IS 7215 and CE: M&P 5.11.1.1, 5.11.2.1 & 5.11.2.2 as guidelines.

3.0 MATERIALS

3.1 CLASSIFICATION OF MATERIALS (commonly used):

P No. Group	Specifications
P1 - Group 1 -	Carbon steel IS 2062 Gr A & B, IS 1239, IS 1161, A 36, SA 515 Gr 60.
P1 - Group 2 -	H.Strength CS :SA105, SA 515 Gr 70, SA 299, SA 516 Gr 70, IS 8500.
P4 - Alloy Steel	SA 387 Gr 11 & Gr 12, SA 182 Gr F 11 & F 12.
P5 – Gr A,	SA 387 Gr 22, SA 182 Gr F 22
P6 -	SA 240-410,429
P8 - Stainless steel	SA 240 - 304 ,309,310, 316, 321, 347

Any other materials as specified in the drawings.

3.2 Raw materials used shall conform to the relevant specification as given in drawings and applicable TDC/PO. Any substitution of materi-als shall be done only with prior approval of engineering through applicable documents. Where subcontractors procure the raw materials, the same shall have valid test certificates.

3.3 Raw materials shall be free from visual defects like cracks, seams, laps, laminations,heavy pitting etc. When defects are noticed in visual inspection the same shall be confirmed using appropriate NDE techniques and repaired using applicable approved process .

3.4 All materials are procured with permitted dimensional tolerances of the material speci-fications and / or TDC. Wherever required, the raw materials shall be corrected prior to fabrication to achieve the required product tolerances.

3.5 Customer supplied materials are to be verified as per SP 0626.

3.6 The requirements of material traceability shall be as indicated in the respective drawings.

3.6.1 Product Attest “P” items indicated as in drawings are traceable to the test certificates and identified with material Specification, grade and melt number by stamping.

3.6.2 CERTIFIED items indicated as "C" in drawings are traceable to material Specification / grade only and identified by stamping / engraving / stenciling / painting.

3.6.3 Raw materials not covered by the above shall be identified by its W.O.No / material code / Specification / grade by painting / stenciling / engraving.

3.6.4 All subdeliveries shall be identified by its material code by painting or through name plates / tags.

3.7 When materials (including stock) are to be upgraded for special contract requirements QC shall ensure that the respective specification / contract TDC (as applicable) are complied..

4.0 FABRICATION

4.1 MARKING, CUTTING AND PREPARATION

4.1.1 Raw material shall be marked and cut to size by shearing, machining, saw cutting , flame or plasma (for SS materials) cutting. Flame cut edges shall be cleaned to remove slag. Uneven edges shall be dressed by grinding. Gas cutting notches shall be filled up by welding using compatible electrodes and ground before taking up for further fabrication.

4.1.2 Wherever raw materials supplied / available are not sufficient for the sizes required, the same can be built up using the splicing instructions given in the respective SQPs/ Drawings (Incl. Production Notes) / DCN.

4.1.3 Layout for size and shape shall be marked before cutting (for other than CNC applications) The tolerance for marking shall be maintained within + 2mm unless otherwise specified. The diagonal difference shall be within 3 mm.

4.1.4 The markings shall be punched at convenient intervals and bordered with white paint.

4.1.5 Stainless Steel (SS) materials shall be cut using plasma cutting or shearing only. Any further dressing/ grinding of cut surfaces should be done with separate and clean abrasive wheels.

4.1.5.1 The cut edges should be smoothly ground.

4.1.5.2 Notches above 3 mm or 20 % 'T' shall be thoroughly cleaned and welded by using a qualified WPS and examined visually and by LPI . The repaired surfaces are to be cleaned to bright metal surface.

4.1.6 Clip / Cleat angles above 10mm thick used for beam connections which are sheared to length shall require heat treatment.

4.1.7 Heat treatment shall be done after shearing for P4 materials t>12.5mm and for P5 materials t>10mm.

4.1.8 The requirements of preheat for gas cutting are as follows:

Carbon steel	t <= 50mm :	: Nil
Carbon steel	t > 50mm :	: 100 º C.min.
Alloy steel (P4)	t < =25mm :	: Nil
Alloy steel (P4)	t > 25mm :	: 150 º C
Alloy steel (P5)	All	: 150 º C
Stainless steel	Not applicable	

4.1.8.1 Stress relieving for gas cut edges shall be as follows.

Material	Thickness	Heat treatment cycle
P1	> 50 mm	600 º - 650 º C for 30 minutes . Furnace cool (Alternatively, the cut surface can be ground / machined upto 3 mm to remove HAZ)
P4	> 16 mm	650 º – 700 º C for 30 minutes . Furnace cool
P5	All	680 º - 730 º C for 30 minutes . Furnace cool
SS (plasma)	Any	Not required

4.1.9 The prepared plates shall be visually inspected and repaired if required as per SIP:NP:06.

4.1.10 The raw materials after cutting shall be identified with relevant WO No., DU No., Part No. and Material Spec / Grade (transferred).

4.2 FORMING

4.2.1 Forming shall be done using proper tooling free from damages. Method of forming and work centre shall be identified in OPS / relevant QWI refered in PO.

4.2.2 Forming operations of sheets / plates shall be done by rolling / pressing. Circularity of rolled shells shall be checked using templates (of length > ¼ of ID).

4.2.3 Suitable nonmetallic padding shall be provided while forming of stainless steels to avoid contamination.

4.2.4 All formed components shall be checked for orientation, angle, and other dimensions as per drg. All formed parts shall have smooth finish and shall be free from bends, folds and sudden transitions.

4.2.5 Minimum thickness after forming shall be ensured whenever specified in drg.

4.2.6 Tolerances for formed components when not specified in drg. Shall be as follows

a) St.Length / Dia, Width & Height : + 1 mm / M, 5 mm Max
b) Verticality : 1 mm / M, 5 mm Max
c) Squareness : 1 mm / M of length / Dia
d) Straightness : 1 mm / M, 5 mm Max
e) Radius : + 5 mm
f) Bend Angle : + 2º
g) Ovality : 1%
h) E.P Angle : + 5º / - 2.5º
i) Diagonal diff : 3 mm

4.3 WELDING

4.3.1 WELDING CONSUMABLES

4.3.1.1 Welding consumables conforming to the qualified welding procedures shall be used. However the following guide lines are provided.

4.3.1.2 Only Basic coated electrodes shall be used in the following cases:-

a. All Strength welds like welds in main ceiling girders, flange butt welds in other beams, columns etc.
b. For all structural welds, or when thickness of any one member of the weld joint is > 12 mm (unless otherwise indicated in the drawings / Qualified WPS).
c. For welding of high tensile steels like IS 8500, SA299, SA515 Gr.70, SA516 Gr.70.

4.3.1.3 Rutile electrodes may be used for other weld joints.

4.3.1.4 All low hydrogen electrodes (EXX 16 & EXX 18) shall be dried in the baking oven at 350 deg.C for 2 hours and the electrodes shall be held at 100 deg.C until they are used.

4.3.1.5 All rutile electrodes (EXX 13) shall be dried at 100 deg. C for 1 hour min. and held at 100 deg.C till use.

4.3.1.6 Fluxes for SAW shall be dried at 200 deg.C for 1 hour min. before use. Height of flux bed while drying in pan or oven, shall not be more than 100mm.

4.3.1.7 Unless otherwise specified , SS consumable shall be baked as per Electrode manufacturer's recommendations and stored at 120 º - 150 º C until use.

4.3.2 FIT UP

4.3.2.1 Proper fit up shall be ensured before welding as per Drawing. Tack welding or mechanical clampings shall be used to maintain the fit up requirements before and during welding.Bridge pieces used during fit up shall be of ferritic for ferritic materials and stainless for stainless steel materials.

4.3.2.2 Dimensions of the cross sections of groove welded joint shall be within the following tolerances w.r.t . drawing requirements:

	Root not back gouged	Root back gouged
1. Root face of joint(land)	± 2 mm	Not limited
2. Root opening of joint (with out backing)	± 2 mm	+ 2 mm - 3 mm
Root opening of joint* with backing)	+ 6 mm - 2 mm	Not Applicable
3. Groove angle of of joint	+ 10º - 5º	+ 10º - 5º

*(NOTE): Root opening wider than permitted by above tolerances but not greater than twice the thickness of the thinner part or 19mm,whichever is less may be corrected by edge buildup to acceptable dimensions prior to welding. Such build up edge shall be MPI / LPI checked.

4.3.2.3 For C. S. fillet welds, the parts shall be as close as practicable and gap shall be limited to 5 mm (If gap exceeds 2 mm, the leg of fillet shall be increased by the amount of gap but in no case shall exceed 4.8 mm). For thickness 75 mm and above gap up to 8 mm can be permitted provided suitable backing is used.

4.3.2.4 For S. S. fillet welds, the parts shall be as close as practicable. Gaps 2 mm and above upto 5mm are acceptable if the fillet size is increased by an amount equal to the gap.

4.3.2.4 Parts to be joined by butt welds shall be properly aligned. An offset not exceeding 10% of the thickness of the thinner part joined can be permitted, but in no case more than 3.2 mm, is permitted.

4.3.3 PRE HEATING

4.3.3.1 Pre heating requirements for welding shall be as per Clause 4.6.7 and controls shall be exercised as detailed below. No preheating is required for stainless steels.

4.3.3.2 Preheating shall be maintained during the entire process of welding.

4.3.3.3 Preheating is to be done using gas burner or induction / resistance heating. The temperature must be uniform and verified using thermal chalks or thermocouples prior to start of welding as well as during welding for a width of 't' (maximum) or 75 mm whichever is less.

4.3.3.4 Where interpass temperature control is required during welding, the temperature must be ensured using thermal chalks / thermocouples. Inter pass nitrogen / air cooling can be adopted to maintain inter pass temperature in case of stainless steels.

4.3.3.5 Wherever post heating is specified, the preheating shall be continued after welding till attaining the post heat temperature and maintained for the required time and cooled slowly by wrapping suitable insulating blankets like asbestos.

4.3.4 Welding shall be performed using qualified procedures and qualified personnel. Edge preparation and welding details shall be as per drawing.

4.3.5 For items to be manufactured at subcontractor's works , for requirements of qualification of procedure and personnel as per SIP:NP: 07 shall be followed.

4.3.6 When double bevel welding is adopted, back gouging and grinding is to be done. Back gouged groove shall be checked with PT / MT before welding from second side.

4.3.7 Proper sequence of welding shall be adopted to minimise distortion. The distortion of the finished jobs, if any may be corrected by mechanical means / hot correction.

4.3.7.1 For welding of SS extreme care is to be taken in weld sequencing to minimize the weld distortion and shrinkage. For complex weldments a weld sequence instructions may be prepared by contractor prior to work commencement. Weld joints likely to have high shrinkage should be welded (with minimum restraints) before welding other joints providing allowance for shrinkage.

4.3.7.2 While cutting long web plates suitable camber may berequired to compensate for the distorion during cutting and welding.

4.3.8 All butt welds of divider plate and guide vanes in ducts shall be flush ground inside.

4.3.9 The use of jigs and fixtures is recommended where ever practicable. Suitable allowances shall be provided for weld shrinkage. Proper sequence of welding shall be followed to control the distortion during welding.

4.3.10 All temporary attachments shall be welded with the required preheat. After their removal welded spots shall be ground flush and LPI checked.

4.3.11 Groove welds shall preferably be made with minimum reinforcement unless and otherwise specified in drawing / SQP. In case of butt welds, reinforcement shall not exceed 3.2 mm. and shall have gradual transition to the plane of the base material surface.

4.3.12 The surface of the welds shall be free from coarse ripples, overlaps, undercuts and abrupt ridges to avoid stress raisers.

4.3.13 Where parts of different thicknesses are welded or surface offset is more, the transition shall be made gradual by grinding / machining with 1: 2.5 taper.

4.3.14 Stray arcs shall be avoided to the extent possible. Arc spots if noticed shall be ground and checked by LPI / MPI. Thickness requirements shall be ensured after grinding.

4.4 WELD REPAIRS

4.4.1 Removal of defective weld / portions of the base material may be done by machining, grinding, chipping, gas cutting, oxygen gouging or carbon arc gouging. Defective portions of the weld shall be removed without substantial removal of sound base metal.

4.4.2 For under sized welds additional weld metal shall be deposited using an electrode preferably smaller than that used for making original weld limited to 4mm in diameter. The surfaces shall be cleaned thoroughly before deposition.

4.4.3 Defective welds/base metal shall be repaired by removing or/and rewelding as follows:

4.4.3.1 Overlap / excess weld metal shall be removed by grinding.

4.4.3.2 For excess concavity, crater, undersize & undercuts, deposit additional weld metal after cleaning the weld surface.

4.4.3.3 For Cracks in weld or base metal, ascertain the extent of crack by suitable NDE / acid etching, remove the crack to sound metal upto each end of the crack by arresting the ends for further propagation and reweld.

4.4.3.4 For weld porosity, slag inclusions & lack of fusion remove defective portions & reweld

4.5 HOT CORRECTION

4.5.1 Members which require hot correction are to be supported at suitable locations and mark the locations for heating.

4.5.2 Heat the locations marked by using neutral flame. Torches used for heating shall be moved continuously & uniformly over selected area to avoid localised over heating.

4.5.3 For Carbon steels the maximum temperature shall not exceed 650 ° C and shall be ensured using thermal chalks / thermocouples.

For alloy steels P4 – 705º C , P5 – 735º C temperatures are to be maintained for hot corrections

4.5.3.1 For Austenitice stainless steels the maximum temperature shall not exceed 430 ° C and shall be made known to inspection authorities . Otherwise , after hot correction solution annealing at 1050 – 1100 deg C is to be done.

4.5.3.2 For Ferritic/Martensitic/Duplex stainless steels the maximum temperature shall not exceed 315º C and shall be made known to inspection authorities . The temperature shall be ensured using thermal chalks / thermocouples.

4.5.4 Additional dead weights may be placed over the positive side of the bend depending upon the requirement to accelerate hot correction.

4.5.5 Allow for natural cooling. Accelerated cooling shall not be adopted. Remove the dead weights used after cooling.

4.5.6 Wherever the correction for distortion affects the weld joints, applicable NDE shall be repeated after the correction.

4.6 POST WELD HEAT TREATMENT (PWHT)

4.6.1 The process controls (temperature control and recording) for heat treatment shall cover the activities before, during and after heat treatment.

4.6.2 The weldment shall be cleaned to free of grease, oil etc. prior to heat treatment.

4.6.3 PWHT shall be done in a furnace or by local heating a band (including the entire weld and adjacent area of the base metal) .

4.6.4 The thermocouples and recording instruments shall be calibrated as per applicable standards and records maintained. The furnace shall have been qualified and calibrated.

4.6.5 All materials to be heat treated in furnace shall be loaded in such a way that they shall not be subjected to direct flame impingement. Jobs shall be preferably loaded on raised plat forms so that no material projects into the plane of burners. Alternatively flame deflectors may be provided in front of the burners to avoid direct flame impingement. Ensure loading of test coupons wherever applicable. The furnace temperature shall not exceed 315 º C at the time of loading material / weldment.

4.6.6 Number of thermocouples and their location shall be decided covering maximum and minimum thickness and covering all the zones. The temperature variation within 5 meters shall not exceed 140 º C during heating period (above 315 º C).

4.6.7 The **temperature requirements** for Pre heating, Post Weld Heat Treatment(PWHT) & temperatures are as below.(Unless otherwise specified.)

Material	Thickness	Pre heating	PWHT Temp.	Remarks
P1 Gr 1&2	t < 38	Nil	600 – 650 º C	a) For all butt welds in plate welded girders when t > 50mm.
	T= 39-62	100 º C		
	t> 63	150 º C		
P4 Gr 1&2	All	150 º C	680 – 700 º C	a)All butt welds in tension member b)All fabricated components when t>16mm(Note1)
P5 Gr 1&2	All	150 º C (Note2)	680 – 730 º C	All welds (Note 3)
P8	300 type 400type	120 º C 205 º C	- -	

Note 1 All fabricated structural components of P4 materials with any member above 16mm thickness, the entire assembly shall be post weld heat treated. However when size of fillet weld is less than 12 mm, PWHT is not required for non load carrying members.

Note 2 All welds on P5 material shall be post heated at 250 º C for 2 hrs or 150 º C for 4 Hrs, immediately following welding.

Note 3 All welds of P5 material shall be post weld heat treated. In case where the size of fillet is less than 12 mm, PWHT is not required for non load carrying members.

4.6.7.1 The **soaking time** shall be as follows:

a. For P1 materials the soaking time shall be 1 hr/inch of thickness(t) (2.5 mts / mm) upto 2" and 2 hrs + 15 minutes for each additional inch for t > 2".
b. For P4 & P5 materials the soaking time shall be 1 hr/inch of thickness (2.5 mts / mm) upto 5" and 5 hrs + 15 minutes for each additional inch for t > 5".

c. For comb ination cycles mentioned above, calculate the minimum soaking time for individual components as 2.5 minutes/mm of the thickness of weld/material whichever is applicable. Soaking time selected for the cycle shall not exceed the limits given below:

Material	Thickness (mm)	Max. soaking time (minutes)
P1 (A,B,C), P4, P5A, P1 (A,B) + P4, P4 + P5A	Up to 25 mm	125
	26 - 50 mm	200
	51 - 80 mm	250
	81 - 150mm	375
P1C + P4, P1 + P3	Up to 25 mm	65
	26 - 50 mm	125

4.6.7.2 Unless otherwise specified, in case of mixed loads of materials not covered under simulation HT, the following heat treatment temperatures shall be followed. In such cases, guidelines for soaking can be taken from Clause 4.6.9.

For components having butt joint between P1 & P4, or P3 & P4, the cycle shall be 630 - 670º C.

Where a component has a butt joint between P4 & P5A, the cycle shall be 680 - 710º . C.

Where a component has a butt joint between P1 & P3, the cycle shall be 620-660 º. C

For P1+P5A material combination, follow the WPS requirements

The following jobs shall not be combined in the same cycle during PWHT.

Separate jobs of P1 and P4 Separate jobs of P4 and P5

4.6.8 The following rules shall apply to establish the thickness to be used in determining the soaking time for PWHT.

4.6.8.1 For Butt welds, the thickness shall be the thickness of the material at the weld. For bar stock, the thickness shall be the diameter.

4.6.8.2 For fillet welds, the thickness shall be the throat thickness. If a fillet weld is used in conjunction with a groove weld, the thickness shall be the greater of the depth of the groove or the throat thickness.

4.6.8.3 For partial penetration branch welds, the thickness shall be the depth of the groove prior to welding.

4.6.8.4 For repairs, thickness shall be the depth of the groove as prepared for repair welding.

4.6.8.5 For combination of different welds in a component, maximum thickness of weld shall govern.

4.6.9 Requirements of Rate of Heating (ROH) above loading temperature 315 º C and Rate of Cooling (ROC) are as given below. During heating and cooling, variation in temperature between thermocouples shall be 85 º C maximum, unless otherwise specified.

Thickness	ROH / ROC (Max) Above / upto 315 º C
Up to 25mm	220 º C / hour
26 - 50 mm	95 º C / hour
50 – 75 mm	70º C / hour
Above 75 mm	55 º C
For S.S Matl	200 º C / hour min (Forced air cooling)

4.6.10 In case of interruption during Heat treatment the following action has to be taken depending on the stage of occurrence:

Type of Heat treatment	Stage of interruption	Action
Annealing & stress relieving	Heating	Heat treat subsequently as specified
	Soaking	Heat treat subsequently for balance soaking
	Cooling	If the ROC during interruption period meets the specified rate, cool subsequently at required rate upto 400º C. Otherwise, reheat to the soaking temperature, hold for 15 minutes and then cool at the specified rate
Normalising(N) Tempering (T) &, Soln. annealing (S)	Heating	Heat treat subsequently as specified
	Soaking	Heat treat subsequently for full soaking(N,S) / Balance soaking (T)
	Cooling	Not applicable

4.6.11 Local heat treatment can be carried out by Resistance heating or Induction heating. For local heat treatment of weld joints, width of the heated band on either side of the weld must be at least 3 times the width of the weld groove of the thickest part or 3 times the highest section thickness, whichever is greater.

4.6.11.1 The width of the insulation band beyond the heating band shall be at least twice the total width of the heating band.

4.6.11.2 A minimum of three thermocouples shall be placed such that at least one is on the weldment and the other two on the base material on either side of the weldment.

4.6.11.3 The winding arrangement shall be established to attain the required temperature. The initial rate of heating shall be minimum such that it stabilises at the required rate of heating before reaching 400 deg C.

4.6.12 After heat treatment, the charts shall be correlated with the job and cleared by QC. The chart shall contain cycle no, Date, W.O and DU details. Temperature, ROH, ROC and soaking time shall be calculated, entered in the chart and signed off by QC.

4.6.13 Wherever applicable the test coupons shall be tested and reports obtained to complete the clearance of heat treatment operation.

5.0 NON-DESTRUCTIVE TESTING

5.1 The requirement of NDE, extent and type of examination shall be as per respective product SQP and / or CQP .Wherever product SQP is not existing the following requirements shall apply.

5.2 Visual inspection shall be performed as per SIP:NP:06

5.3 RADIOGRAPHY.

a. All Butt welds of Carbon steel for thickness t >= 32mm
b. All butt welds of alloy steels for thickness t >12.0mm for P5 and T > 16mm for P4.
c. All butt welds in monorails.
d. SS butt welds of T > 16mm unless otherwise specified.

5.3.1 All radiographic films shall possess Firm code , RT agency, Cust. No, Part No, RT reference No. and weld location reference no. The job shall be numbered with Radiograph no.

5.4 MPI / LPI BEFORE PWHT

a. All flame cut edges of Carbon steel for t > 37.5 mm and alloy steels for t > 12mm.
b. All butt welds joining plate members in which one of the plate member is over 25 mm thick for Carbon steel and over 12 mm thick for alloy steel.
c. All fillet welds between tension flange and web.
d. All fillet welds joining plate members in which both the plate members are over 25 mm thick for Carbon steel and over 12 mm thick for alloy steel.
e. For all butt welds of CS & AS weld groove after back chipping prior to welding from second side.
f. All main fillet welds for SS require LPI
g. MPI/LPI for all fillet welds & HAZ of SA387 Gr.22 materials after HT.

5.5 All NDE shall be carried out by qualified personnel as per BHEL NDT procedures. Where subcontractors use their own procedures for NDE the same shall have the approval of BHEL NDTL.

6.0 MACHINING

6.1 GENERAL

6.1.1 Ensure of raw material identification throughout the machining process. Traceability to the contract shall be ensured by stamping or marking / painting or by tags(WO No.and DU / Part no.)

6.1.2 Where the material identification is likely to be removed during cutting or machining , the transfer of material identification shall be ensured.

6.1.3 In case of components / part processed items received from Subcontracting / other shops, ensure the completeness and clearance by QC / Customer Inspector through Inspection Reports / OPS.

6.1.4 Proper care shall be taken during handling of materials at all stages of manufacture. Items stored in the shop floor shall be properly identified and preserved to prevent mixup and damages / rusting / warpages.

6.1.5 All Machined surfaces shall be properly protected and stored. Wherever long storage is envisaged, they shall be preserved with grease / rust preventive oils and protected suitably with polythene / gunny bag or plastic peel off coatings.

6.2 MARKING

6.2.1 The marking on machined components shall be in such a location which will not be detrimental to the surface finish requirements of the component.

6.2.2 Purpose of marking is to:

1. Ensure availability of machining allowance.
2. Identify locations for machining.
3. Provide reference for setting and inspection.

6.3 PROCESS CONTROLS

6.3.1 The following shall be ensured for selection of work centers, tools, jigs and fixtures:

a The work centre for machining shall be identified in OPS / loading sheet based on the process capability of the machine or Machine accuracy established to suit the tolerances.

b Test hardwares (Jigs, Fixtures and Templates) used as a means of inspection / process control shall have been qualified through first off trials and shall be regulated through valid number. The same shall be reflected in the OPS / loading sheet .

c Softwares used in case of CNC / NC machines shall have been validated through trials or inspection of similar components produced and accepted.

d All cutting tools shall have been ensured for its correctness before use. In case of regrinding of tools they shall be verified after regrinding.

6.3.2 The following shall be ensured before setting the job on the machine, during processing and after completion of machining:

a Ensure the verticality and flatness of the job after clamping by using the reference markings or dialing the surfaces. Ensure the adequacy of clamping.

b Ensure proper clamping of the correct tool in to the tool holders.

c After machining the machined surfaces shall be cleaned and all corners shall be deburred. After removing from the machine they shall be properly stored.

d Before starting reaming ensure proper material allowance for finish operation.

e During drilling, reaming and tapping the removal of chips shall be done periodically to prevent clogging of chips. For deep drilling ensure that run out and drill travel are verified in free condition and ensure proper clamping of the tools.

6.4 INSPECTION

6.4.1 Ensure completeness of all final machining operations. Dimensional inspection shall be done with relevant drawings. Ensure use of calibrated instruments / gauges.

6.4.2 Unless otherwise specified in the drawing or SQP, the following tolerances can be used for untoleranced dimensions.

1.Linear Tolerance (:millimeters) - Medium

PERMISSIBLE DEVIATIONS FOR BASIC SIZE RANGE						
Up to 6	From 6 TO 30	from 30-120	From 120-400	From 400-1000	From 1000-2000	Above 2000
± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2.0

2. Angular Tolerance

a. Assembly characteristics ± 0.5º
b. Other characteristics ± 1º

7.0 FINAL INSPECTION

7.1 All dimension shall be inspected as per relevant drawings. Tolerances for fabricated items when not specified in drawings shall be as per clause 4.2.6.

8.0 CLEANING AND PAINTING

8.1 All the temporary cleats, bridge pieces shall be removed carefully so as to avoid damage to parent material. Temporary tack welds shall be ground smooth. Complete assembly shall be cleaned to remove mill scales, spatter, slag, rust, oil or grease.Surfaces shall be prepared and painted as per SIP:PP:22 (latest). Site EPs shall be applied with weldeable primer . All site EP shall be protected suitably from mechanical damage.

8.2 All temporary stiffeners / attachments used for transportation and handling that are removed after site assembly shall be painted with yellow paint.

8.3 Match marking and flow direction for applicable components shall be as per the respective product SQP./Drawing

8.4 The following details shall be clearly marked with relavant details by paint, bordered and covered by one coat of transparent varnish

Project Name :
Work order number :
Component / Assly. Designation :
DU Number :
Weight :
Sub-contractor Name / Code :

8.5 Tension flanges in girders are to be identified by hard punching indicating `TENSION FLANGE'.

8.6 For subcontracted items the firm code shall be punched and bordered with white paint.

QUALITY CONTROL PROCEDURE

FOR SPLICING NORMS FOR SHEETS / PLATES / STRUCTURALS APPLICABLE TO ESP COMPONENTS FABRICATION

PREPARED BY :

DEPARTMENT	NAME & Designation S/Shri	SIGNATURE
QA	K. Jothi Arulanandam Dy.Mgr/QA	

REVIEWED BY:

DEPARTMENT	NAME & Designation S/Shri.	SIGNATURE
EDC / AQCS	C. Ganesh Sr.Mgr/AQCS	
OUT SOURCING	N. Nandagopal Sr.Mgr/OS	
QUALITY CONTROL	O. K. Abdulhuq Sr.Mgr/QC-OLI	
QUALITY ASSURANCE	R. Arunachalam Mgr/QA	

APPROVED BY

DEPARTMENT	NAME & Designation S/Shri	SIGNATURE
QA	G. BALASUBRAMANIAN SR.DGM / QA, QC(Proc.) & BE	

REV. NO.	EFFECTIVE DATE	REVISIONS MADE
03	30.05.2013	Amendment A1 merged. Feedback from OS and Engg (AQCS) Splicing Norms with applicable Drawing for carbon steel materials and SS Liner Sheet were added and re-issued.
02	03.03.2000	Feedback from MSA and Engg were included and re-issued.
01	16.06.1999	All amendments were merged, feedback from Engg and MSA were included and re-issued.
00	30.10.1985	Original Issue

HISTORY OF RECORD OF REVISIONS

1.0 SCOPE

1.1 This Quality Control Procedure (QCP) specifies the requirements for splicing of sheets / plates / structural which may warrant joints to make the required length / width in order to achieve the final product as per drawing.

1.2 This QCP is applicable to Sheets / Plates / Structural – Angles, Beams of all types, Sections of Rolled / Built up, Rounds, Pipes and Tubes.

1.3 The splicing norms dealt in this QCP is applicable to following ESP components ;

1.3.1 7X-X42 Outer Roof Assy
1.3.2 7X-X44 Hopper Upper & Middle
1.3.3 7X-X45 Hopper Lower with SS Liner Sheet
1.3.4 7X-X46 Insulator Support Panels
1.3.5 7X-X47 Inner Roof Panel Assy
1.3.6 7X-X49 Casing Shell Panels
1.3.7 7X-X50 Inlet / Outlet Funnel

1.4 This QCP covers both Carbon Steel and SS Liner Sheet materials applicable to ESP Components.

2.0 SPLICING NORMS - GENERAL POLICY

2.1 The fabricator or OS cutting plan section shall categorically try to avoid joints as much as possible with the supplied raw materials.

2.2 Further to explain the point no. 2.1 – the fabricator and OS cutting plan section shall try to make the supplied raw materials without any joints to cover up the loaded quantities – Eg., Out of 10 Nos of casing shell Panels loaded - maximum no. of panels shall be accommodated without any joints by fabricator and only to reduce the material wastage the balance quantity of casing shell panels shall be made with permitted joints as applicable.

2.3 The joints permitted are considered with a following view only

2.3.1 To reduce the material wastage
2.3.2 To make the best use of supplied raw materials sizes without prejudice to appearance and quality of final product as applicable
2.3.3 Aesthetic appearance shall not be sacrificed in accommodating the splicing norms.
2.3.4 Splicing Joints shall be avoided where a cross member is meeting or on bolt hole region. This is to be strictly adhered by fabricator and shall study the drawing fully with all the matching components.

2.4 ESP Components where joints are not permitted

2.4.1 Shock Beam
2.4.2 Rapping Shaft
2.4.3 Vertical Beam
2.4.4 Foundation Bolt
2.4.5 Suspension Rod
2.4.6 Emitting Frame Top, Middle and Bottom
2.4.7 Collecting Suspension Arrangements
2.4.8 Lifting Holder
2.4.9 Vertical Stay
2.4.10 Shock bar

3.0 SPLICING NORMS – SPECIFIC TO RAW MATERIALS

3.1 SHEETS / PLATES (CARBON STEEL)

3.1.1 The preparation of joints shall be staggered one so that formation of (+) plus type joint is avoided. The minimum offset (staggering) to avoid the plus type joint shall be minimum 100mm.

3.1.2 For a surface area including 2 Mtr X 2 Mtr and less - the permitted smallest dimension of any piece shall be minimum 400 mm (either length wise or breadth wise) and the same will be 600mm minimum for more than 2 Mtr X 2 Mtr surface area – Refer sketch - S1

3.1.3 The distance between nearest stiffener and the joint parallel to it shall be minimum 50mm – Refer sketch – S1

3.1.4 The vertical joint is permitted on the taper portion. However the distance between meeting of the vertical joint with the horizontal joint shall be minimum 100mm – Refer sketch – S1

3.1.5 Butt weld reinforcement shall be ground flush wherever stiffeners cross them.

3.1.6 When bending of the plate is done before welding, the parallel joints shall be minimum 100 mm away from the bend line. The weld quality shall be ensured by

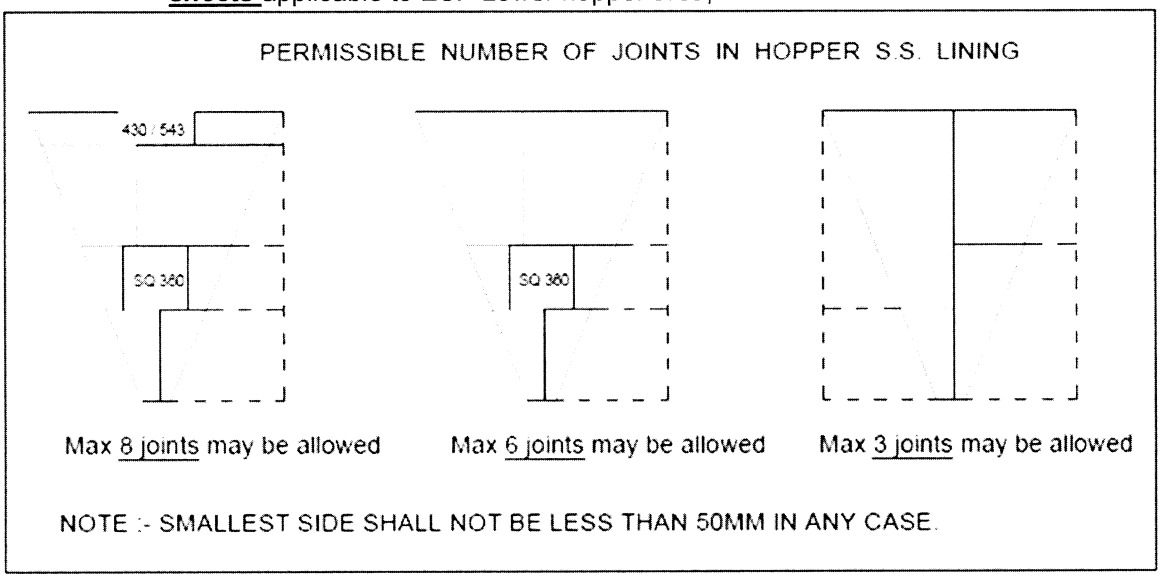
MPI / LPI. If the weld joint is subjected to bend, the weld shall be checked by LPI subsequent to bending.

3.1.7 The maximum number of permitted joints shall be as given below for carbon steel sheets / plates

Sl. No.	Surface Area in Sq. Mtr	Maximum No. Of joints permitted put together both axis (X & Y)
1	Less than & Up to 2	1
2	More than & Up to > 2 < 5	3
3	More than & Up to > 5 < 10	6
4	More than & Up to > 10 < 15	7
5	More than & Up to > 15 < 20	9
6	More than & Up to > 20 < 25	11
7	More than & Up to > 25 < 30	13
8	More than > 30	15

NOTE: The above permitted joints supersedes the maximum no. of joints given in clause no. 4.13 & 4.14 of SQP:ESP:284 Rev.01 Dtd.06.06.2007

3.1.8 The maximum number of permitted joints shall be as given below for ***SS Liner sheets*** applicable to ESP Lower hopper area;



3.2 ANGLES, CHANNELS, BEAMS (BOTH ROLLED / BUILT UP - INCLUDING NPB&UB) APPLICABLE TO ESP ROOF BEAMS & SUPPORTING COLUMNS 7X-X28 and 7X-X81, 82, 83 & 84

3.2.1 The splicing norms for Angles, Channels and Beams (both rolled / built-up) shall be strictly followed as per the drawing no.1-79-081-02331 Rev.00.

3.2.2 Any change other than given in above referred drawing shall be approved by Engg (AQCS) and the request for the same shall be forwarded by cutting plan section of OS Dept.

3.2.3 Only one joint is permitted on the transverse roof beams.

3.3 " H " BEAMS APPLICABLE TO CASING STRUCTURE COLUMNS – 7X-X48 (BOTH ROLLED / BUILT UP)

3.3.1 The splicing norms for "H" Beams shall be strictly followed as per the drawing no. 4-79-000-00763 Rev.00.

3.3.2 Maximum two joints ie., one for shop and another for site / field shall be permitted for a maximum length of 16.5 Mtr of section considering ODC constraints.

3.3.3 Joints on flange shall be staggered by minimum 300 mm avoiding falling of joint on the same side of the built up sections.

3.3.4 The splice plate provided for web joints shall not foul with the gusset plates provided on the "H" beams and a minimum clearance of 50 mm shall be maintained.

3.3.5 The minimum distance permissible between a joint and the nearest gusset / bracket location shall be 200mm.

3.4 RODS, ROUNDS, PIPS AND TUBES

3.4.1 No joint is permitted if the length of rod is 2 M or less.

3.4.2 Minimum length for splicing using sleeve shall be 500mm for tubes

3.4.3 Only one joint is permitted for Tie Rods / Strut

4.0 EDGE PREPARATION, WELDING, WELD NDE DETAILS :

4.1 Check for material specification of plates / sections which are to be joined to avoid mix up of material. TCN to be obtained for change of material.

4.2 Electrode selection shall be as per the respective WPS.

4.3 Welding shall be followed with suitable methods of sequence and controls to minimize the weld distortion.

4.4 Weld over joint shall be avoided and minimum distance between stiffeners parallel to weld joint is 50mm.

4.5 Wherever, back grinding is not feasible due to location of the plate / sheet, root welding to be carried out with 3.15mm electrode and LPI to be carried out after thorough cleaning and repeat LPI after final welding.

4.6 Following are the guidelines for Edge Preparation (EP) if not specified in drawing;

a) **Plates / Sheets up to 5mm :** No EP required. Provide 2 to 3 mm root gap, weld on both sides. MPI to be conducted after final welding.

b) **Plates of 6 mm :** No EP required. Weld shall be with square butt with 2 to 3 mm gap. Weld from first side and turn the plate for back grinding and conduct root LPI. Complete the weld and conduct the final MPI.

c) **Plates of 7 & 8 mm :** Single "V" , 60° EP, Weld from V side and turn the plate, back grind and conduct LPI, complete the Weld. Final MPI.

d) **Plates above 8 mm :** Double "V" , 60° EP, Weld one side, Carryout back grind and conduct LPI to ensure sound metal and weld from other side. Final both side MPI after completion of weld.

e) **For Structural (Angle, Channel, Beam)** : Single "V" , 60° EP, Weld from V side and back grind and conduct LPI. Complete the weld, conduct final LPI before splice plate setting.

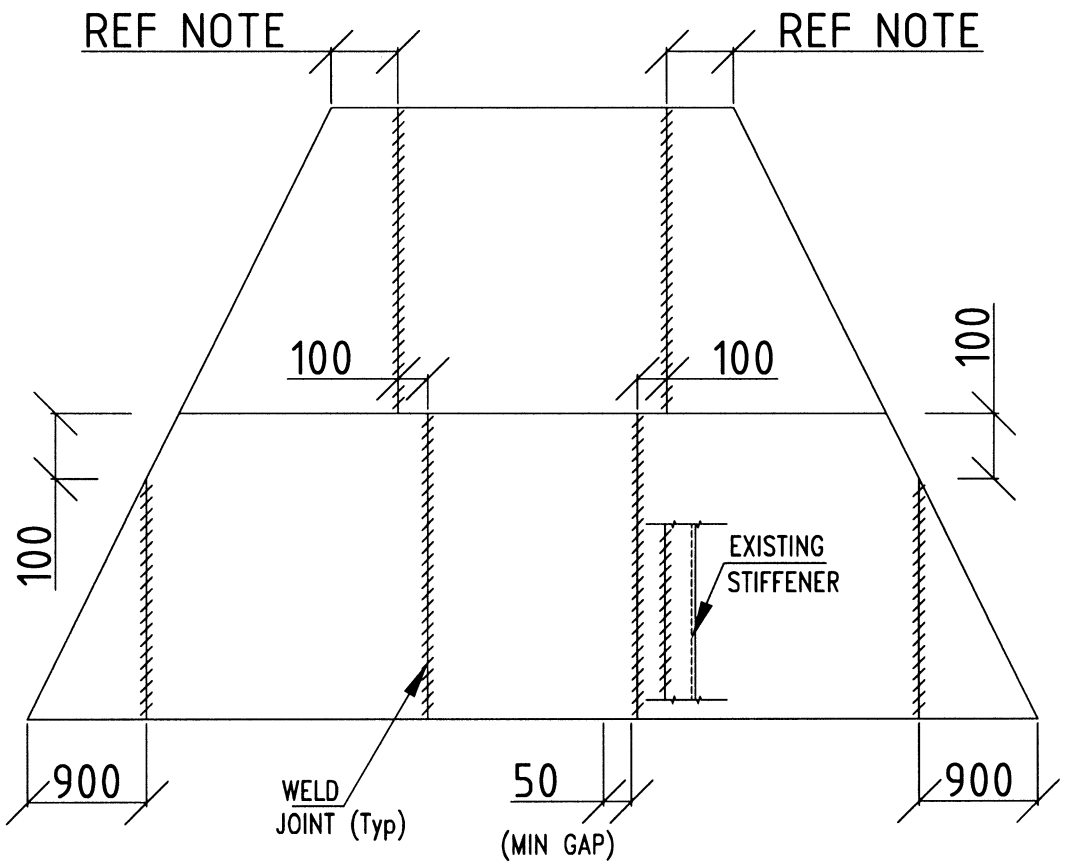
Note:

1. Splice plate details shall be taken from relevant fabrication Engg drawing.
2. Splice Joint shall be avoided where a cross member is meeting.
3. The weld should be ground flush and smooth and the proper splice plate is placed & welded.

!!!@@@###

QUALITY CONTROL PROCEDURE FOR SPLICING OF SHEETS, PLATES AND OTHER STRUCTURAL ITEMS

SKETCH FOR CLAUSES 3.1.2 TO 3.1.4



NOTE : MINIMUM DIMENSION OF SPLICED PLATE = 200 MM FOR DUCT WALL OF ANY SIZE

ALL DIMENSIONS ARE IN MM

BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPALLI 620 014
QUALITY ASSURANCE

PROCEDURE FOR VISUAL INSPECTION OF NON PRESSURE PARTS

REV.	DATE	PREPARED	REVIEWED	APPROVED
00	15/07/96	P.S.Narayanan	A.R.Reddy	V.Raghavendran
01	28/03/04	A Francis	G S N Murthy	C R Raju

REVISION STATUS

REVISION NO:	CLAUSE NO	DETAIL OF REVISION
00	----	1) PR:QE:021/02 renumbered as SIP:NP:06.
		2) Editorial corrections for clarity.
		3) Clause 3.1 modified.
01	3.1	Code related change
	3.2	For better clarity
	3.2.1	-do-
	3.2.3	Code related change
	3.2.5	For better clarity
	4.4	Code related change

1.0 SCOPE

1.1 This procedure details out the visual inspection of all base metal surfaces and weld joints of Non pressure parts.

2.0 REFERENCE DOCUMENTS

AWS D 1.1 & Relevant drawings

3.0 VISUAL INSPECTION OF GAS CUT EDGES

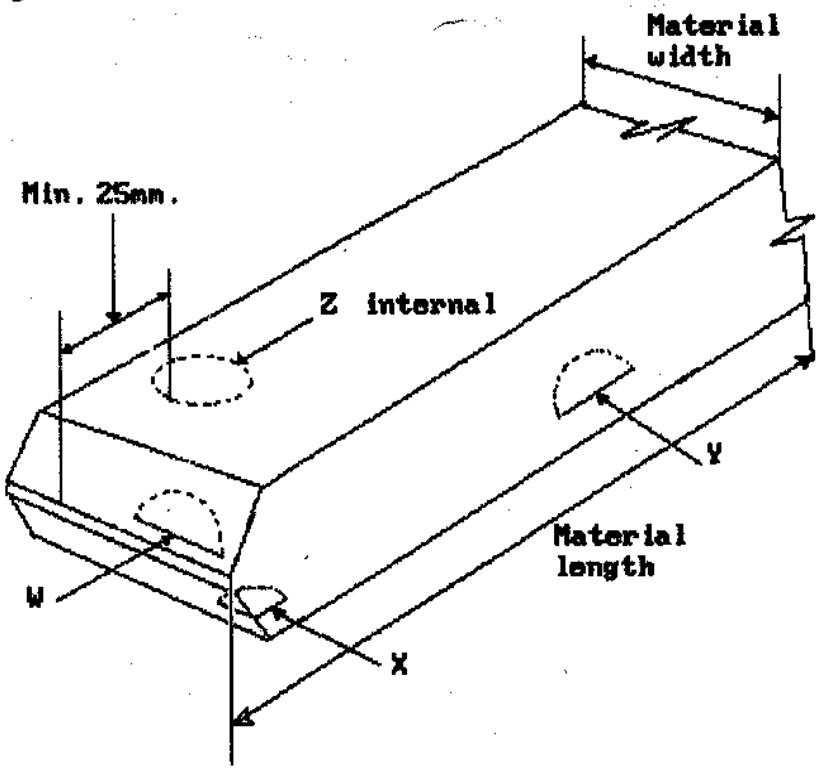
3.1 Acceptability and repair of mill induced laminar discontinuities in cut surfaces

Description of Discontinuity	Repair Required
Any discontinuity 25mm in length or less	No repair .
Any discontinuity over 25mm in length and 3mm max. depth (after grinding & confirmation of depth on 10% of total such locations)	No repair
Any discontinuity over 25mm in length with depth over 3mm but not greater than 6mm.	Remove by grinding and weld
Any discontinuity over 25mm in length with depth over 6mm but not greater than 25mm.	Completely remove and weld.
Any discontinuity over 25mm in length with depth greater than 25mm.	See Cl.3.2

3.2 For discontinuities over 25mm in length with depth greater than 25mm, discovered by visual inspection (and subsequent grinding for depth assessment) of plate cut edges/ bevel edges before welding or during examination of welded joints by radiography or ultrasonic inspection, following procedure shall be followed:

3.2.1 Prior to completing the weld joint, the discontinuities such as (W),(X) or (Y) shall be determined visually (for length) and by NDT (UT, and /or MPI) for depth and recorded for the size and shape of discontinuity as per Fig.1.

Fig.1 EDGE DISCONTINUITIES IN CUT PLATE



3.2.2 The repair of the discontinuity by welding shall be allowed in case area of discontinuity does not exceed 4% of the cut area with the following exceptions. If the width of the discontinuity or the aggregate width of discontinuities on any transverse section, as measured perpendicular to the plate length, exceeds 20% of the plate width, the limit of 4% area shall be reduced by percentage amount of the width exceeding 20% (e.g., if the discontinuity is 30% of plate width, the area of discontinuity cannot exceed 3.6% of the plate area). The discontinuity on the cut edge of the plate shall be gouged out to a depth of 25mm beyond its intersection of the surface by chipping, or carbon arc gouging, or grinding and blocked off by welding with manual shielded metal arc process in layers not exceeding 3mm in the thickness.

3.2.3 If discontinuity (Z) not exceeding the allowable area is discovered after the joint has been completed and is determined to be 25mm or more away from the face of the weld, as measured on the plate surface, no repair of discontinuity is required. If the discontinuity (Z) is less than 25mm away from the weld, it shall be gouged out to a distance of 25mm from the fusion zone of the weld by chipping, air carbon arc gouging or grinding. It shall then be blocked off by welding with low hydrogen SMAW process for at least four layers not to exceed 3mm thickness per layer. Submerged arc or other welding process may be used for remaining layers.

3.2.4 If the area of discontinuity (W), (X), (Y) or (Z) exceeds the allowable limits of Cl.3.2.2, the plate or sub-component shall be rejected.

3.2.5 The aggregate length of weld repair shall not exceed 20% of length of plate surface being repaired.

4.0 VISUAL INSPECTION OF WELDS

4.1 Visual examination of welds shall be performed after completion of welding and subsequent cooling to room temperature. However for ASTM A514 and A517 steels visual examination of welds shall be performed only after 48 hours of completion of welding.

4.2 All welds shall be cleaned to remove slag, spatter etc. and visually examined for defects like crack, undercut, porosity, lack of fusion etc.

4.3 The welds shall also be examined for size, shape and reinforcement.

4.4 **ACCEPTANCE CRITERIA AND DISPOSITION DETAILS ARE AS FOLLOWS**

Nature of defects	Acc. norms	Disposition
1) Crack, Lack of fusion, Overlap	Not accepted	Confirm by LPI/MPI, repair and retest.
2) Crater (Except at the ends of stitch welds outside the required length)	Not accepted	Fill by weld deposit.
3) Undercut		
For T < 25.mm	Up to 1.0 mm accepted. (Upto 2.0 mm if within 50mm for any 300 mm weld Length.)	To be ground & merged/ welded otherwise.
For T => 25.4 mm	Up to 2 .0 mm accepted.	>2.0mm to be ground and merged/welded
4) Porosity- Transverse Butt Welds	Piping porosity not permitted	
Porosity for other Butt/Fillet welds	One pore of <= 2.5 mm for Each 100 mm of Weld length is permitted.(*)	(*)Combined length of pores in fillet welds in web to stiffener: 10mm for 25 mm weld & 20mm for 300mm weld is however acceptable.
Weld contour		
1) Face of fillet	Flat or concave(meeting the throat) accepted. convexity is acceptable as below. 2mm for weld width <= 8mm 3mm for weld width > 8mm < 25 mm 5mm for weld width >= 25 m	
2) Size (Minimum)	As per drawing. Under size permitted as below(*) 2mm for nominal size $\leq$ 5mm 2.5mm for nominal size 6mm 3mm for nominal size $\geq$ 8 mm * if undersized weld length is less than of 10% of the total weld length.	
3) Reinforcement (groove	Max. 3 mm	

BHARAT HEAVY ELECTRICALS LIMITED

TIRUCHIRAPALLI 620 014

QUALITY ASSURANCE

QUALITY ASSURANCE

SIP: NP: 07/02

WELDING/WELDER QUALIFICATION FOR STRUCTURAL APPLICATIONS

REV.	DATE	PREPARED	REVIEWED	APPROVED
00	15/07/96	P.S.Narayanan	A.R.Reddy	V.Raghavendran
01	13/10/03	A Francis	GSN Murthy	C R Raju
02	25/11/09	T. Palanisamy	Bikramaditya Roy	Ravikumar V

Revision no	Clause no	Revision details
00	--	--
01	--	1.PR:QE:172/00 Renumbered as SIP:NP:07
		2.Editorial corrections for bettor clarity
02	--	1.Completely modified

1.0 SCOPE

1.1 This procedure details out the requirements of Welding procedure qualification/ Performance Qualification tests for welders and welding operators/ Welding procedure specification and maintenance of records for the same at sub Vendor works for structural application.

1.2 REFERENCE DOCUMENTS

1.2.1 AWS D1.1/D1.1M:2008.

2.0 WELDING PROCESS

a. **SMAW** -Shielded Metal Arc Welding.
b. **SAW** --Submerged Arc Welding.
c. **#GMAW** –Gas Metal Arc welding. (Note 1to3 to be strictly followed)

#Note,

1. Prior approval for GMAW to be obtained from BHEL/quality.
2. Gas Mixture of 80% Argon & 20% CO2 to be ensured.
3. All Production welds shall be done inside the closed shed only.

3.0 WELDING PROCEEDURE QUALIFICATION

3.1 Prepare draft WPS and get it approved by BHEL WTC.

3.2 Consumable selected for draft WPS shall be as per BHEL approved brand.

3.2.1 All NDE and pre treatment for plate before/after cutting & during/ after welding shall be as per the respective QCP & SQP.

3.3 Test plate of size 180x380mm of Specified thickness-2 nos for all butt (fig 5), corner (Fig 9) & fillet (fig 2) weld joints.

3.4 Minimum procedure qualification test requirement for Structural Fabrication : Carbon Steel to IS 2062 E250 GR A OR B.

Sl. NO	Process	PL. thick	Pre-heat	PWHT	Type of Jt.	Test-position	Position qualified
1	SMAW	25mm	NIL	NIL	Groove butt weld	1G	1G,1F
2	SMAW	40mm	YES 100deg.C	NIL	Groove butt Weld	2G	1G,2G,1F,2F
3	SMAW	56mm	Yes 100deg.C	Yes	Groove Butt weld	1G	1G,1F
4	SMAW	10mm	NIL	NIL	Corner weld	3G	3G, 3F
5	SMAW	*	NIL	NIL	Fillet	3F	3F
6	SAW	25mm	NIL	NIL	Butt weld	1G	1G,1F
7	SAW	25	Yes 100deg.C	NIL	Butt weld	1G	1G & 1F
8	SAW	56mm	YES 100deg.C	NIL	Corner weld	1G	1G & 1F
9	SAW	*	NIL	NIL	Fillet	1F	1F
10	SAW	*	NIL	NIL	Fillet	1F	1F
11	GMAW	10mm	NIL	NIL	fillet	3F	1F
12	GMAW	10mm	NIL	NIL	Groove butt weld	2G	1G,2G,1F,2F

Note:

1.0 * Ref fig 8 for size of test plates for fillet welds.

2.0 For all other material combinations separate procedure to the relevant code/standard shall be qualified before start of production welds.

3.0 SAW corner groove weld qualification with 15°+30° groove angle (ref fig9) shall be done along with plate groove butt weld.

4.0 For pipe WPS qualification Dia. 2 inch of schedule 80 and 6 inch of schedule 120 are to be welded in 5G & 2G position respectively. This qualifies for all sizes, positions and unlimited thickness of pipes and tubes.

3.5 Base material other than Carbon steel, applicable welding process is SMAW only. In such cases PQR shall be qualified as per AWS D.1.1.

3.6 Test shall be done in presence of BHEL/ QC or BHEL nominated AIA.

4.0 **BASE MATERIAL.**

4.1 Test plate base material shall match with drawing or other engineering Documents.

4.2 Test plate weld surface shall be ground smooth and free from Oil & scales.

5.0 **WELDING REQUIREMENT**

5.1 Weld groove configuration and dimensions shall be as shown in the Draft WPS, drawing or Sketch authorized by engineering for processing.

5.2 All Procedure qualification and production welds of SAW process shall be done in 1G/1F position only.

5.3 Details of process and consumable used for welding such as Preheat, consumable size, brand name, AWS classification for electrode, Wire and flux, Shielding gas etc shall be recorded and maintained.

5.4 Details of the welding parameters Such as Welding current, voltage, travel speed, wire feed, shielding gas mixture & gas flow rate etc shall be recorded and maintained.

5.5 Details of number of layers and passes of groove or fillet welds (fig6) shall be recorded.

5.6 Back gouge/grind the second side as applicable and ensure weld soundness by MT/PT before second side weld.

5.7 Complete the weld and ensure weld soundness by applicable NDE (MT, PT, and RT or UT).

5.8 Necessary PWHT (as per draft WPS) shall be done before marking the test Specimen for mechanical test.

5.9 The defective portion of the welds in the test plate shall be discarded and not repaired

6.0 Test plate Specimen & test requirement:

6.1 Test Specimen for butt welded test plate as per fig 5 and Fillet/ corner welded test plate as per fig 7 shall be punched with inspecting engineer's stamp before cutting the test specimen.(No. of test specimen shall be as per table-2)

6.2 WPS test specimen requirement for mechanical test are as follows:

Table 2

Test pl. thickness & dia. In mm	***Reduced Section tensile***	***Bend test 4t,180^0***			***Macro***	***thick qualified***		***Dia. Qualified***
		Root	*face*	*Side*		*Min.*	*Max.*	
T 3 to 10	***2***	***2***	***2***	*******	***--***	***3mm***	***2T***	***--***
T>10 T < 25	***2***	***--***	***--***	***4***	***--***	***3mm***	***2T***	***--***
T25 & over	***2***	***--***	***--***	***4***	***----***	***3mm***	***Unlimited***	***--***
Dia. 50 & t6	***2***	***2***	***2***	***-***	***--***	***3mm***	***20mm***	***Dia.20-100***
Dia. 150 t12	***2***	***2***	***2***	***-***	***--***	***5mm***	***Unlimited***	***Dia.>100mm***
Corner/ fillet weld	***--***	***--***	***--***	***--***	***3***	***5mm***	***Unlimited***	***--***

**For 10mm plate or wall thickness, a side bend test may be substituted for each of the required face- and root- bend tests.*

7.0 Mechanical test

7.1 Prepare the test specimen as per AWS D1.1 and move to BHEL Lab or NABL accredited lab for mechanical testing.

7.2 Mechanical test to be done in presence of BHEL/QC or BHEL nominated AIA.

8.0 Preparation of PQR & WPS

8.1 Generate qualified WPS and PQR (as per the format enclosed in page 9 and 10) indicating all process parameters, Mechanical/ NDE test results, reports as applicable and submit to inspection engineer for verification and approval.

9.0 Welder/ Welding operator qualification (WQ)

9.1 The welder/ welding operators engaged for procedure qualification tests are automatically qualified for production welding.

9.2 Test material: for carbon and alloy steel respective materials shall be used for test.

9.3 Test plate size: 200x200x25 mm or 200x200 and respective plate thicknesses.

9.4 WQ Test and production position qualified are as follows.

Table 3.

Weld type	Test Position	Production position qualified
Plate Groove	**3G**	**1G, 2G, 3G, 1F, 2F & 3F**
Plate groove	**1G**	**1G & 1F**
Plate fillet	**1F**	**1F**
Plate Fillet	**3F**	**1F, 2F & 3F**
Pipe Groove	**2G & 5G**	**All position.**
Pipe fillet	**4F**	**1F,2F & 4F**

Note: Additional position can be qualified if required. Only qualified personnel shall be engaged in respective positions for production weld.

9.5 WQ Test requirement: Two Nos of side bend tests or 100% RT for butt welded test piece. Macro examination at three faces for fillet welds as per fig 7.

9.6 On successful test results WQR (as per the format enclosed in page 8) to be prepared & countersigned by inspection engineer and maintained for verification.

9.7 **WQ period of effectiveness:**

Qualification is effective unless : 1) The operator or welder is not engaged in welding for a period exceeding six months or unless 2) There is a specific reason to question his ability.

10 **Documentation:**

10.1 Prepare consolidated list of qualified WPS, Welder and Welding operator qualification records and maintain.

11 **Qualification–Types & Limitations**

11.1 Requalification of WPS is required in the following cases

Sl. No	Welding variable	SMAW	SAW	GMAW
1.	Change from Low hydrogen to non low hydrogen electrode	Yes	--	--
2.	Change from wire & flux combination	--	Yes	--
3.	Change in nominal filler metal diameter by	>0.8mm	Increase	yes
4.	>7% Change in voltage each dia. used	--	Yes	Yes
5.	% change in travel speed	--	>15	>25
6.	Change in position qualified	Yes	Yes	Yes
7.	A decrease in Groove angle	Yes	Yes	Yes
8.	A decrease in Root gap	Yes	Yes	Yes
9.	An increase in root face	Yes	Yes	Yes
10.	Addition or deletion of PWHT	Yes	Yes	Yes

12 **PQR/ WPS requirement for Different strength Base materials**

12.1 For dissimilar composition of Low strength to high strength welded connections separate PQR and WPS shall be qualified.

12.2 In such cases Low hydrogen electrodes shall only be used. (Preheat,Post heat and PWHT as per applicable SQP and draft WPS).

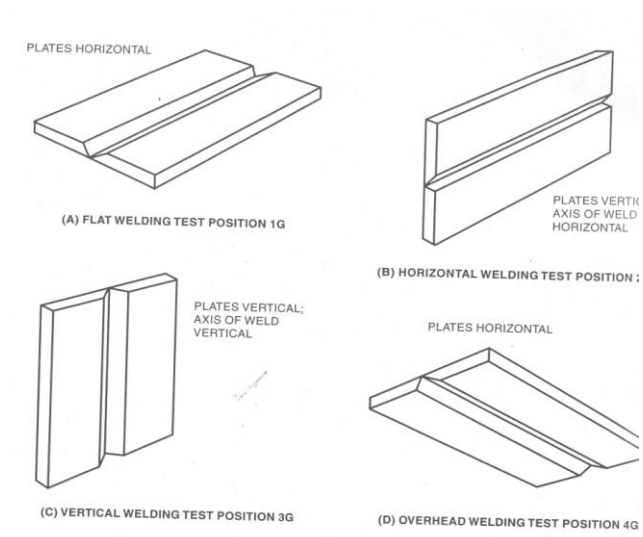


Figure 1

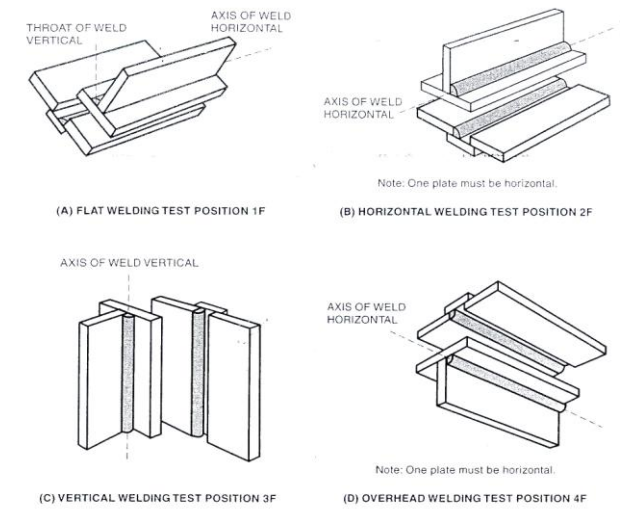


Figure 2

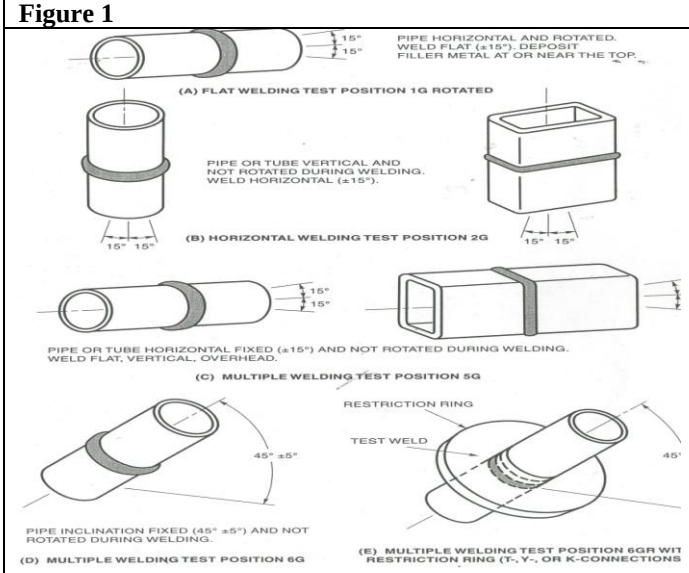


Figure 3

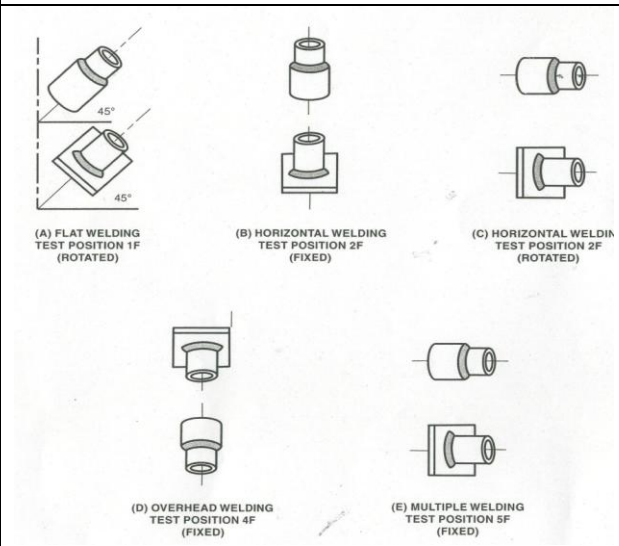


Figure 4

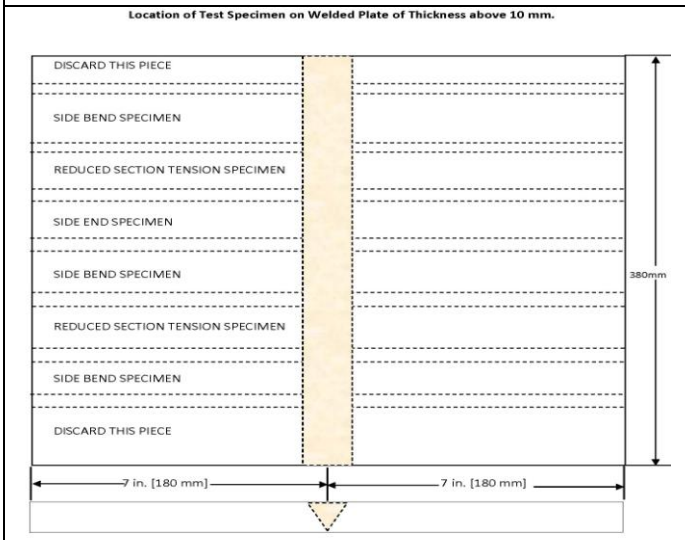


Figure 5

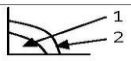
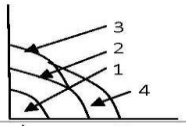
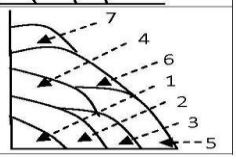
Fillet size	No. of layer	No. of Passes	Joint layer & passes
Up to 10mm	1	1	
12	1 2	1 2	
16	1 2 2	1 2 3	
20	1 2 3 3	1 2 3 4	
25	1 2 3 3 4 4 4	1 2 3 4 5 6 7	

Figure 6

Figure 7 Fillet weld test specimen Details

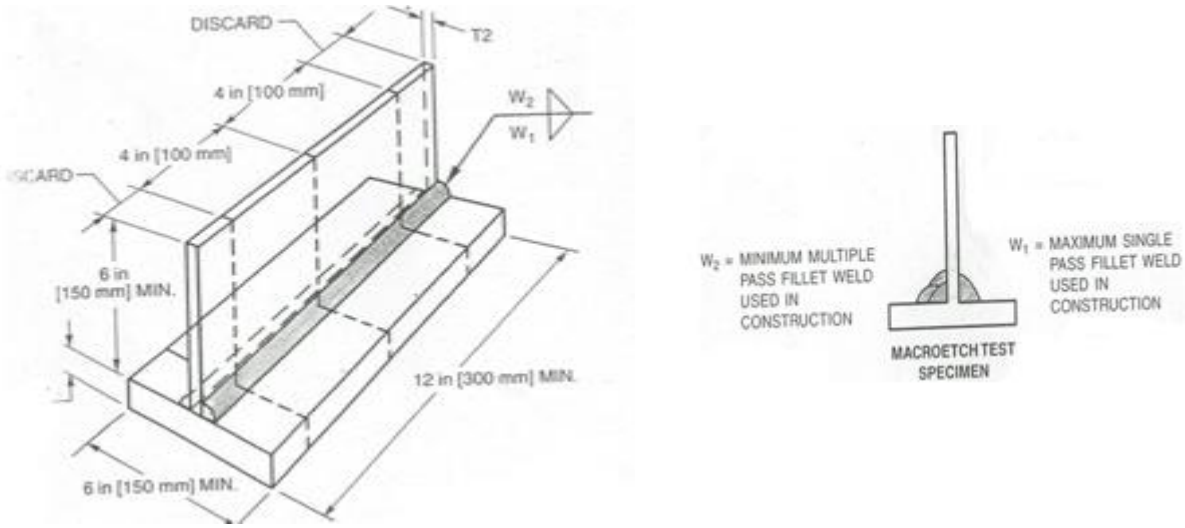
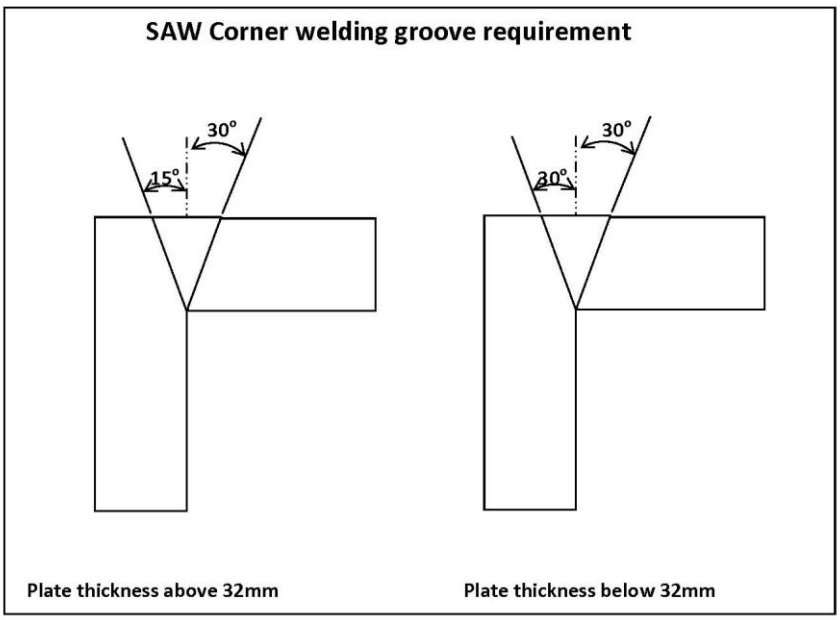


Figure 8 Fillet weld Test plate Selection details

Weld Size in mm	T1 minimum	T2 minimum
5	12	5
6	20	6
8	25	8
10	25	10
12	25	12
16	25	16
20	25	20
>20	25	25
Note: Where the maximum plate thickness used in Production is less than the value shown above, the Maximum thickness of the production plates may be Substituted for T1 & T2.		

Figure 9



WELDER, WELDING OPERATOR, OR TACK WELDER QUALIFICATION TEST RECORD

Type of Welder _____

Name _____ Identification No. _____

Welding Procedure Specification No. _____ Rev _____ Date _____

Variables	Record Actual Values Used in Qualification	Qualification Range
Process/Type [Table 4.12, Item (1)]		
Electrode (single or multiple) [Table 4.12, Item (7)]		
Current/Polarity		
Position [Table 4.12, Item (4)]		
Weld Progression [Table 4.12, Item (5)]		
Backing (YES or NO) [Table 4.12, Item (6)]		
Material/Spec.	to	
Base Metal		
Thickness: (Plate)		
Groove		
Fillet		
Thickness: (Pipe/tube)		
Groove		
Fillet		
Diameter: (Pipe)		
Groove		
Fillet		
Filler Metal (Table 4.12)		
Spec. No.		
Class		
F-No. [Table 4.12, Item (2)]		
Gas/Flux Type (Table 4.12)		
Other		

VISUAL INSPECTION (4.8.1)

Acceptable YES or NO _____

Guided Bend Test Results (4.30.5)

Type	Result	Type	Result

Fillet Test Results (4.30.2.3 and 4.30.4.1)

Appearance _____ Fillet Size _____

Fracture Test Root Penetration _____ Macroetch _____

(Describe the location, nature, and size of any crack or tearing of the specimen.)

Inspected by _____ Test Number _____

Organization _____ Date _____

RADIOGRAPHIC TEST RESULTS (4.30.3.2)

Film Identification Number	Results	Remarks	Film Identification Number	Results	Remarks

Interpreted by _____ Test Number _____

Organization _____ Date _____

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in conformance with the requirements of Clause 4 of AWS D1.1/D1.1M, (_____) *Structural Welding Code—Steel.*
(year)

Manufacturer or Contractor _____ Authorized By _____

Form N-4 Date _____

WELDING PROCEDURE SPECIFICATION (WPS) Yes ☐
PREQUALIFIED _____ QUALIFIED BY TESTING _____
or PROCEDURE QUALIFICATION RECORDS (PQR) Yes ☐

Identification # _____
Revision _____ Date _____ By _____
Authorized by _____ Date _____
Type—Manual ☐ Semiautomatic ☐
Machine ☐ Automatic ☐

Company Name _____
Welding Process(es) _____
Supporting PQR No.(s) _____

JOINT DESIGN USED
Type:
Single ☐ Double Weld ☐
Backing: Yes ☐ No ☐
Backing Material:
Root Opening _____ Root Face Dimension _____
Groove Angle: _____ Radius (J–U) _____
Back Gouging: Yes ☐ No ☐ Method _____

BASE METALS
Material Spec. _____
Type or Grade _____
Thickness: Groove _____ Fillet _____
Diameter (Pipe) _____

FILLER METALS
AWS Specification _____
AWS Classification _____

SHIELDING
Flux _____ Gas _____
Composition _____
Electrode-Flux (Class) _____ Flow Rate _____
_____ Gas Cup Size _____

PREHEAT
Preheat Temp., Min. _____
Interpass Temp., Min. _____ Max. _____

POSITION
Position of Groove: _____ Fillet: _____
Vertical Progression: Up ☐ Down ☐

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW) Short-Circuiting ☐
Globular ☐ Spray ☐
Current: AC ☐ DCEP ☐ DCEN ☐ Pulsed ☐
Power Source: CC ☐ CV ☐
Other _____
Tungsten Electrode (GTAW)
Size: _____
Type: _____

TECHNIQUE
Stringer or Weave Bead: _____
Multi-pass or Single Pass (per side) _____
Number of Electrodes _____
Electrode Spacing Longitudinal _____
Lateral _____
Angle _____
Contact Tube to Work Distance _____
Peening _____
Interpass Cleaning: _____

POSTWELD HEAT TREATMENT
Temp. _____
Time _____

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals		Current		Volts	Travel Speed	Joint Details
		Class	Diam.	Type & Polarity	Amps or Wire Feed Speed			

Form N-1 (Front)

Procedure Qualification Record (PQR) # _____
Test Results

TENSILE TEST

Specimen No.	Width	Thickness	Area	Ultimate Tensile Load, lb	Ultimate Unit Stress, psi	Character of Failure and Location

GUIDED BEND TEST

Specimen No.	Type of Bend	Result	Remarks

VISUAL INSPECTION
Appearance _____
Undercut _____
Piping porosity _____
Convexity _____
Test date _____
Witnessed by _____

Radiographic-ultrasonic examination
RT report no.: _____ Result _____
UT report no.: _____ Result _____

FILLET WELD TEST RESULTS

Minimum size multiple pass Macroetch		Maximum size single pass Macroetch	
1. _____	3. _____	1. _____	3. _____
2. _____		2. _____	

Other Tests

All-weld-metal tension test
Tensile strength, psi _____
Yield point/strength, psi _____
Elongation in 2 in, % _____
Laboratory test no. _____

Welder's name _____ Clock no. _____ Stamp no. _____

Tests conducted by _____ Laboratory

Test number _____

Per _____

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, an tested in conformance with the requirements of Clause 4 of AWS D1.1/D1.1M, (_____) *Structural Welding Code—Steel*
(year)

Signed _____
Manufacturer or Contractor
By _____
Title _____
Date _____

Form N-1 (Back)

BHARAT HEAVY ELECTRICALS LTD
BOILER AUXILIARIES PLANT
TANIPET-632 406 (INDIA)
QUALITY ASSURANCE DEPT.

STANDARD QUALITY PLAN FOR WELDING

MASTER COPY

Q.P.No.SQW01
REV.No.NIL
DATE10-06-93
PAGE 01of02

PREPARED BY: V. Jayaram | REVIEWED BY: M Tambekh | APPROVED BY: M Tambekh

No.	COMPONENT & OPERATION	CHARACTE-RISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE STANDARD	FORMAT OF REC	AGENCY	REMARKS
	2	3	4	5	6	7	8	9	10	11
1	WELDING ELECTRODE/ FLUXES	CHEMISTRY	M	LAB TEST	EACHBATCH	AWS A5.1,5.7 5.5,5.17OR 5.18	AWSA5.1.5.5 5.7,5.17or 5.18	TC	SUPP-LIER	*T.C's WILL BE MAINTAINED BY WTC
2	STORAGE OF ELECTRODES/ FLUXES IN STORES	METHOD OF STORAGE	MAJOR	VISUAL	100%	AS PER AWS 5.8,5.17	A5.1,5.5, 5.18 etc		STORES WTC	
3	ISSUE CONTROL	METHOD OF ISSUE	MAJOR	WQR	10%	AS PER WTC	DP&DI		WTC	
4	WELDER QUALIFICATION	WQR	MAJOR	LIST OF QUALIFIED WELDERS IN PRODN BAYS TO BE CHECKED	100%	ONLY QUALIFIED WELDERS AS PER WQR SHALL BE USED FOR WELDING THAT PARTICU-LAR WELD.		LIST OF QUAL IFIED WELDER	WTC	VERIFICATION OF RECORD i.e,WQR
5	PROCDURE QUALIFICATION	WPS	MAJOR	WPS TO BE VERIFIED FOR THE PARTICULAR MATL.COMB -INATION MATL COMB INATION	100%	ONLY THE QUALIFIED/PRE-QUALIFIED PROCEDURE FOR PARTICULAR MATERIAL COMBINATION AND POSITION METHOD SHALLL BE USED		LIST OF QUA LIFIED WPS	WTC	VERIFICATION OF RECORDS i.e, WPS
6	BAKING & DRY-ING OF LOW H2 ELECTRODES	DRYNESS OF LOW HYDRO-GEN ELECTRO-DES	MAJOR	VISUAL	RANDOM	WTCI:002/REV 02 DT.15.7.93 AWS D.1.1 (LATEST)		LOG BOOK	WTC	VERIFICATION OF RECORDS AT RANDOM

STANDARD QUALITY PLAN FOR WELDING

Q.P.SQPWO1
REV.NO.NIL
DATE10.06.93
PAGE02OF02

1	2	3	4	5	6	7	8	9	10	11
7	PREHEAT,INTER PASS HEAT POST HEATING	TEMPERATURE OF JOB	MAJOR	BY THERMAL CHALK	RANDOM	PR:QA:/WPS/ OPS AND APPLICABLE	COLOUR CHANGE TO INDICATE CORRECT TEMP	—	PRODN/ QC	WITNESS AT RANDOM
8	ROOT WELDING OTHER WELDING	QUALITY OF WELD, INTER PASS CLEANING WIRE BRUSHING GRINDING	MAJOR	VISUAL	RANDOM	AS PER APPLI CABLE WPS, OPS,QCP,PR:QA	NO CRACKS ALLOWED		PRODN/ QC	WITNESS WELD REINFORCEMENT WELD UNDERCUT STANDARD REF. OF INSTRUMENT USED
9	NDE	QUALITY OF WELD	MAJOR	UT,RT PT,MT	AS PER APPLICABLE WI	AS PER APPLICABLE WORK INSTRUCTIONS		HC	QC	WITNESS
10	FILLET SIZES OF FILLET WELD	SIZE OF WELD	M	FILLET GAUGE CHECK	100%	AS PER DRAWING		HC	QC	WITNESS
11	POST WELD HEAT TREATMENT	CORRECTNESS OF SRT CYCLE	C	VERIFICA-TION OF CYCLE AS PER PRODUCT HT CYCLE FROM HT SCHEDULE HT:001	100%	TEMPERATURE AT WHICH JOB LOADED IN FURNACE HEAT ING RATE SOAKING RATE SOAKING TIME COOLING RATE TEMPERATURE TO WHICH JOB TO BE FURNACE COOLED	AS PER SRT CYCLE IN HT:001 FOR THE PARTICULAR COMPONENT	HC	PRODN/ QC	VERIFICATION HT CYCLE