

		CORPORATE STANDARD			AA0622101	
					Rev. No. 02	
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CLASSIFICATION OF WELDS, THEIR INSPECTION, TESTING AND ACCEPTANCE						
1.0 SCOPE						
1.1 This standard defines four grades of welds in steels viz. grade-I, grade-II, grade-III and grade-IV that are carried out in BHEL. It also covers the inspection requirements, testing and acceptance standards for these grades of welds to ensure that quality welds are produced.						
1.2 Welds occurring on products manufactured to any particular code of practice by contractual or statutory obligations shall follow welding, inspection, testing acceptance etc. as per the relevant codes.						
1.3 The grade of welds shall be chosen and specified in the drawings based on considerations of weld joint efficiency and the type of joints.						
2.0 CLASSIFICATION						
2.1 GRADE-I						
Grade-I shall apply to full penetration butt welds, full throat welds and corner welds for following applications.						
a) Welds subjected to stresses more than 60% of yield point of the welded metal at working temperature.						
OR						
b) Structures subjected to highly dynamic or severe alternating stresses.						
OR						
c) Structures operating above 250°C or below 0°C						
2.2 Grade-II						
2.2.1 Grade-II shall apply to full penetration or partial penetration butt welds for following applications						
a) Welds subjected to stresses between 40 to 60% of yield point of the welded metal at working temperature						
OR						
b) Structures subjected to dynamic or alternating stresses of medium intensity or severe static stresses.						
OR						
c) Structures operating above 150° C to 250° C						
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2.2.2 Grade-II partial penetration welds are not desirable and shall only be used where stress concentration at the root of welds is not of in significance.

2.3 GRADE-III

2.3.1 Grade-III shall apply to full penetration or partial penetration butt welds and fillet welds for following applications

a) Welds subjected to stresses below 40% of yield point of the welded metal at working temperature.

OR

b) Structures subjected to light to medium static stresses and no dynamic loading is involved.

OR

c) Weld seams which are not possible to be checked for leaks by conventional methods of testing such as hydraulic testing etc.

2.4 Grade-IV

2.4.1 Grade-IV shall be specified for all general production welding of lightly stressed nature and for weld seams which can be checked by hydraulic testing for leaks.

2.5 Qualified welding procedure and welders shall be used for all grades of welds.

2.5.1 For the purpose of classification of welds a compound weld i.e. a combination of butt and fillet welds, shall be considered as butt weld.

2.5.2 Type of joints not covered in the standard shall be decided by the designer in consultation with welding technologist.

3.0 INSPECTION REQUIREMENTS

3.1 Table-1 indicates the inspection requirements during various stages of welding for each grade of weld.

Table-1 Inspection Requirements during various stages of welding

Requirement	Grade-I	Grade-II	Grade-III	Grade-IV
3.1.1 Type of joint	Stress relieved full penetration butt joints welded from both the sides or one side.	Stress relieved full penetration butt joints welded from both sides or one side.	Full penetration or partial penetration butt welds or fillet welds, welded from both the sides or one side.	All types of general production welds. Can be used for partial, full penetration fillet or butt welds, welded from both the sides or one side.
3.1.2 Weld joint Efficiency (Applicable for full Penetration butt Welds only)	1.00	0.85	0.70	0.55
3.1.3 Edge preparation before welding	(a) Weld preparation shall be made by machining/ flame cutting as called for in drg. The flame cut preparation shall be ground to about 1.5 mm to get bright smooth face. (b) Visual examination of weld preparation, supplemented by random dye penetrants testing and visual examination for fit up. In case of Steam Turbine Cylinders & Chest etc. 100 mm width to be radiographed as specified in relevant drawing. (c) Examine ultrasonically for lamination and harmful segregation in an area 75 mm deep along the edge preparation, if the visual or dye penetrant inspection reveals defect	(a) Weld preparation shall be made by flame cutting and grinding. (b) Visual examination of weld preparation and for fit up.	(a) Weld preparation shall be made by flame cutting and grinding. (b) Visual examination of weld preparation and for fit up.	(a) Weld preparation shall be made by flame cutting or grinding (b) Visual examination of weld preparation and fit up.

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Requirement	Grade-I	Grade-II	Grade-III	Grade -IV
3.1.4 Back chipping of run in joints welded from both sides	(a) Back chipping shall be done. (b) 100% visual examination shall be carried out (magnifying glasses can be used) and supplemented by random dye penetrant test/magnetic particles test.	(a) Back chipping shall be done only in the case of full penetration welds. (b) 100% visual examination shall be carried out (magnifying glasses can be used) and supplemented by random dye penetrant test/magnetic particles test.	(a) Back chipping shall be done only in the case of full penetration welds. (b) 100% visual examination shall be carried out (magnifying glasses may be used). If considered necessary will be examined by dye penetrant/magnetic particles test.	(a) Back chipping not required.
3.2 On completion of butt welds	(a) 100% visual examination shall be carried out in the vicinity of welds for the strikers, undercuts, cleats, tacks & blended. The entire butt weld area & heat affected zone shall be dye penetrant/magnetic particles tested. (b) 25 to 100% of weld length shall be examined by radiographic/ultrasonic tests depending upon the product and customer requirement. Extent of percentage of testing shall be specified on the drawing by the designer. Weld to be radiographed need not be ground or otherwise smoothed for the purpose of radiographic test unless its surface irregularities or junction with the base metal would interfere with the interpretation of weld defects observed in the radiographs.	(a) 100% visual examination shall be carried out in the vicinity of welds for arc strikes, undercuts, cleats, tacks & gouges & shall be ground and blended. The entire butt weld area & heat affected zone shall be dye penetrant/magnetic particles tested. (b) 10% of weld length shall be examined by radiographic/ultrasonic tests depending on the product & customer requirement. Weld to be radiographed need not be ground or otherwise smoothed for the purpose of radiographic test unless its surface irregularities or junction with the base metal could cause objectionable weld defects to be observed in the radiographs.	(a) 100% visual examination shall be carried out in the vicinity of welds for arc strikes, undercuts, cleats, tacks & gouges & shall be ground and blended. The entire butt weld area shall be dye penetrant/magnetic particles tested. (b) Ultrasonic or radiographic testing is required unless specified by customer/product needs.	(a) Weld shall be subjected to visual examination, only zones of doubt may be subjected to dye penetrant/magnetic particle testing.

Requirement	Grade-I	Grade-II	Grade-III	Grade -IV
As above	(c) Weld surface shall be ground smooth when tested by ultrasonic means. On either side where the probe has to traverse, the search surface should be free of weld spatter, dirt and loose scale so as to permit intimate contact with the surface.	(c) Weld surface shall be smooth when tested by ultrasonic means and sharp ripples on weld surface to be removed by grinding or chipping.	(c) Weld surface shall be ground smooth when tested by ultrasonic means and sharp ripples on weld surfaces to be removed by grinding or chipping.	
Note: Ultrasonic test or Radiographic test shall be carried out before heat treatment. For items subject to critical service conditions specified by the designers, ultrasonic/radiographic tests may be repeated after heat treatment.				
3.3 On completion of fillet welds	Not applicable, as fillet welds are not to be used for grade-I welds.	Not applicable, as fillet welds are not to be used for grade-II welds.	Quality of weld shall be assessed on the basis of; (a) Fit up of the joint (b) Visual appearance of the finished weld (c) Dye penetrant/magnetic particles inspection of the complete length of weld shall be carried out only in case of doubt. (d) Air testing shall be carried out if considered necessary.	Weld shall be subjected to visual examination and only zones of doubt may be subjected to dye penetrant/magnetic particle testing.

3.3.1 JOINT EFFICIENCY

- a) The joint efficiency will be less by 5% of the specified joint efficiency, if the joint is welded from one side only.
- b) The joint efficiency for un-stress relieved fabrication of grade-I and grade-II will be 5% less than the specified joint efficiency. For the other grades joint efficiency is given on the basis of joints without stress relieving.

3.3.2 ULTRASONIC/RADIOGRAPHIC EXAMINATION-EVALUATION AND RETESTS

- a) In case the above examination reveals that the examined length of the weld is acceptable as per the standard, the entire representative length of the weld shall be considered acceptable.
- b) In case this examination reveals that the examined weld is un-acceptable as per this standard the quantum of length of weld inspected adjacent to the defective region shall be doubled for radiographic/ultrasonic test. If the additional examination also shows that the weld is unacceptable the 100% radiographic/ultrasonic examination of all welds must follow, for acceptance or rejection.
- c) If on examination of double the length it is found acceptable then the defective portion noticed earlier shall be rectified and retested for ultrasonic/ radiographic examination.

3.3.3 Welded joints will be subjected to hydraulic or other leak tests called for on the drawing.

3.3.4 Hydraulic tests if called for shall be carried out after stress relieving (if stress relieving is required).

4.0 ACCEPTANCE STANDARDS

4.1 Unacceptable defects in any grade of weld are detailed below and are dependent upon whether the joint being welded is a full penetration butt weld, partial penetration butt weld or a fillet weld. If these defects are not present then the welds are considered acceptable.

4.2 UNACCEPTABLE DEFECTS

Table 2, 3, 4, 5 below give unacceptable defects for grade-I, grade-II, grade-III & grade-IV welds respectively.

TABLE-2 UNACCEPTABLE DEFECTS FOR GRADE-I WELDS

Nature of defect	BUTT WELDS		FILLET WELDS
	Full Penetration	Partial Penetration	
Crack	Unacceptable		
Lack of fusion	Unacceptable		
Lack of Penetration	Unacceptable (a) If the individual slag line is greater than $\frac{1}{3}$ T for T upto 56mm. 19mm for T above 56mm. OR (b) If the width of the individual slag line is greater than 1.6 mm for weld thickness upto 19mm. 2.4 mm for weld thickness from 19 mm to 56 mm. 3.2 mm for weld thickness above 56 mm.	Not applicable	Not applicable
Group of slag inclusion	Any group of slag inclusions in a line with an aggregate length greater than T in a length shorter than 12T is unacceptable, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.		
Porosity	Porosity in excess of that shown in the ASME Sec VIII Div-1 appendix 8 is acceptable. The radial (through wall) nature of worm holes as to be considered in stringent level compared to porosity.		
Surface defects	Weld bead shall smoothly match the base metal. No undercut is acceptable.	Not applicable	Not applicable
Weld Reinforcement	The weld reinforcement below 1.5 mm and more than 3 mm is unacceptable.		

POROSITY FOR GRADE-I WELDS OF STEAM TURBINE COMPONENTS ONLY

In case of grade-I welds of Steam Turbine components eg. H.P & I.P. Cross under pipe welds and any other primary H.P or I.P. Steam Pipe welds, the porosity shall be adjudged as given below

- a) The total area of porosity which when projected radially through the weld shall not exceed $0.025 \text{ cm}^2/\text{cm}$ thickness of the weld in any square cm. of projected weld area (or shall not exceed 0.01 sq. inch per inch thickness of the weld, in any sq. inch of projected weld area). If it exceeds the weld is not acceptable.
- b) Any single pore or gas hole having a diameter greater than those below shall be unacceptable
 - 1.6 mm for weld thickness upto and including 12 mm.
 - 2.4 mm for weld thickness over 12 mm upto and including 25 mm.
 - 4 mm for weld thickness over 25 mm upto and including 50mm.
 - 4.3 mm for weld thickness over 50 mm upto and including 75 mm.
 - 5.6 mm for weld thickness above 75 mm.
- c) Aligned porosity shall be acceptable provided the summation of the diameters of the pores is not more than T in a length of 12T and each pore is separated by a distance atleast 6 times the diameter of the largest adjacent pore.

Surface defects: Welds with significant undercuts or overlaps which form a notch at the toes of the welds or abrupt ridges or valleys or excessive weld reinforcements are not acceptable.

Note: 'T' is the thickness of thinner plate being welded in mm.

TABLE-3 UNACCEPTABLE DEFECTS FOR GRADE-II WELDS

Nature of defect	BUTT WELDS		FILLET WELDS
	Full Penetration	Partial Penetration	
Crack	Unacceptable	Unacceptable	
Lack of fusion	Unacceptable	Unacceptable	
Individual slag line	Unacceptable if the individual slag line is longer than $\frac{2}{3}$ T. The maximum length of acceptable imperfections shall be 19 mm. Any imperfection shorter than 6 mm shall be acceptable for any plate thickness.		
Group of slag inclusion	Any group of slag inclusion in line with an aggregate length greater than T, in a length of 6 T (or proportionately for weld length shorter than 6 T) is unacceptable when the distance between the successive imperfections exceeds 3 L, where 'L' is the length of longest imperfection in the group.		Not applicable
Porosity	Excessive porosity is unacceptable. It shall be assessed as per porosity chart given in ASME Sec VIII Div-1 Appendix 8.		
Surface defects	The undercut shall not exceed 0.5 mm for the thickness of plate upto and including 20 mm and 0.8 mm beyond 20 mm. The left out thickness after undercut shall not be however less than the minimum required thickness.		

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TABLE-4 UNACCEPTABLE DEFECTS FOR GRADE-III WELDS

Nature of defect	BUTT WELDS		FILLET WELDS
	Full Penetration	Partial Penetration	
Crack	Unacceptable	Unacceptable	Unacceptable
Lack of fusion	Unacceptable	Unacceptable	Unacceptable
Lack of penetration	Unacceptable	Unacceptable	Unacceptable
Slag inclusion	Unacceptable if the individual slag line is longer than T. The maximum length of acceptable imperfection shall be 25 mm. Any imperfection shorter than 6 mm shall be acceptable for any plate thickness.		Unacceptable
Group of slag inclusion	Any group of slag inclusion in line with an aggregate length greater than T, in a length 4 T (or proportionately for weld length shorter than 4 T) is unacceptable except when the distance between the successive imperfections exceeds 3L where 'L' is the length of longest imperfection in the group.		
Porosity	Excessive porosity is unacceptable		
Surface defects	Weld with pronounced undercuts, overlaps or abrupt ridges or valleys are not acceptable		
Leg lengths	Not applicable	Not applicable	In case of fillet weld the variation in leg lengths shall not exceed 3 mm provided the shorter length conform to required min. leg lengths.

Reinforcement: Reinforcement below 1.5 mm & beyond 3 mm is not acceptable

TABLE-5 UNACCEPTABLE DEFECTS FOR GRADE-IV WELDS

Nature of defect	BUTT WELDS		FILLET WELDS
	Full Penetration	Partial Penetration	
Crack	Any crack visible on the surface will not be acceptable		
Lack of fusion	Not applicable		
Lack of penetration	Not applicable		
Slag inclusion	Not applicable		
Groups of slag inclusion	Not applicable		
Porosity	Excessive porosity exposed to surface is not acceptable		
Surface defects	Welds with excessive amount of pronounced undercuts, abrupt ridges or valleys and spatters shall not be acceptable		
Leg lengths	Not applicable	Not applicable	In case of fillet weld the variation in leg lengths shall not exceed 3 mm provided the shorter length conform to required min. leg lengths.

Reinforcement: Reinforcement below 1.5 mm & beyond 3 mm is not acceptable

4.3 PERMISSIBLE DEFECTS IN PARTIAL PENETRATION AND FILLET WELDS**4.3.1** Permissible defects in Grade-II/III partial penetration Butt Welds

Defects not exceeding those permitted i.e. Table-3 for Grade-II and Table-4 for Grade-III partial penetration butt welds and defects at the root of a weld in an area that shall not extend further than 3 mm from the bottom of penetration, when examined by non-destructive means.

4.3.2 Permissible defects in GRADE-III Fillet Welds

Defects not exceeding those permitted in Table-4 for grade-III fillet welds and defects at the root of the weld not exceeding further than 1.5 mm from the junction of the plates when examined by non-destructive testing means.

5.0 Referred Standards

- 1) ASME Sec VIII Div-1