CONSTRUCTION STANDARD

FOR

WELDING OF PLANT PIPING SYSTEMS

CONTENTS :

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1. SCOPE

This Standard covers the minimum requirements for welding work to be carried out for installation of on-plot piping in oil, gas and petrochemical industries.

The Standard relates to the requirements pertaining to welding techniques to be used, the qualification of welder/welding operator and welding procedure together with testing and recording involved.

It also deals with inspection, testing, limit of acceptability and heat treatment of production weld, if required.

Facilities to which this Standard applies are indicated in scope of ANSI/ASME B31.3 and B31.8.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

IPS (IRANIAN PETROLEUM STANDARDS)

G-SF-110	"Radioactive Protection Against Source"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

BOILER AND PRESSURE VESSEL CODE

Section IX	"Welding and Brazing Qualification"
Section V	"Non-Destructive Examination"

ANSI/ASME (AMERICAN NATIONAL STANDARDS INSTITUTE/AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ANSI/SAME B-31.1 (1989)	"Power Piping"
ANSI/ASME B-31.3 (1990)	"Chemical Plant and Petroleum Refinery Piping"
ANSI/ASME B-31.8	"Gas Transmission and Distribution Piping Systems"

AWS (AMERICAN WELDING SOCIETY)

ANSI/AWS A 3.0	"Standard Welding Terms and Definitions"

ASNT (AMERICAN SOCIETY FOR NON-DESTRUCTIVE TESTING)

SNT-TC-1A	"Recommended Practice for Non-Destructive Personnel"

BSI (BRITISH STANDARDS INSTITUTION)

BS 3923	"Methods for Ultrasonic Examination of Welds"

3. DEFINITIONS AND TERMINOLOGY

Definitions and terms used in this Standard conforms to those adopted by ANSI/AWS A3.0. In addition, following definitions shall hold.

3.1 Sour Water Service

All process streams containing either:

a) Liquid water and at least 10 PPM of H_2S or;
b) Liquid water and at least 10 PPM of H_2S, cyanides and small amounts of water-soluble organic acid.

3.2 Engineer

The person or party representing the Company for supervision and sound execution of the project.

3.3 Inspector

A person or persons appointed in writing by the Company Engineer who is (are) entrusted with inspection of pipework during installation.

3.4 Executor

The executor is the party which carries out all or part of welding work for the piping project.

4. ABBREVIATIONS

UTS Ultimate Tensile Stress.
RT Radiographic Testing.
UT Ultrasonic Testing.
IQI Image Quality Indicators.
SFD Source Film Distance.
DWSI Double Wall Single Image.
DWDI Double Wall Double Image.
WPS Welding Procedure Specification.
PQR Procedure Qualification Record.
BHN Brinell Hardness Number.
HAZ Heat Affected Zone.

5. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

6. QUALIFICATION OF WELDING PROCEDURE AND WELDER PERFORMANCE AND TEST RECORDS

No production welding shall be carried out before Welding Procedure Specification (WPS), Procedure Qualification Record (PQR) and Welding Performance Qualification (WPQ) are qualified in accordance with requirements of ASME, Section IX.

6.1 The welding procedure specification proposed by the Executor shall be submitted to the Engineer for his review and approval at least two weeks before the date of qualification test.

6.2 Tests required for qualification of WPS shall be organized by the Executor taking the followings into consideration:

6.2.1 All materials and equipment required for preparation of test piece and welding including measuring instruments, etc. shall be supplied by the Executor unless otherwise specified.

6.2.2 After completion of welding, the Executor shall prepare test specimens for delivery to an approved test center.

6.2.3 After completion of mechanical test three copies of WPS(S) and related PQR(S) approved by the Inspector shall be submitted to the Engineer.

6.2.4 Weld performance, preparation of test specimens and conducting of the mechanical test shall be in the presence of the Inspector.

6.2.5 All expenses involved in preparation of test weld, test specimen and conducting mechanical test shall be incurred by the Executor unless otherwise specified.

6.3 The Executor shall submit to the Engineer a list containing names of the welders to be qualified at least one week before date of the test.

6.4 All activities for the welder(s) test shall be organized by the Executor who is responsible for the costs involved.

6.5 A welder whose sample welds fail to meet the Acceptance Requirements of this Standard may be retested, at the Engineers discretion, after he has had further training. The retest shall consist of one sample weld in each position in which the welder failed in his previous test.

6.6 Re-qualification of a welder may be required whenever there is reason to question his ability to make welds that meet the requirements of this Standard or when he has not performed welding of similar qualification for a period of two months.

6.7 Test pieces to qualify the welder(s) shall be selected from pipe diameter, wall thickness ranges and position of welding that will be involved in production welding.

6.8 The required welder qualification tests are divided into a nondestructive and a destructive test series within the following restrictions:

6.8.1 For all materials with P-numbers indicated in ASME Code, Section IX, i.e. Ferrous, Aluminum, Copper, Nickel and Titanium base material, welder qualification test may be performed by either destructive or non-destructive method.

6.8.2 In respect of materials which are not covered in the above paragraph qualification of welders shall be established by destructive test only.

6.9 The welder qualification test may be terminated at any stage of the testing whenever it becomes apparent to the inspector supervising the test that the welder is not following the welding procedures or does not have the skill required to produce satisfactory results.

7. USE OF BACKING RINGS AND CONSUMABLE INSERTS

High quality root pass welds should be made using a butt joint without backing and a root shielding gas. Backing rings, when used, shall conform to requirements of ANSI/ASME B-31.1 Clause 127.2.2.

8. PRODUCTION WELDING

a) Before any production welding is started, a detailed WPS and PQR shall be qualified and/or established "related to the intended specific project.

All essential variables of the WPS shall be listed.

Under no circumstances may a welder perform any welding on piping systems in any position other than those for which he has been successfully qualified. Any such weld will be completed, removed and replaced at the Executor's expense by a qualified welder.

b) The Executor shall protect all electrodes from any deterioration or damage. Electrodes that show sings of deterioration or damage shall be rejected and replaced at Executor's expenses. Welding machines shall be operated within the amperage and voltage ranges recommended by the manufacturer for each size and type of electrode. Any welding equipment which does not meet these requirements shall be repaired or replaced upon the Engineer's instruction.

c) Joint preparation shall be made according to ANSI B 31.3.

8.1 End Preparation for Welding

Material to be welded shall be cut to the required size and shaped for welding pipe such as thermal, cold and plasma cutting. For high alloy steels only plasma cutting is acceptable. The cut edges shall be dressed back by machining or grinding to meet the following requirements:

8.1.1 Pipe ends shall be free of any foreign materials. The surface to be welded shall be smooth, uniform, free of laminations, tears, scale, slag, greese, paint and other deleterious material which might adversely affect the welding.

8.1.2 End preparation is acceptable only if the surface is reasonably smooth and true, and slag from oxygen or arc cutting is cleaned from thermally cut surfaces. Discoloration remaining on a thermally cut surface is not considered detrimental oxidation.

Note:

Before welding, all foreign matter shall be removed from the beveled ends. If any of the ends of the pipe joints are damaged to the extent that satisfactory welding contact can not be obtained, the damaged pipe ends shall be cut and beveled to the satisfaction of the Engineer with a beveling machine.

The cost of all beveling shall be borne by Executor should lamination, split ends, or other defects in the pipe be discovered the pipe joints containing such defects shall be repaired or rejected as directed by the Engineer.

8.1.3 Weld edges of stainless steels, low alloy steels and nickel base pipes prepared in the manner mentioned above shall be inspected before welding by either magnetic particle or die penetrant method.

8.2 Alignment

8.2.1 In socket weld assembly, the pipe shall be inserted into the socket to the maximum depth and then withdrawn approximately 2 mm away from contact between the end of the pipe and the shoulder of the socket. In sleeve pipe joints without internal shoulder, there shall be a distance of approximately 2 mm between the butting ends of the pipe.

8.2.2 The fit between the socket and the pipe shall conform to applicable standards for socket weld fittings and in no case shall the inside diameter of the socket or sleeve exceed the outside diameter of the pipe by more than 2 mm.

8.2.3 The space between abutting pipe ends, when aligned for welding, shall be such as to insure complete penetration without burn-through. For pipe having the same dimensions the spacing should be approximately 1.5 mm. The align-

ment of the abutting pipe ends shall be such as to minimize the offset between pipe surfaces. For pipe of the same nominal wall thickness the offset shall not exceed 1.5 mm.

8.2.4 Flanges shall be attached to piping so that the bolt holes straddle the established centerlines (horizontal, vertical, or layout centerlines) but shall meet the orientation of equipment.

8.3 Production Welding Operation

8.3.1 Documents relating to qualified welding procedures and result of tests on performance of welders/operators shall be available before production welding gets started.

8.3.2 No welding shall be performed if there is undesired weather condition including rain, snow, high wind, blowing sand etc., windshield may be used when practical.

8.3.3 Preheating shall be performed if specified in the relevant WPS.

8.3.4 Seal welds

Where seal welding of threaded joints is performed, threads shall be entirely covered by the seal weld. Seal welding shall be done by qualified welders.

9. INSPECTION OF PRODUCTION WELD

9.1 Visual Inspection

9.1.1 Visual inspection before performing production weld

a) Pipe end

Inspect that the form and dimensions of the pipe end are in accordance with the WPS using appropriate measuring devices.

b) Cleanness

Inspect immediately prior to welding to ensure that fusion faces and adjacent material have the cleanness required. Wire brushing, dry grinding or other mechanical means or solvent as appropriate, may be used for cleaning.

c) Fit-Up

Check that fit-up (gap and alignment) of the parts to be welded including any backing material is in accordance with WPS, using appropriate measuring devices.

d) Welding consumables

Check the classification of the welding consumables against what is cited in welding procedure.

e) Preheating

when preheating is required, check that the conditions specified in the welding procedure are observed so as to give a satisfactory temperature distribution around and through the joint to be welded without interfering with access for welding.

9.1.2 Visual inspection during progress of production weld

a) Back gouging

When back gouging is required by qualified welding procedure check that the back of the first pass is gouged out by suitable means to clean sound metal before welding is started on the gouged outside. The shape and surface of the resulting groove should be such as to permit complete fusion of the run to be deposited.

b) Inter pass

Check that each pass of weld material is cleaned before it is covered by a further pass, particular attention shall be paid to the junctions between the weld metal and the fusion faces. Visual examination shall be made for any visible defects such as cracks, cavities or other deposition faults so that remedial action can be taken before further weld metal is deposited.

In the case of multi-pass welds, check that the conditions specified in the welding procedure for interpass temperature are observed.

9.1.3 Visual inspection following completion of production/repair weld

a) Cleaning and dressing

All slag shall be removed by manual or mechanical means otherwise flaws may be obscured. When dressing of the weld face is required, it shall be ensured that overheating of the joint due to the grinding action, grinding marks and uneven finish are avoided.

In the case of fillet welds and butt welds that are to be dressed flush, ensure that the joint merges smoothly with the parent metal without under-flushing.

b) Penetration and root examination

In the case of butt welds made from one side only, entire joint shall be inspected to ensure that inadequate penetration, any root concavity, burn-through or shrinkage grooves are within the acceptable limits using appropriate measuring devices and optical or other aids if necessary from the access point of view.

In the case of butt welds made from two sides, partial penetration butt welds and fillet welds, penetration cannot be checked visually after welding. When necessary, alternative inspection methods shall be used.

c) Contour

The contour of the weld face and the height of the excess weld metal, shall be checked, using appropriate measuring devices. Surface of the weld shall be regular and the pattern and pitch of weave marks shall present an even and satisfactory visual appearance.

d) Weld width

The weld width shall be consistent over the whole of the joint and shall be according to dimensional requirements given on the working drawing. In the case of butt welds, the weld preparation shall be at least completely filled.

e) Undercut

Any undercut shall be measured with appropriate measuring devices and shall be checked against the acceptance criteria.

f) Overlap

Toes of the weld where the weld width is excessive shall be carefully inspected for weld fusion.

g) Weld flaws

Weldment and heat-affected zone shall be inspected using optical aids (if necessary).

9.2 Inspection by Non-Destructive Testing

9.2.1 General

9.2.1.1 All non-destructive testing shall be performed in accordance with the requirements and methods specified in ASME, Section V.

9.2.1.2 Non-destructive testing and examination of welds shall be carried out according to detailed written procedures prepared by the Executor and approved by the Inspector.

9.2.1.3 personnel responsible for various aspects of non-destructive testing including testing operation, inter- pretation, evaluation and reporting shall have qualifications and experience acceptable to the Engineer.

9.2.1.4 Selected welds for N.D.T. shall include representative sample of each welder's work. Selection of welds for N.D.T shall be made by the Inspector.

9.2.1.5 The welds shall be accepted in the undressed condition unless dressing is necessary, in the opinion of the inspector, to effect satisfactory non-destructive testing.

9.2.1.6 The Executor shall submit to the Inspector certificate of calibration for all NDT equipment to be used for weld inspection.

9.2.2 Liquid penetrant examination

9.2.2.1 Initial procedure

Liquid penetrant examination shall be performed in accordance with Article 6 of ASME, Section V, Edition 1989.

9.2.2.2 Procedure revision

A revised procedure shall be prepared by the Executor and approved by the Inspector for the following cases:

a) whenever a change or substitution is made in the type or family group of penetrant materials (including developers, emulsifiers, etc.) or in the processing techniques;

b) whenever a change or substitution is made in the type of precleaning materials or processes;

c) for any change in part processing that can close surface openings of discontinuities or leave interfering deposits, such as grinding, grit blasting and power brush cleaning or acid treatments.

9.2.2.3 Techniques

Either a color contrast penetrant technique or a fluorescent penetrant technique shall be used. For each technique, one of the following three types of penetrant systems shall be used:

a) Water washable.
b) Post-emulsifying.
c) Solvent removable.

9.2.3 Magnetic particle examination

9.2.3.1 Procedure

Examination procedures shall be prepared in accordance with ASME, Section V.

Article 7, Edition 1989.

9.2.3.2 Method of examination

Examination shall be done by the continuous method; that is, the magnetizing current remains on while the examination medium is being applied and while excess of the examination medium is being removed.

9.2.3.3 Material of particle

The ferromagnetic particles used as an examination medium may be either wet or dry, and may be either fluorescent or non-fluorescent. If dry particles are used prior approval of the inspector shall be obtained.

9.2.3.4 Techniques

One or more of the following five magnetization techniques may be used provided that prior approval of the inspector is obtained.

a) prod technique;
b) longitudinal magnetization technique;
c) circular magnetization technique;
d) yoke technique;
e) multidirectional magnetization technique.

9.2.3.5 Calibration of equipment

Calibration shall be made according to ASME Section V.

9.2.3.6 System and sensitivity evaluation

The overall performance and sensitivity of examination system (i.e. combination of the magnetic particle material/magnetic particle equipment. The sequence of operation and the level of magnetizing field) shall be monitored with the test block at regular intervals to assure the system performance is properly maintained: A reference block or fabricated test piece with known discontinuities shall be prepared for above demonstration.

9.2.3.7 Demagnetization

When residual magnetism in the part could harmfully interfere with the subsequent processing or usage, the part shall be demagnetized after completion of the examination.

9.2.3.8 The final pass of attachment welds to P-4, P-5 and P-6 materials shall be magnetic particle examined after final post weld heat treatment.

9.2.4 Ultrasonic examination

9.2.4.1 General

The ultrasonic testing of the weld shall be carried out by manual scanning using an A-scan and shall be performed with written procedure. The procedure shall include but not limited to the following information:

a) Type of ultrasonic flaw detector.
b) Weld type and welding procedure.
c) Joint design.
d) Surface condition.
e) Type of standard block.
f) Reference block and it's relative reflectors.
g) Type of probes.
h) Method of sensitivity setting for parent metal testing.
i) Method of sensitivity setting for weld metal.
j) Scanning techniques.
k) Reporting requirements.
l) Acceptance standard.
m) Operators qualification.

9.2.4.2 Equipment

9.2.4.2.1 Frequency

The equipment shall be capable of working at a test frequency within the range 1 MHz to 5 MHz.

9.2.4.2.2 Time base linearity

The linearity of time base shall be within 2% over the whole range.

9.2.4.2.3 Amplifier linearity

The amplifier shall be linear to an accuracy of ±1 dB at any point within the range 20% to 80% of full screen height.

The amplitude control of flaw detector shall be made according to Appendix I, Article 5, ASME, Section V.

9.2.4.3 Operators

Operators shall be certified by the requirements of ASNT recommended practice SNT-TC-1A Level II or III.

If required, the operator shall demonstrate his ability to perform the test, using the actual equipment and the technique to be employed.

9.2.4.4 Scanning

9.2.4.4.1 Parent metal

Parent metal at both sides of welded joints, to the extend necessary for weld examination, shall be scanned using straight beam technique for:

a) Locating any flaws, such as laminations and tears.
b) Determining actual material thickness.

9.2.4.4.2 Weld metal

The weld examination shall consist of scan from both sides:

a) of the weld root;
b) of the side fusion faces;
c) of the weld body;
d) in addition to scanning for defects lying transverse of the weld.

9.2.4.5 Sensitivity setting

Sensitivity setting for straight and angle beam probe shall be made according to Part 1, BS 3923 (1978).

9.2.5 Radiographic examination

9.2.5.1 General

Production welds shall be inspected by radiographic examination according to approved procedure, and carried out after post weld heat treatment when required.

9.2.5.2 Procedure

Radiographic procedure shall include but not limited to the following:

a) material and thickness range;
b) type of X-ray tube or isotope;
c) strength of isotope used or X-ray voltage;
d) radiography technique;
e) film type;
f) intensifying screens used;
g) type of image quality indicator, place and numbers;
h) sensitivity;
i) density;
j) processing time and temperature;
k) reporting requirements

9.2.5.3 Techniques

A single wall exposure technique shall be used for radiography whenever practical. When it is not practical to use single wall technique, a double wall single image technique (DWSI) and for pipes with DN less than 90 (NPS 3½) double wall double image (DWDI) technique shall be used.

9.2.5.4 Film type

Radiography shall be made using industrial radiography film type Class II ASTM, equivalent to D7 normally and D4, if required in the opinion of the Inspector, in special cases. Fluorescent and fluorometallic screens are not acceptable.

9.2.5.5 Image quality indicators (IQI)

Wire type penetrameter shall be used to measure radiographic sensitivity. In special cases other type of penetrameters may be used. Max. sensitivity shall not exceed 2 where:

$$\text{Sensitivity} = \frac{\text{size of thinnest wire}}{\text{thickness of specimen}} \times 100$$

Number of penetrameters and placement shall be made according to SE-142 ASME, Section V.

9.2.5.6 Film density

Film shall be exposed so that the H & D density through the weld metal shall not be less than 1.8 not greater than 3.0 for transparent based film.

9.2.5.7 Selection of radiation sources.

9.2.5.7.1 X-ray

Minimum voltage of X-ray tubes shall not be less than 200 KV.

9.2.5.7.2 Gamma Ray

Minimum source strength shall be 10 curies for IR 192 and 5 curies for cobalt 60.

9.2.5.8 Darkroom

Processing shall be carried out in a darkroom with the following facilities as minimum requirement:

- **a)** Automatic or manual processing devices with temperature indicating controller (T.I.C).
- **b)** Loading bench.
- **c)** Red light (subdued light).
- **d)** Adequate ventilation.
- **c)** Drying bench.
- **f)** Clean and washable floor.

9.2.5.9 Processing

Processing shall follow a standard technique with five separate stages; Development, stop bath, fixing, washing and drying. Development time and temperature shall be controlled according to standard (4 min. at 20°C) or film manufacturer's recommendations.

Excess density due to additional developing time or higher temperature shall not be allowed.

The Inspector or the Engineer is allowed to visit processing condition to evaluate the quality and density of radiographs.

9.2.5.10 Personnel

The personnel employed in carrying out radiography conforming to this Standard shall be certified in accordance with the recommendations of ANST recommended practice SNT-TC-1A. Radiographic personnel should obtain a certificate of competence for working with radiation sources from Atomic Energy Organization of Iran.

9.2.5.11 Quality of radiographs

All radiographs shall be free from mechanical, chemical and other blemishes, and shall overlap sufficiently to ensure no portion of the joint remains unexamined.

9.2.5.12 Identification

a) Consideration shall be given to following for image identification. A system shall be used to produce permanent identification on the radiograph of weld. Consecutive letter/number series and the date of the radiograph shall be plainly and permanently included on the radiograph.

b) Markers, usually in the form of lead arrows or other symbols, shall be placed alongside but clear of the outer edges of the weld to identify its position.

c) In general, permanent marking of the workpiece shall be used to provide reference points for the accurate relocation of the position of each radiograph.

9.2.5.13 Interpretation

Only level II or III NDT personnel in accordance with SNT-TC-1A for radiography shall interpret images. The radiographer shall examine each radiograph and shall determine the acceptability of each weld based on Chapter VI ANSI/ASME B 31.3-1990. The radiographer shall describe to the Inspector those weld defects that he considers cause for rejection of the weld. The Inspector will make final interpretation on all welds.

9.2.5.14 Radiation safety

Whenever X-ray equipment or radioactive sources are in use, adequate precautions shall be taken to protect the radiographer and others in the vicinity. Radiation hazards shall be minimized by adherence to requirements cited in IPS-G-SF-110.

9.2.5.15 Random radiography

Where 10 percent radiography is specified the following rules shall be applied:

a) At least 10 percent of the number of welds within the specified line class shall be radiographed around their total circumference.

b) At least 10 percent of the number of welds made by each welder shall be radiographed around their total circumference. If a welder makes less than 10 welds, one of these shall be fully radiographed.

c) Radiographs shall sample the entire range of pipe sizes that have been welded, where practicable.

d) Since the intent of 10 percent examination is to evaluate the quality of welder performance, radiographs shall be made as soon after weld completion as practicable.

9.2.5.16 Radiography of pipe material with P-No=1

Radiographic examination for field weld of these pipes are not mandatory. However, if process condition (i.e. operating pressure and temperature and also service fluid) warrants, in the opinion of the Engineer, radiographic examination shall be performed at the rate of 10%.

9.2.5.17 Radiography of pipe material with P-No>1

Field welds of these pipes shall be examined by radiography of the rate of 100%.

9.2.6 Brinell hardness test

9.2.6.1 Submerged arc welding procedure qualifications for P-1, -P-3 and P-4 group materials shall have a hardness not exceeding 225 Brinell in the weld deposit.

9.2.6.2 On production welds for P-5 and P-6 group material a Brinell hardness test shall be taken on ten percent of the butt-welds in each P-groups material for all air hardening filler metal. If less than ten welds are made per P-group one weld shall be tested. Brinell hardness shall not exceed 225 BHN.

9.2.6.3 The Brinell hardness testing shall be limited to piping and tubing greater than DN 100 (NPS 4) and a wall thickness over 6.35 mm.

9.2.6.4 Carbon steel welds subject to Paragraph 3.1a of this Standard (sour water service) shall have a maximum Brinell hardness of 200.

9.2.6.5 Carbon steel welds subject to Paragraph 3.1b of this Standard (sour water service) shall have a maximum Brinell hardness of 185.

9.2.6.6 Hardness test results and locations shall be recorded. The Engineer shall be permitted to witness hardness testing and shall have access to test results.

9.3 Inspection by Destructive Testing

9.3.1 When the qualified welders perform welding, the Engineer shall have the right to cut out one weld made by each welder on the works to prove the quality of his workmanship. This weld will be selected at random by the Engineer. The Executor shall bear all expense in connection with cutting out and replacing this initial test weld for each welder even if the weld is found on test to be entirely satisfactory.

9.3.2 Twelve coupons may be cut for testing and of these coupons four may be used for tensile test, four for nick break test and two each for root bend and face bend tests. The Standard of the tests will be in accordance with ASME, Section IX, Part A.

10. WELD DEFECTS AND ACCEPTANCE CRITERIA

10.1 Welds which are deposited by procedures differing from those properly qualified and approved shall be rejected and completely removed from the piping.

10.2 Weld metal shall be properly fused with the parent metal without significant undercutting or overlapping at the toes of the weld; slight intermittent undercut shall be permitted provided that it does not form a sharp notch and that it meets the following requirements.

The stop and start of each run of weld shall merge smoothly and shall show no pronounced hump or crater in the weld surface.

10.3 Acceptance criteria shall be as stated in the engineering design and shall at least meet the limits stated in Table 341-3.2A of ANSI/ASME B.31.3.

10.4 For ultrasonic examination of welds supplementary acceptance criteria cited in Clause 344.6.2 of ANSI/ASME B.31.3 shall be considered.

11. WELD REPAIR

11.1 When a defective weld is detected either visually or by any other method in accordance with Section 10 of this Standard, it shall be removed to sound metal and repaired. Repair weld shall be made using qualified welding procedure as well as qualified welders/welding operators. Preheating and heat treatment shall be as required for the original welding.

11.2 External undercut shall be repaired by grinding off the weld cap in the undercut location and recapping the location.

11.3 No weld containing cracks, regardless of size or location, is acceptable. Cracked welds shall be cut, removed and rewelded.

11.4 On completion of repair the weld shall be radiographed whether the defect in the original weld was detected by radiographic examination or not.

11.5 When a defective weld has been detected the next two welds produced by the same welder shall be radiographed.

11.6 Should two or more welder participate in making a defective weld, the Executor and Engineer shall together decide which welder is responsible for the defective work. The Engineer shall have the right to cut out welds for further test. The test welds (except the initial free test referred to in Clause 9.3) that meet the specified requirements and specifications when properly tested, shall be replaced by a satisfactory tie-in at Company's expense. In the even any test weld cut from the line does not prove satisfactory to the Engineer when properly tested, it shall be replaced at the Executor's expanse. Test welds shall be cut out as soon as practicable after completion to avoid unnecessary delay and expense. When welding the line together at places where the test weld has been cut, one weld will be used if it is practicable to pull the line back into position, otherwise, two welds will be made by setting in a pipe with a minimum length of 2½ times the pipe diameter, or 1.25 meters whichever is the longer.

12. PRE-AND POST-WELD HEAT TREATMENT

12.1 General Requirements

12.1.1 Heat treatments may be carried out either full body or locally, depending on:

- Type of heat treatment.
- Material composition of pipe.
- Number and sizes of pipe.
- Availability and cost of energy.
- Required accuracy of heat treatment.
- Welding process and welding consumable.
- Code requirement.

12.1.2 Heat treatment shall be carried out in accordance with a qualified heat treatment procedure specification. Which is submitted by the Executor for approval of the Inspector.

12.1.3 During heating up and cooling down, no temperature gradient shall exceed:

100°C/m in axial direction, nor
40°C/m in tangential direction,
to be checked by temperature recorder.

12.1.4 For wall thicknesses of pipe upto and including 20 mm the rate of heating shall not exceed 200-250°C/h.

12.1.5 For wall thicknesses of pipe over 20 mm the rate of heating shall not exceed:

5500/t°C/h (t = maximum pipe wall thickness)

or

55°C/h.

whichever is greater.

12.1.6 The workpiece shall be cooled to 400°C whereby the cooling rate is limited as follows:

- For wall thickness of pipe <20 mm
275°C/h

- For wall thicknesses ≥20 mm 6
6875/t°C/h (t = maximum pipe wall thickness)

or 55°C/h,
whichever is the greater.

12.2 Preheat Requirements

12.2.1 Preheating of the parent metal prior to any welding, tack welding and thermal cutting, may be necessary to avoid cold cracking of certain ferritic steels in the weld and HAZ. Preheating could also be required for welding of non-ferrous materials to remove moisture or to prevent hot cracking.

12.2.2 For preheating temperatures below 200°C fuel gas/air burner systems, high-velocity gas/oil burners or infrared elements may be employed either locally or in a furnace.

12.2.3 For preheating temperatures above 200°C electric resistance or induction heating is preferred although infrared radiators are acceptable.

12.2.4 An even temperature distribution is required.

12.2.5 Temperature control may be carried out with tempil stick, digital pyrometers or contact thermometer.

12.2.6 For piping shop welds electrical heating is preferred, but ring torches are allowed when burning sulphur-free fuel.

12.2.7 When required for field welds of piping, the following methods of preheating shall be applied:

a) For DN <250 (NPS <10) heating by appropriate torches is allowed
b) For DN ≥250 (NPS ≥10) electrical heating or heating by means of infrared or ring burners is required.

12.2.8 The following requirements shall be adhered to for the preheating zone:

a) Width of the heated zone is 2 t (t = wall thickness) with a minimum of 100 mm on each side of the weld.

Width of the insulated zone = width of zone heated +150 mm.

b) For pipe butt welds, the width of the heated band on each side of the weld is 2.5 t, with a minimum of 75 mm.

c) Special attention shall be paid to the extent of heated bands in order not to aggravate the problems related to residual stress distribution, such as cracking, buckling and distortion.

12.2.9 Where weld preheating is specified, welding should continue without interruption.

12.2.10 For Cr-Mo steel with a wall thickness of 25 mm the above preheat shall always be applied.

12.2.11 For other ferritic steels, intermediate lowering of preheat temperature is permitted only when at least 50% of the weld is completed. The joint shall be cooled under insulation. Preheating shall be restored to the specified temperature and maintained for 30 minutes, before the welding is recommenced.

12.2.12 Minimum preheat temperature required and recommended for materials of various P-numbers are given in Table 330.1.1 of ASME/ANSI B.31.3.

12.2.13 Preheat requirements for an unlisted material shall be specified in the WPS.

12.3 Post-Weld Heating Treatments (PWHT)

This section covers basic practices which are suitable for most welding operations, but not necessarily appropriate for all service conditions.

12.3.1 Methods of heating

Heat treatment shall be carried out by one of the following methods, ensuring that the minimum stipulated temperature is achieved through the thickness of the pipes.

a) Heating in a stationary industrial furnace.
b) Local heating:

1) Portable muffle furnace.
2) Induction coils.
3) Resistance heaters. The method of securing resistance heating elements around the joint shall be capable of holding the elements securely in contact with the pipe work throughout the heat treatment cycle. Any fixing, e.g., galvanized wire, likely to be injurious to the joint shall not be used.

Selection of the method for heat treatment is subject to prior approval of the Engineer. Manually-operated gas torches shall not be used.

12.3.2 P.W.H.T. requirements

Any PWHT shall conform to the requirements stipulated in one of the following documents provided that approval of the Engineer is obtained.

a) table 331.1.1 in ASME/ANSI B 31.3;
b) approved welding procedure.

12.3.2.1 The upper limit of the PWHT temperature range given in Table 331.1.1 in ASME/ANSI B 31.3 is a recommended value which may be exceeded provided the actual temperature does not exceed the lower critical temperature of material which is given in table below.

APPROXIMATE LOWER CRITICAL TEMPERATURE

MATERIAL	APPROXIMATE LOWER CRITICAL TEMPERATURE °C
Carbon steel	725
carbon molybdenum steel	730
1 %Cr- ½%Mo, 1¼%Cr-½%Mo	775
2¼ %Cr-1%Mo, 3%Cr-1%Mo	805
5 %Cr-½%Mo	820
7 %Cr-½%Mo	825
9 %Cr-½%Mo	810

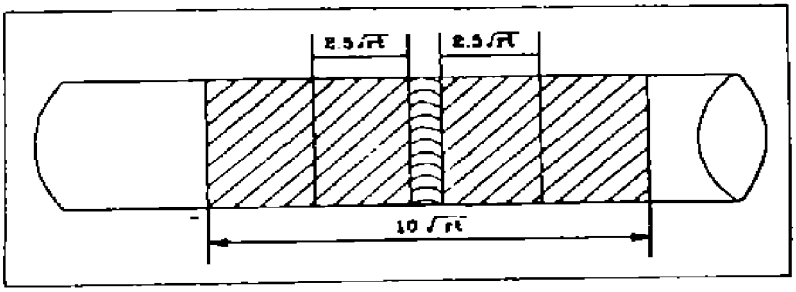
12.3.2.2 When parts of two different P-Numbers are joined by welding, the post weld heat treatment shall be that specified for the material requiring the higher PWHT temperature.

12.3.2.3 When a non pressure part is welded to a pressure part and PWHT is required for either part, the maximum PWHT temperature shall not exceed the maximum temperature acceptable for the pressure retaining part.

12.3.2.4 Caution is necessary to preclude metallurgical damage to some materials or welds not intended or qualified to withstand the PWHT temperatures required.

12.3.2.5 It is preferred that PWHT be carried out in a stationary industrial furnace, but when it is necessary to apply a local heat treatment, the temperature gradient shall be such that:

a) For the butt joint welds the length of material on each side of weld is at least 2.5 $\sqrt{r.t}$ where r is the bore radius and t is the pipe thickness at the weld, and minimum insulation width shall be 10 $\sqrt{r.t}$.

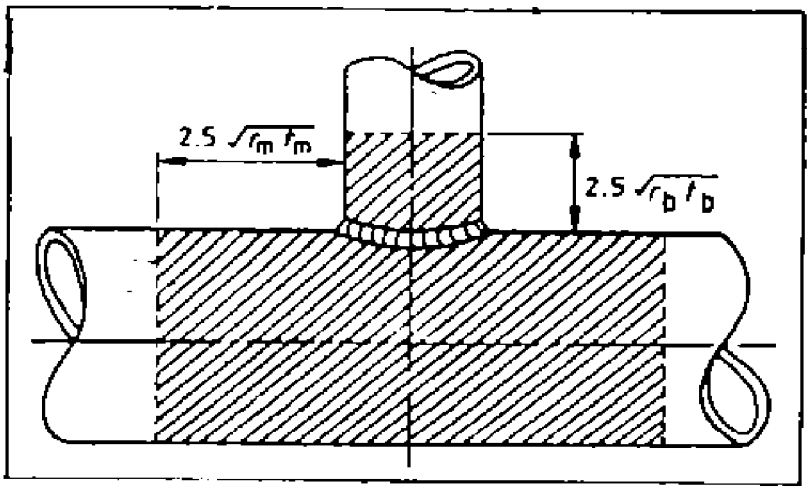


MINIMUM INSULATION WIDTH

b) For branch connection welds the length of material from each crotch is at least:

1) 2.5 $\sqrt{r_m t_m}$ along the main pipe where r_m is the bore radius and t_m is the thickness of the main pipe;

2) 2.5 $\sqrt{r_b t_b}$ along the branch pipe where r_b is the bore radius and t_b is the thickness of the branch pipe.



Notes:

r_m **is the bore radius of main pipe;**
t_m **is the thickness of main pipe;**
r_b **is the bore radius of branch pipe;**
t_b **is the thickness of branch pipe.**

AREA (SHADED) TO BE HEATED FOR THE LOCAL TREATMENT OF BRANCH CONNECTIONS

12.3.2.6 PWHT is not required for non ferrous material.

Note:

Definition of thickness referred to in sub Section 12.3 of this Standard shall be that cited in ANSI/ASME B31.1 Clause 132.4.

12.3.2.7 All lines in caustic service with operating temperature more than 60°C or with caustic concentration exceeding 25% by weight shall be post weld heat treated according to Table 331.1.1 of ASME/ANSI B31.3 P-No. 1.

12.3.2.8 All lines in sour water service shall be post weld heat treated according to Table 331.1.1 of ASME/ANSI B31.3 P-No. 1.

12.3.2.9 All lines operating in amin service above 65°C shall be post weld heat treated according to Table 331.1.1 of ASME/ANSI B31.3 P-No. 1.

13.3.2.10 After post weld heat treatment, hardness of weld deposit of lines described in the 3 above mentioned paragraphs shall not exceed 200 BHN.

12.3.3 Alternative heat treatment

Alternative heat treatment shall be in accordance with ANSI/ASME B31.3 Clause 331.2.1.

12.3.4 Hardness test

Hardness tests of production welds are intended to verify satisfactory heat treatment. Where a hardness limit is specified in Table 331.1.1 in ASME/ANSI B31.3, at least 10% of welds in each furnace heat treated batch and 100% of those locally heat treated shall be tested. The hardness limit applied to the weld and to the heat affected zone (tested as close as practicable to the edge of the weld).