CONSTRUCTION STANDARD

FOR

WELDING OF TRANSPORTATION PIPELINE

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1. SCOPE

This standard covers the minimum requirements for welding work to be carried out for installation of off plot piping.

Notwithstanding the sub-division of the standard under different headings, every part of it shall be deemed supplementary and complementary to every other part.

The standard relates to the requirements pertaining to welding techniques to be used, the qualification of welders/welding operators and the procedure employed in welding steel pipes.

The standard also deals with inspection, testing, limit of acceptability as well as removal of weld defects and repair, or rewelding.

Facilities to which this Standard apply and its coverage are indicated in scope of ANSI /ASME B 31.4 and ANSI / ASME B 31.8.

2. REFERENCES

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

B 31.4	"Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols"
B 31.8	"Gas Transmission and Distribution Piping Systems"
B 31.3	"Chemical Plant and Petroleum Refinery Piping"

API (AMERICAN PETROLEUM INSTITUTE)

API STD	1104-1988	"Standard for Welding Pipelines and Related Facilities"
API SPEC	5L	"Specification for Line Pipe"

ANSI / AWS (AMERICAN NATIONAL STANDARD INSTITUTE / AMERICAN WELDING SOCIETY)

ANSI / AWS	D10.12	"Pipe, Welding Plain Carbon Steel"
ANSI / AWS	A3.0	"Welding Terms and Definitions"
ANSI / AWS	A5.20	"Carbon Steel Electrodes for Flux-Cored Arc Welding"
ANSI / AWS	A5.1	"Specification for Covered Carbon Steel Arc Welding Electrodes"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

ASTM	E-94	"Guide for Radiographic Testing"
ASTM	E-317	"Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems without the use of Electronic Measurement Instruments"
ASTM	E-142	"Standard Method for Controlling Quality of Radiographic Testing"
ASTM	E-92	"Standard Test Method for Vickers Hardness of Metallic Materials"
ASTM	A-370	"Standard Test Methods and Definitions for Mechanical Testing of Steel Products"

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO	148	"Steel-Charpy Impact Test (V notch)"

BSI (BRITISH STANDARDS INSTITUTION)

BS	3971-1980	"Specification for Image Quality Indicator for Industrial Radiography"
BS	2633	"Specification for Class 1 Arc Welding of Ferritic Steel Pipe Work for Carrying Fluids"
BS	2910-1986	"Methods for Radiographic Examination of Fusion Welded Circumferential Butt Joints in Steel Pipes"
BS	4871	"Fusion Welding of Steel"

IRANIAN ATOMIC ENERGY Regulation of Radiation Protection.

3. UNITS

International System of Units (SI) in accordance with IPS-E-GN-100 shall be used.

4. WELDING TERMS AND DEFINITIONS

Definitions pertaining to welding as used in this standard conform to the adopted definitions established by the American Welding Society and contained in ANSI / AWS A 3.0

5. BASIC REQUIREMENTS

Prior to the start of any welding work covered by this standard , the contractor's proposed welding procedure shall be established and qualified and welders to be employed on project shall undertake qualification tests to demonstrate their ability in producing welds with suitable mechanical properties and soundness. Welding operators are also required to be qualified.

The welds are expected having yield strength and ultimate tensile strength equal to or greater than the pipe metal in addition to other mechanical properties.

The quality of production welding shall be checked continuously throughout execution of project by nondestructive methods. Destructive examination may also be adopted by welding inspector to check the quality of weld.

The welding inspector shall have the right to visit the work or stay at site as and when required. They should have full authority to accept or reject production welds, approve or reject proposed welding procedure, qualification of welders or welding operators, preheating and interpass temperature, stress relieving and any other activities pertaining to welding work on the off-plot piping system.

6. QUALIFICATION OF WELDING PROCEDURE (GENERAL)

Prior to the start of production welding covered by this standard, a welding procedure shall be established and qualified by testing to demonstrate that welds having suitable mechanical properties and soundness can be continuously produced. The tests shall be conducted in presence of the Engineer or his nominated inspector. Welding procedure shall be qualified as required by API STD 1104 and this standard.

The qualified welding procedure(s) shall specify pipe material, welding position ,welding process, number of beads, type and size of filler metals to be used for individual bead, polarity and current for each electrode classification to be used.

Filler metals shall be shown in each welding procedure by AWS Grade. A system shall be employed to identify and to retain the identity of all filler metals.

Filler metal shall be properly selected so that when joining pipes of similar material, the deposited weld metal shall match the chemistry and the mechanical properties of the base metal as closely as possible.

The procedure shall specify whether preheating or postweld heat treatment (PWHT) must be performed when materials, welding consumables, thickness, weather conditions and mechanical restraints make either or both of them necessary (A statement such as PWHT if required is not acceptable). All welding procedures specifying PWHT must indicate the following cycle.

a) Heating rate (maximum)
b) Holding temperature (maximum and minimum)
c) Holding time
d) Cooling rate (maximum)

The preheat temperature given in qualified welding procedure shall be observed and checked by the use of temperature indicating crayons approved by the engineer. In special cases thermocouple parameters or other suitable method, as decided by the engineer, shall be used to assure that the required temperature is obtained prior to and maintained during the welding operations.

Thermocouple (if used) shall be located in positions within 5 times wall thickness or 50 mm from the outside edge of the fusion faces whichever is the greater.

For measurement and recording post weld heat treatment, if required by welding procedure(s), thermocouples shall be used. In post weld heat treatment, if required, cycle specified in the qualified welding procedure shall be observed.

For special heat treatment methods such as exothermics, the process and specific heat treating package may be specified in lieu of the above.

The adequacy of heat treatments required to reduce or limit hardness shall be checked by hardness measurements.

Methods for cleaning and conditioning (i.e. power grinding or drying) the surfaces to be welded shall be detailed in the welding procedure specification and tailored for the base metal (s) and for the beveling and welding processes.

The procedure shall specify that double welded joints shall be cleaned to sound metal in the back side of the joint unless it can be demonstrated that an acceptable weld can be made without this operation.

Welding procedure shall also specify line-up clamps (external or internal) to be used in production welding and condition of their removal.

The welding procedure shall be followed during qualifying tests and recorded in detail.

The established welding procedure shall be adhered to during welding performed under this standard.

Variables (e.g. different grades of pipe materials, wall thickness and sizes) requiring separate qualification of welding procedure, under requirements of API 1104, shall be followed.

7. QUALIFICATION OF WELDERS OR WELDING OPERATORS (GENERAL)

The welding procedure qualification tests establish the properties of the weldment, not the skill of the welder or the operator of automatic and machine welding equipment.

The welders and the welding operators shall also be qualified in accordance with the rules laid down in sections 3 and 9 of API STD 1104.

7.1 Qualification of Welder

Each welder shall make a complete test weld (stringer bead, hot pass, filled and cap welds) regardless of the type of weld he is assigned for; the objective of this test being to demonstrate the ability of the welder in producing welds with suitable mechanical properties and soundness.

The quality of the test welds shall be checked by destructive examination of the weld specimens or nondestructive method to be acceptable; complete weld specimens which have been removed for destructive examination shall meet the requirements of API STD 1104 for welder qualification by destructive testing.

A welder who has made welds for qualifying weld procedure is considered qualified in that procedure provided that the procedure is established.

Welder qualification tests shall be conducted in the presence of the inspector nominated by the Engineer who has last say on pass or fail and his decision is unquestionable.

Welders shall be required to qualify in accordance with section 3 of API STD 1104, but unless otherwise directed by the company , on full specification as that used in the line and employing the welding procedure that has been qualified. Alternatively, but only by agreement with the company, the welders may be approved on the basis of "MULTIPLE QUALIFICATION" as prescribed in clause 3.3 when the requirements of sub-clause 3.3.1 of the API 1104 shall be subject to agreement.

A record of qualified welders, showing the date and results of the tests shall be retained during the construction involved and for six months thereafter.

7.2 Qualification in Automatic Welding

Each automatic welding unit and its operator shall be qualified by producing an acceptable weld using the qualified procedure as described in section 9 of API 1104.

The completed weld shall be tested by destructive methods and/or nondestructive methods. The completed test weld shall meet the requirements of clauses 3.4 through 3.7 of API STD 1104. Each operator shall have received adequate training in the operation of the equipment prior to commencement of production welding and shall be thoroughly familiar with the equipment he operates. Requirements of section 9 of API STD 1104 shall be adhered to in respect of automatic welding.

8. INSPECTION OF THE QUALITY OF PRODUCTION WELD (GENERAL)

Continuous visual inspection is essential as a routine supervision. In addition nondestructive testing shall be performed consisting of radiographic and ultrasonic examination.

The method used shall produce indications of potential defects which can be accurately interpreted and evaluated.

The extent of radiographic inspection shall be decided by the Engineer depending on the workmanship shown on the part of the contractor and result of weld inspection obtained.

However, a procedure has been given for frequency of radiographic inspection in the relevant succeeding paragraph which deals with the radiographic examination in detail. Each weld to be examined shall be inspected completely around its entire circumference.

The radiographic procedure shall comply with the requirements of section 8 of API STD 1104; alternatively BS 2910 may be adopted.

Fillet welds shall be inspected by ultrasonic and/or radiographic method as applicable.

When radiographic or ultrasonic examination is used, it shall be demonstrated that the equipment and the technique to be used are satisfactory to the Engineer.

The operator of nondestructive test equipment shall be qualified to use the equipment, apply technique and interpret the result of the examinations. The operator of NDT equipment shall be approved by the Company.

9. STANDARDS OF ACCEPTABILITY OF WELDS

Size and type of defects located by radiography or other nondestructive test methods shall be limited within the degree of acceptability determined by section 6 of API STD 1104. However, the Engineer or his nominated inspector may reject any weld which appears to meet these standards of acceptability if, in his opinion, the depth of a discontinuity may be detrimental to the weld.

10. REMOVAL OF DEFECTS AND REWELDING (GENERAL)

Injurious defects, except cracks, in all passes of completed weld can be removed to sound metal and repair can be made. Repaired area shall be inspected by the same non destructive method previously used for initial weld. Crack defects are considered unrepairable. Defect in repaired area is also regarded unrepairable.

11. WELDING OF BRANCH CONNECTIONS AND THEIR REINFORCEMENT (GENERAL)

All basic requirements of section 1 of BS 2633 for welded joints between pipes and fittings and also supplementary specific requirements detailed in sections 3 and 5 of BS 2633 shall be applied in determining the full procedure requirements. All steps of works including preparation, assembly and welding procedures shall comply with the relevant clauses of BS 2633.

12. WELDING ELECTRODES

AWS Classification carbon steel electrodes shall be used for welding pipes manufactured according to API specification 5L.

Low hydrogen electrodes shall be used for repair welding , and welding of pipes inside compressor stations and pump stations and tie-ins.

Coated electrodes shall be used for manual shielded arc welding. Filler metal conforming to ASTM / AWS specifications shall be used for semi-automatic or automatic submerged arc or gas shielded arc welding.

13. WELDING PROCESSES

Of all the 45 methods available as welding process, the shielded arc welding processes are used in pipe welding . The most widely used of all shielded arc welding processes for off-plot piping installation are as follows:

a) Manual shielded metal arc welding process.
b) Semi-automatic shielded metal arc welding process.
c) Full automatic shielded metal arc welding process.

Method (a) is commonly used in field production welding employing covered electrodes.

Methods (b) and (c) have wide application in double jointing at pipe yards before transporting of pipes to the pipeline route for stringing. Method (b), specially submerged arc welding employing granular flux, is extensively used for double jointing at pipe storage sites, if double jointing is approved by the Company.

14. PREHEATING AND POST WELD HEAT TREATMENT

14.1 To obviate risk of crack in heat affected zone preheating of joint prior to commencement of welding is essential under some conditions discussed in the relevant succeeding paragraphs of this standard. Preheat temperature as specified in qualified welding procedure shall be observed.

The preheating temperature shall be checked by suitable method approved by the Engineer to assure that the required temperature is obtained prior to and during the welding operation.

14.2 Stress relieving of welds, if required, shall conform to requirements described in clause 434.8.9 of ANSI / ASME STD B 31.4 or clause 825 of ANSI / ASME / STD B31.8 whichever is appropriate.

14.3 Preheating is essential under the following conditions: %mn

a) Carbon steels having a carbon equivalent $(\%C + \frac{\%mn}{4})$ in excess of 0.65 (ladle analysis).

b) Carbon steels having a specified carbon content in excess of 0.32% (ladle analysis).

c) Preheating may also be required for steels having lower carbon or carbon equivalent when conditions exist that either limit the welding technique that can be used, or tend to adversely affect the quality of the weld.

d) When the ambient temperature is below five degrees Celsius.

e) When the risk of crack exists in the heat affected zone.

f) For weld repair.

g) For completing an incomplete weld left at the end of the previous working day.

h) For welding of various fittings/appurtenances to the pipe having different wall thicknesses or of different types of material unless, during the establishment of the welding procedure, it is determined that the preheating is not necessary.

15. DETAILED WELDING STANDARD FOR CONSTRUCTION OF OFF-PLOT PIPING

15.1 General Requirements

15.1.1 The contractor shall weld the pipeline over its entire length and install pipeline fittings and appurtenances as shown on the working drawings.

If double jointing is approved by the company, it shall be done at pipe storage sites prior to transportation of pipes for stringing.

15.1.2 All welding operations, welding materials, qualification of welding procedures and welders/welding operators, inspection and testing, standards of acceptability, repair or removal of defects, record of welding and weld test records shall conform to requirements of API STD. 1104, except where the requirements are more stringent by this standard.

15.2 Supply of Labor, Materials and Equipment

The contractor shall supply all necessary labor, materials and equipment (Except company supply materials specified in the contract agreement) and equipment for:

i) Handling and preparation of pipes for welding and double jointing (if applicable).

ii) Welding and double jointing of the pipeline, as required.

iii) All welding procedures and the welder/operator qualification tests.

iv) Equipment and consumables for radiography and ultrasonic inspection of welds including films and other consumables, film processing, interpretation, recording and storage.

v) Supply, transport, handling and storage of consumable materials such as electrodes, etc.

vi) Repair of welds.

15.3 Welding Procedures and Welder's Qualifications

a) The contractor shall organize the welding procedure and welder's qualification tests in such a way that they are completed at least one week before the date fixed in the general schedule for the start of the welding operations on site or at a fixed place.

The contractor shall notify the Engineer, in writing at least ten days in advance of commencing the tests.

b) The welding procedure(s) and welder qualification test(s) shall be carried out by the contractor in the presence of the Engineer and with the equipment and material intended to be used for the production work on the work site, in the contractor's workshop and in the yards.

c) All the tests shall be carried out in conditions identical to those for production welding (particularly the speed and duration of welding). The duration of cleaning shall not be included in the welding time.

d) For the welder qualification test(s), each welder shall make his mark along the weld, beside the section for which he is responsible.

15.3.1 Qualification of welding procedure.

15.3.1.1 Prior to the start of production welding the contractor shall establish, document and submit for the Engineer's approval the welding procedure(s) and the Engineer-furnished certificate of qualification forms duly completed for each procedure.

The contractor shall establish and qualify procedure(s) for the different steel grades, wall thickness and size of pipe, as required by section 2 of API STD 1104 (with due consideration to clause 2.4 concerning the need to re-establish the welding procedure on the basis of essential variables). In this context following requirements shall be taken into account.

a) The Engineer will require individual procedures to be established and qualified for different steel from different manufacturers of pipe plates and/or for variations in material chemistry. In this respect requirements of clause 2.3 of API STD 1104, heat input, preheat and post heat, shall be taken into consideration . Also consideration shall be given to clause 2.4 (essential variables) of API STD 1104.

b) Recording of qualified welding procedure: The details of each qualified procedure shall be recorded. This record shall show complete results of the procedure qualification test. Forms similar to those shown in Figs 1 and 2 of API STD 1104 should be used. These records shall be maintained as long as that procedure is in use.

15.3.1.2 Testing of welded joints for qualification of welding procedure

15.3.1.2.1 Testing of butt weld joints

The required test specimens shall be cut from the test joint at locations shown in figure 3 clause 2.6 of API STD 1104. The number of specimens, method of preparation of specimens and the destructive tests they are to be subjected shall conform to paragraphs 2.6.1 through 2.6.5.3 of API STD 1104 (including all relevant figures and tables).

The specimens shall be prepared and the test made as described in clause 2.6 of API STD 1104.

The specimens shall meet the test requirements as described in paragraphs 2.6.2.3 (for tensile strength), 2.6.3.3 (for nick break), 2.6.4.3 (for bend tests) and 2.6.5.3 of API STD 1104.

In addition, the following tests shall be carried out on test joints of pipes manufactured as API grade 60 or higher, (i.e. pipes having steel with SMYS of 413 MPa or higher):

a) All test welds shall be radiographed in accordance with API STD 1104, paragraph 3.6 (Radiography, butt welds only) and with additional requirements of radiographic inspection of this standard. Only welds passing the radiographic inspection shall be selected for sectioning for destructive testing.

b) Vickers Hardness tests shall be carried out in accordance with Appendix A of this standard and with ASTM E-92. One test specimen shall be taken from each quadrant of the root bead and of the finished weld. The difference in Vicker Hardness (HV) Values shall not be greater than 20 over the parent metal, and the maximum value shall not exceed the following value.

TYPE OF WELDING	MAXIMUM ACCEPTABLE VICKER HARDNESS (HV)	
	ROOT BEAD	FINISHED WELD AND HEAT AFFECTED ZONE
AUTOMATIC OR SEMIAUTOMATIC WELDING UNDER SHIELDING ATMOSPHERE	380	320
MANUAL WELDING	300	250

c) Charpy V impact tests shall be performed on each finished weld for toughness indication. The tests shall be performed on each finished weld in accordance with ASTM A 370 and ISO 148 as indicated in Appendix (B) of this standard.

Two samples shall be taken from each finished weld.

Three charpy V notch test specimen shall be taken from each sample and prepared as shown in Appendix B of this standard.

The specimens shall be tested at -10°C and the minimum impact value obtained shall be the following:

i) 3.4 daj as minimum average of obtained values for the three specimens taken from the same sample, for all size specimen.

ii) 2.7 daj as minimum impact value for each specimen, for full size specimen.

15.3.1.2.2 Testing of fillet weld joint

Cutting specimens from the test joint and the minimum number of specimens to be taken for destructive tests shall be as per figures 10 and 11 respectively (clause 2.8.1 API STD 1104), the specimens shall be prepared in accordance with the said clause. The specimens shall be subject to Nick-Break test.

The specimens shall meet the test requirements for soundness as described in clause 2.8.3 of API STD 1104.

15.3.2 Qualification of welder / operator

Welders employed in installation of pipework shall successfully pass the welder qualification tests, as described in section 3.0 of API STD 1104 before commencement of production welding. The welder who successfully completes the welding procedure tests shall thereby be approved in those procedures without undergoing welder qualification tests. The qualification tests of welders shall be conducted in the presence of the Engineer.

Welders shall make test weld using a qualified welding procedure. According to qualification tests made welders can have single qualification or multiple qualification.

A welder who has successfully completed the weld qualification test described in clause 3.2.1 of API STD 1104 shall obtain single qualification and is qualified only within the limits of essential variables described in paragraph 3.2.2 of API STD 1104 .

A welder who has successfully completed the two weld qualification tests (butt weld test and full size branch connection test) described in clause 3.3.1 of API STD 1104 shall be qualified to weld in all positions, on all wall thicknesses, joint design, fittings and on all pipe diameters. In this context requirements outlined in paragraph 3.3.1 of API STD 1104 shall be strictly adhered.

Operators of automatic welding machines shall pass a performance test demonstrating to the Engineer their ability to produce acceptable welds using the qualified procedure(s) in accordance with clause 9.6 of API STD 1104.

Each qualified welder or welding operator shall be assigned an identification number. If a welder leaves the work due to loosing his qualification or any other reasons, the number assigned to him by the company inspector shall not be given to any body else.

15.3.2.1 Testing of weld joint for welder qualification

a) Visual examination of test weld

In this connection reference shall be made to clause 3.4 of API STD 1104.

b) Destructive examination of test weld

Shall be made in accordance with clause 3.5 of API STD 1104. The examination includes procedures for preparation and testing of specimens for tensile, Nick-break and bend in respect of butt welds and also sampling and testing of fillet welds. Clause 3.5 also describes the requirements a sound weld shall meet.

c) Radiographic examination of test weld (butt welds only)

Requirements of clause 3.6 of API STD 1104 shall be observed in this respect.

- To obtain single qualification, as required by clause 3.2 of API STD 1104, the test weld shall meet the requirements of items (a) and either item (b) or item (c) above.

-To obtain multiple qualification, as required by clause 3.3 of API STD 1104, the first test weld (butt weld) shall meet the requirements of items (a) and either item (b) or item (c) above. In addition, the second test weld must exhibit complete penetration around the entire circumference. Complete root beads shall not contain any burn-through exceeding 6.5 mm. The sum of the maximum dimensions of separate unrepaired burn-through in any continuous 305 mm. length of weld shall not exceed 12.7 mm.

15.3.2.1.1 Destructive testing of test welds for welder qualification

15.3.2.1.1.1 Butt welds

Location and number of specimens to be taken from each test weld (for tensile, Nick break and bend test), preparation of specimens, description of the tests to be performed and requirements for soundness of the weld shall conform to clauses 3.5.1 through 3.5.5 of API STD 1104. Consideration shall be given to fig. 12 and table 3 in this respect.

15.3.2.1.1.2 Fillet welds

Location and number of the specimens to be removed are described in clause 3.5.6 of API STD 1104 (including fig. 10). Preparation of the specimens, reference to test method and requirements for soundness of the weld are described in clauses 3.5.6 and 3.5.7 of API STD 1104. As indicated in clause 3.5.7 method of preparation of specimens and method of their test and also requirements for soundness of the welds are same as those described in clause 2.8 of API STD 1104 concerning qualification of welding procedures.

15.3.2.2 The validity of qualification of a welder or welding operator shall be maintained subject to the following conditions:

a) That the welder or welding operator has worked on identical parts for a total duration of at least four consecutive weeks.

b) That the partial or total inspection of the welds which he has performed proved to be of a high standard.

15.3.2.3 Qualification of a welder shall be considered invalid under the following conditions.

a) If percentage of rejected welds (performed by the welder and examined by radiography) exceeds six percent of the total number of welds performed by the welder for two consecutive days.

b) If the welder is not engaged in a given process of welding (i.e. arc or gas) for a period of six months or more. Welder or welding operator who fails the qualification tests or who has lost his qualification during the course of his work,may, after a further training of minimum of fifteen days, take another qualification test. Following a second failure or second withdrawal of qualification, he shall not be permitted to apply for a third test.

15.3.2.4 Records of qualified welders

A record shall be made of the tests given to each welder and of the detailed results of each test. A form similar to figure 2 of API STD 1104 should be used (this form should be in sufficient detail to demonstrate that the qualification test embodied the various requirements prescribed in this standard).

A list of qualified welders and the procedures in which they are qualified shall be maintained.

A welder may be required to requalify if there is question about his ability. Records of qualified operators shall be maintained as recommended in clause 9.7 of API STD 1104.

15.4 Preparation of Joint for Production Welding

15.4.1 Before welding , the pipe ends shall be inspected for defects and cleaned of any foreign material. The surfaces to be welded shall be smooth, uniform, free of laminations, tears, scale, slag, grease, paint and other deleterious material which might adversely affect the welding.

15.4.2 Bevels shall be cleaned to a bright metal finish, internally and externally to at least 10 mm. wide. Any dent larger than allowed by API STD or any crack close to ends shall be cut and rebevelled.

15.4.3 Field beveling should be made by machine tool or machine oxygen cutting. Beveling by hand cutting torch shall not be allowed. The beveled ends shall be reasonably smooth and uniform, and dimensions shall be in accordance with the qualified welding procedure. Soundness of rebevelled pipe ends shall be checked by the dye penetrations.

15.4.4 The cost of all field beveling shall be borne by the contractor unless the Engineer is convinced that the field beveling is due to the mill defects and not caused by the contractor.

If rebevelling is due to the mill defect, in the opinion of the Engineer, the company shall incur the expenses for refacing and rebevelling.

15.4.5 Cutting of pipe ends shall be performed in such a way that the plane of the root face shall be perpendicular to the pipe axis.

Any irregularity shall be ground out by a power sander or grinder to make the bevel and land equivalent to a mill bevel.

The contractor shall, immediately after the cutting, mark indelibly on the remaining pipe crop ends, the pipe number and the pipe mill label.

15.5 Alignment

15.5.1 The alignment of the abutting ends shall be such that minimizes the offset between surfaces and that the longitudinal welds are staggered by at least 20 degrees or by a distance of at least ten times the wall thickness of the thickest pipe, whichever is greater.

The longitudinal weld shall be located in the top two quadrant of the pipe circumference.

The alignment of abutting pipe ends shall be such that the offset between ends are kept within acceptable limit and allowance is made for contraction during welding. Cold dressing shall only be used in case of slight misalignment.

Hot dressing shall be used for correcting excessive misalignment.

The contractor shall obtain the engineer's approval for hot dressing.

15.5.2 For pipes having the same outside diameter and the same nominal wall thickness, the offset between surfaces shall not exceed 1.5 mm. Any greater offset provided it is caused by dimensional variations, shall be equally distributed around the circumference of the pipe.

Hammering of the pipe to minimize misalignment and obtain proper line up shall be held to minimum. If inevitable, bronze or brass headed hammer shall be used.

For pipes having the same outside diameter and different wall thickness, the difference between the wall thicknesses shall not exceed 1.5 mm. However, when the difference in wall thicknesses exceeds 1.5 mm. the contractor may carry out the following with the Engineer's approval:

a) Internally taper the thicker pipe end by machining its inside surface to give the above mentioned alignment with a taper not steeper than 1 in 4.

b) Alternatively insert a transition piece of appropriate thickness and length.

15.5.3 Internal tapering, if required, shall be accomplished by the use of a portable lathe machine furnished by the contractor and approved by the Engineer.

Internal tapers shall not be flame cut.

15.5.4 The longitudinal seam welds shall be located as follows:

i) Straight pipes: Top ½ primeter of the pipe or 180 degrees.
ii) Horizontal bends: Top ½ primeter of the pipe or 180 degrees.

iii) For vertical bends butt-welded together: (for two successive bends), the longitudinal welds should be diametrically opposed.

15.5.5 All longitudinal seam welds which come in contact with the dies of the bending machine during the bending operation shall be checked visually and by ultrasonic test for soundness.

15.5.6 The gap between the lands of the pipe beveled ends (space between the abutting ends) shall be uniform and in accordance with the values given in the qualified welding procedure(s) so that the penetration of the stringer-bead is thorough and uniform and the welded metal contracts freely.

15.5.7 To ensure that the pipes are coaxial, suitable internal line-up clamps shall be used in accordance with the specified requirements of the welding procedure(s).

An external line-up clamp shall be used only with the Engineer's approval when the use of internal line -up clamp is not practical.

15.5.8 The misalignment tolerance (the tangent of the angle formed by two successive pipes) shall never exceed 1/100, which corresponds to an angle of 0.57°.

15.5.9 Joint design, including angle of beveling, root face, gap between abutting ends and angle related to a single "V" groove are shown in Appendix C.

15.6 Repair of Defects

Gouges and scratches from 0.40 mm to 0.80 mm in depth (but not exceeding 12½ percent of the nominal wall thickness) and not more than 50 mm in length may be removed by grinding at the discretion of the Engineer.

The remaining wall thickness after grinding shall not be less than ninety-five percent of the nominal wall thickness for the pipe. Gouges and scratches deeper than 0.80 mm or 12½ percent of the wall thickness shall be removed by cutting out the affected portion of the pipe as instructed by the Engineer.

Should laminations, split ends, defective longitudinal weld seams, or other irrepairable defects be found in the pipe, the contractor shall remove the full joint of pipe from the line, as instructed by the Engineer. If the Engineer approves defects are of mill origin, the contractor shall be reimbursed for such approval in accordance with the provision of the contract.

15.7 Weather Conditions and Preheating Requirements

15.7.1 Weather conditions

Welding shall not be done when the quality of the completed weld would be impaired by the prevailing weather conditions, including but not limited to air-born moisture, blowing sands, high winds and ambient temperature being below 5°C. Windshield may be used when practical. The Engineer shall decide if weather conditions are suitable for welding. If the ambient temperature falls below 5°C preheating is required.

No welding shall be performed on wet pipes. In case ambient conditions cause condensation on the pipe, the edges shall be dried by heating.

15.7.2 Preheating requirements

In order to avoid the risk of cracks occurring in the weld heat affected zone it may be necessary to preheat the joint prior to commencement of welding. The contractor shall apply preheating for welding under the conditions specified in clause 14.3 of this Standard.

15.7.3 Preheating may be accomplished by any suitable method, provided that it is uniform for joint and that the temperature does not fall below the prescribed minimum during the actual welding operation and that preheat covers a distance of at least 50 mm or 5 times wall thickness whichever is the greater, on each side of the weld joint.

15.7.4 When welding dissimilar materials having different preheating requirements, the material requiring the higher preheat shall govern.

15.7.5 The preheat temperature will depend upon the welding process selected, the pipe wall thickness, the chemical composition of the pipe material and the ambient temperature.

15.7.6 Thermocouple attachment and junctions

15.7.6.1 Thermocouples shall be in metallic contact with the parts being heated and shall be attached by an approved mechanical method, or temporary localized deposits to an approved procedure, with drilled thermocouple pockets in the deposits which are subsequently removed. Other means of thermocouple attachment shall be used only by agreement between the Engineer and the contractor.

15.7.6.2 Thermocouple junctions and wires shall be protected from flame impingement. To prevent direct radiation from the heating elements on the hot junction when electrical resistance heating is used. Thermocouples shall be covered with a protective wrapping, e.g. asbestos paper.

15.8 Welding Operations-production Welding

15.8.1 The pipe shall not be moved during welding. For position welding, the pipe shall be placed at an adequate distance from the ground to ensure the proper execution of the work.

15.8.2 The contractor shall supply suitable skids and in sufficient number to support the pipe for safe welding. If the pipe is to be supported over the ditch, the skids shall be of sufficient length so as to prevent the ditch from collapsing.

15.8.3 If the welding is to be performed in the bottom of the ditch, the bell- holes shall be of adequate size to permit easy access for welding the pipe.

In any case, the minimum dimensions of these bell-holes shall be as follows:

Length : 2.00 meters
Width : 1.40 meters added to the pipe diameter
Depth : Such that the clearance under pipe be 0.80 meter.

15.8.4 In case of wind, ambient temperature less than five degrees centigrade, welding operations shall not be carried out without taking necessary precautions.

15.8.5 In case of rain, wind and/or sandstorms, etc. special shelters shall be erected to protect the welders and welding.

15.8.6 The contractor shall preheat electrodes in approved ovens. The duration and temperature of preheating the electrodes shall be in accordance with manufacturer's recommendation or AWS classification.

In addition to preheating the electrodes, the low hydrogen electrodes shall be maintained at a temperature ranging between eighty degrees centigrade to one hundred and twenty degrees centigrade prior to their use, as determined in qualified welding procedure(s).The electrode boxes shall be opened only when required for use on site. The electrodes shall be free from any trace of oxidation and shall not stick together. If so found, the Engineer may instruct the contractor as follows:

a) Reject the suspected boxes only.
b) Reject the whole batch containing the suspected boxes. The contractor shall protect all electrodes from any deterioration or damage. Replacement of electrodes that show signs of deterioration or damage shall be made at contractor's expense.

15.8.7 Welding machines shall be operated within the current ranges that are recommended by the electrode manufacturer for each diameter of rod employed and in accordance with the qualified welding procedure(s).

15.8.8 The contractor shall take necessary precautions to ensure that no arcing occurs between the ground lead of the welding machines and the pipe or fittings. Striking an arc on the pipe or fittings at any point other than the welding groove shall not be permitted. If the pipe is arc burned following remedial actions are needed.

a) All arc burns shall be removed from the pipeline by cutting out a cylinder of pipe containing the arc burns. The length of the cylinder shall be such that permits minimum acceptable distance between two successive welds. Pipe so removed shall be replaced with a good pipe.

b) The depth may be ground out with a power sander or grinder with edge of ground area feathered smoothly into the surrounding area provided that the depth ground out shall not exceed 12.5% of the nominal wall thickness of the pipe. If care is not exercised to prevent accidental arc burns, the contractor shall take one of the courses of actions described above. Which course is required for remedial action shall be decided by the Engineer.

15.8.9 The contractor shall provide and install all temporary connections required to properly earth the pipeline to prevent hazardous conditions from electrical sources in the vicinity of the pipeline during construction.

15.8.10 The position of welders shall be such that the possibility of excessive thermal stresses is eliminated.

15.8.11 Scale and slag shall be removed from each bead and groove prior to application of the succeeding bead. All completed welds shall be cleaned prior to radiographic inspection.

15.8.12 Cleaning shall be made as per welding procedure specification.

15.8.13 The root bead shall be cleaned without unnecessary thinning of the bead except at the point of the electrode change overlap which shall be ground smooth.

To ensure full penetration in a double sided weld, when required by qualified welding procedure, the under surface of the root bead shall be removed by chipping or grinding to give a clean metallic surface.

15.8.14 The time interval between the hot pass and the root bead shall be within the time determined by the qualified welding procedure. Generally the hot pass shall be applied immediately following the stringer bead, to take the advantage of the residual heat from the stringer bead and obviate under bead cracking specially in high tensile pipes.

15.8.15 If two hot passes are applied, the time interval between each of two hot passes shall not exceed the time limit specified by the qualified welding procedure.

15.8.16 Line-up clamps shall be used in accordance with the requirements of the procedure specification. Internal line-up clamp shall be used for pipe sizes 300 DN or larger, use of external clamps shall be permitted when the use of internal clamp, in the opinion of the Engineer, is not practical.

The internal line-up clamp shall not be removed until the completion of hot pass, unless the contractor can prove to the engineer during field production welding that the quality of welding is not impaired as a result of removing the line- up clamp prior to the completion of hot pass.

15.8.17 The line-up clamp shall be inspected for proper adjustment at regular intervals as deemed necessary and at all changes in pipe wall thickness.

15.8.18 The starting points of the different beads shall be at least five centimeters apart.

15.8.19 No weld shall be left at the end of a working day with less than fifty percent of the weld completed.

Root bead shall be made without interruption other than for the changing of electrodes or filler materials or to allow the welder to re-position himself. Weld metal shall not be allowed to cool until the thickness of weld metal deposited exceeds fifty percent of the final weld thickness.

15.8.20 The maximum distance between the root bead team and the finish bead team shall be decided by the Engineer.

15.8.21 The contractor shall ensure that the welded string of pipe is free from injurious defects defined by API 1104.

The welded string of pipe shall be fully supported until all welds have been completed and cooled down.

15.8.22 The finished weld shall be neat and uniform and the crown of the finished weld shall be regular and shall be between 0.5 and 1.5 mm. in hight.

15.8.23 Welding machines, cutting/beveling machines and all other welding equipment shall be maintained by the contractor and kept in good working condition.

15.9 Welding Operations, Tie-in-welds

Tie-in weld is meant to connect followings:

- Pipeline sections,
- A pipe and an accessory (fittings, flanges and valves).

All requirements specified in clauses 15.4, 15.5, 15.7 and 15.8 of this Standard are applicable for tie-in welds. with the addition that tie-in welds shall be made with the use of external clamp and low hydrogen electrode using up hill method in accordance with the qualified welding procedure(s). Crown hight of tie-in welds can be up to 2 mm.

15.10 Welding of Flanges

When welding weld neck flanges to the pipe, the weld shall be of the same quality as that specified for the welds on the mainline.

Internal diameter of the flange neck and pipe may vary in relation to each other and if the difference exceeds 1.5 mm (1/16 in.), the smaller bore shall be machined ground or filed to give proper alignment (i.e. with offset less than 1.5 mm) with a tapper not steeper than 1 in 4. Alternatively, a transition piece shall be inserted that satisfies the same requirements.

When welding the weld neck flanges to the pipe,care shall be taken that the face of the flange is perpendicular to the axis of the pipe. Flange faces shall be carefully handled to prevent any damage to the sealing ring or raised face that might interfere with the proper sealing of the flange when bolted in the pipeline.

15.11 Welding of Branches and Fittings

15.11.1 Angle of branch

In cases where the angle between the main and the branch is unavoidably less than 60°, the welding procedure shall be subject to special agreement and consideration.

15.11.2 Spacing of branches

The spacing of branches on the main pipe shall not be less than 2 times diameter of the line and the lengths of flanged branches shall be such that there is adequate access for satisfactory welding.

15.11.3 Joint preparation

Branch connection and branch openings in the main pipe shall be cut by machining or by thermal cutting. The cut edges shall then be dressed by chipping, filing or grinding to remove any roughness and to produce the specified edge shape.

Protective coating on end bevels are to be removed before welding. The method of removal is to be discussed and agreed with the Engineer.

15.11.4 Branch reinforcement

When the reinforcement is thermally cut to shape the cut edged shall be dressed by filing, grinding or machining.

The reinforcement shall be securely held in position by tack welds which shall be of sound quality welds. Connecting reinforcements shall be butt welds or fillet welds or a combination of these types of welds, made in accordance with the appropriate welding procedure.

15.11.5 Fittings

All fittings shall be grinded and welded from the inside as specified by the Engineer.

15.12 Records of Welding (Welds and Welder Identification)

Records of all welds made during production welding shall be kept and be made available for reference. All welds shall be numbered. The number of welds and identification mark of the welders shall be inscribed by the contractor adjacent to the welds in the top quarter of the pipe. Using an indelible marking process which will not interfere with the application of coating.

Die-Stamping shall not be used. The contractor shall furnish the Engineer with a record of the welds performed each day.

The contractor shall keep welding records which shall be similar to the sample form in Appendix D of this Standard.

The first record shall be reserved exclusively for a statement of materials used and work done, and shall be made out in chronological order of the execution work. It shall be kept day to day, and shall be submitted daily to the Engineer.

The second record drawn up on reproducible tracing paper shall be reserved for the regrouping of the details given in the first record. They shall be arranged in the geographical order of the route taken, so that the accumulated length in kilometers to each weld refers back to the beginning of the pipeline.

As the connections are performed, and at the end of each week, the contractor shall supply the Engineer with three printed records. After pipeline tests, the contractor shall pass over the Engineer the whole set of reproducible sheets and six prints on white paper. As shown in Appendix D. These records shall, in particular, include.

15.12.1 On the first page

a) The date of the performance of the weld.

b) The number of the pipes connected, their grade, design thickness and origins, as well as the nature and identification numbers of the parts, apparatus and equipment connected.

c) The exact length of each pipe.

d) The number of the welds and their distance in kilometers from beginning of the route.

e) The kilometer point of the elbows (in profile and on plan), markers, obstacles and their locations in relation to the nearby welds.

f) The marks of section and tie-in welders.

g) The characteristics of the elbows (angle, size and position marker).

h) Any observation, all information concerning repairs and cuts, the reason for them, as well as the dates of their execution.

i) The atmospheric conditions (temperatures, wind, rain, etc.) at the time of welding.

j) The nature of the ground and the place where the weld is performed.

15.12.2 On the page opposite to the previous one

All location sketches concerning the position of the welds and elbows in relation to the natural obstacles as well as the dimensional drawing of the section connections, of structures for the crossing of obstacles and their connection to the line, sketches of the locations of nearby structures and of parts, apparatus and equipment connected.

15.13 Inspection of Welds at Site (Other Than Non-destructive Methods)

15.13.1 Check for conformity

The contractor shall, at all time during the progress of production welding, ensure that:

a) The electrodes are of the type approved in the qualified welding procedure(s) and that they are stored and handled to preserve their quality.

b) The welding process and technique conform to those which have been approved and all welding parameters (temperature, time between beads, etc.) are fully complied with.

c) The welders are performing the operation for which they are qualified.

d) The welding materials and equipment are in sufficient quantities and are in good maintenance and working condition.

15.13.2 Visual inspection of production welds

This inspection shall verify that preparation, presentation and execution of procedures are complied with. Welding shall be visually inspected to ensure that the execution of welding is in conformity with this standard and the qualified welding procedure(s) and that end preparation and alignment have been properly made.

15.13.3 Destructive test of production welds

Beside the routine supervision and visual inspection, the Engineer shall have the right to inspect sample welds by instructing the contractor to cut and remove them for destructive test, i. e subjecting them to mechanical tests. The inspection may also be made during the welding and before it has been completed. The frequency of this inspection shall be as the Engineer considers necessary.

Destructive testing shall consist of the removal of completed welds, the sectioning of them into specimens and the examination of the specimens. The specimens shall be prepared and meet the requirements of clause 3.5 of API STD 1104.

In case of any doubt left after the non-destructive testing of a weld, the Engineer shall have the right to request Nick-break test, as described in clause 2.63 of API STD 1104, to verify the indications resulting from the non-destructive inspection.

Standard of acceptability of these mechanical tests are described in clause 2.6.3.3 of API STD 1104.

If it is found required, in the opinion of the Engineer, samples, shall be taken from production weld for additional tests to be carried out in laboratory selected by the Engineer.

The Engineer shall have the right to accept or reject any weld not meeting the requirements of the method by which they are to be inspected. The welder or welders who make a weld which fails to comply with the requirements may be disqualified from further work.

Should sample weld fails to conform to the standard of acceptability, all costs of removal, rewelding, tests and inspection of new weld shall be borne by the contractor; otherwise the Company shall incur all expenses involved in this respect.

15.14 Non-destructive Inspection of Production Welds

The contractor shall perform non-destructive testing of the welds. Joint shall be thoroughly cleaned and burnished by means of mechanical brushes and buffers and spatter removed immediately prior to weld inspection.

The contractor shall prepare detailed procedure for all nondestructive tests and techniques to be used for inspection of production welds for approval of the Engineer.

The contractor shall produce certificate of calibration for all NDT equipment to be used for weld inspection.

Operators of non-destructive inspection equipment may be required to demonstrate the capability of the procedure to detect rejectable defects. They may also be required to demonstrate their ability to properly perform the tests and interpret the indications given by the equipment. Methods of non-destructive inspection are described in paragraphs 15.14.1 and 15.14.2 below.

Non-destructive testing personnel shall be certified in accordance with the recommendations of ASNT recommended practice SNT-TC-1A for the test method used. Only level II or III personnel shall interpret test results.

15.14.1 Radiographic inspection of production welds

15.14.1.1 Radiographic techniques

X-rays shall be used for welds, where panoramic exposure is possible and pipe wall thickness permits to do so.

Where pipe wall thickness or pipe size does not make use of x-rays and panoramic exposure feasible, the contractor may elect in such cases to use gamma rays employing Ir 192. To use X or gamma rays , the contractor shall obtain the Engineer's approval prior to production of radiographs.

The following techniques are set out for radiographic examination of fusion welded circumferential butt joints.

a) Single wall method: A method of radiographic examination in which the source of radiation is outside the pipe and the film is close to the inside surface of the intervening wall or in which the source is inside the pipe and film is close to the outside of the pipe. Apart from panoramic technique, this method does not have practical application in weld examination of off-plot piping.

b) Double wall method: A method of radiographic examination in which the source of radiation is outside the pipe and the film is close to the outside of the pipe on the side remote from the source of radiation, the radiation passing through both walls of the pipe.

Note:

The penetrated thickness with normal radiation incidence is 2Y as shown in Fig .

b1) Double wall, single image method: An application of the double wall method producing a usable image of only a part of the weld adjacent to the film. (See Fig. 2).

b2) Double wall double image method an application of the double wall method producing usable image of the whole of the weld on three or more films. (See Fig. 3).

This technique is mostly used in gas distribution network and its application is limited to pipes DN 80 and smaller.

15.14.1.2 The practical thickness ranges for X ray and gamma ray sources

The X ray and gamma ray sources tabulated below are suitable for penetrating the thickness of steel specified in table below:

SOURCES	MAXIMUM TICKNESS OF STEEL
X RAY	25 mm
IRIDIUM 192	90 mm

15.14.1.3 Image quality indicators (IQI)

The IQI, also known as penetrameters, are used to provide a guide to the quality of the radiograph. Two basic types of IQI are commonly used which consist of:

Type 1

Wire type with 30 mm length and various diameters as per Table 1 of BS 3971 or DIN 54109 Part 1.

Type 2

Step/hole type consisting of metal plaques each containing a hole. The step thickness and diameter of the drilled holes is given in Table 3 of BS 3971.

The IQI shall be placed on the surface of the weld, on the side of the weld, facing the radiation source, as described in clause 13.2 of BS 2910 DIN 54109 and DIN 54111 Part 1.

Sensitivity of image quality is expressed as the diameter of the smallest wire or drilled hole that can be detected on image by the eye on film viewer.

The sensitivity is calculated in accordance with the following formula:

$$S = \frac{D}{T} \times 100$$

Where:

D = diameter of smallest visible wire (or hole) on the radiograph.

T = thickness of pipe.

Only where the surface facing the source of radiation is inaccessible the IQI should be placed on the film side. If this is done it should be stated in the radiographic reports, as the IQI sensitivity will form that obtained when the IQI is placed on the surface facing the source of radiation.

The sensitivity should not exceed 2% .

The type of penetrameter used in making the procedure qualification radiographs shall be the same for production radiographs.

Method of controlling radiographic quality penetrameter shall conform to ASTM-E-142 or API STD. 1104.

15.14.1.4 Intensifying screens

Lead metal screens should be used in all techniques. The thicknesses of front and back lead screens should be in accordance with the table shown below .

The intensifying screen shall be clean and free of scratch.

Intensifying screens which are used in all testing techniques shall be selected in accordance with Table 4 of BS 2910.

RADIATION	SCREEN MATERIAL	FRONT SCREEN THICKNESS mm	BACK SCREEN THICKNESS mm
X-RAYS 120 KV-250 KV	LEAD	0.02 TO 0.125	0.1 min.
X-RAYS 250 KV-400 KV	LEAD	0.05 TO 0.16	0.1 min.
IRIDIUM 192	LEAD	0.02 TO 0.16	0.16 min.

15.14.1.5 Cassettes

In all cases, precautions shall be taken to ensure good film-screen contact irrespective of whether flexible or rigid cassettes, are used.

All cassettes, whether rigid or flexible, shall have sufficient compression to ensure positive film-to-screen contact. Flat, rigid cassettes shall be used wherever practicable; for welds in curved surfaces, rigid cassettes with a curvature to fit that of the plate or, alternatively, flexible cassettes may be used, provided that close film-to-screen and cassette to object contact can be ensured.

Use of cassets shall be made as per recommendations of BS 2910.

Note:

When appropriate and agreed between the contractor and the Engineer, long lengths of film in commercial packs, with integral metal and intensifying screens, may be used.

15.14.1.6 Radiographic procedures

A detailed procedure for the production of radiographs shall be established and recorded. The radiographic procedure shall comply with the requirements of section 8.0 of API STD 1104 or alternatively with clause 22 of BS 2910 whichever is selected by the Engineer. The proposed procedure shall be submitted to the Engineer to obtain his approval.

Radiation sources and other radiographic equipment, type of film and radiographic technique shall be qualified. The approved radiographic procedure shall specify minimum sensitivity of 2 percent for radiographs.

a) Two percent of the thickness as measured by wires.
b) Two percent of the thickness (2-2t) as measured by step/hole IQI (selected with proper number to suit wall thickness of pipe under test) or approved equivalent, placed on the source side.

15.14.1.7 Selection, storage, processing and viewing of the film shall comply with requirements and guide covers of ASTM STD. E-94.

Exposure geometry shall conform to ASTM STD. E-94 or API STD 1104.

15.14.1.8 Radiographers shall be qualified in accordance with the recommendations of the American Society For Non-destructive Testing (Recommended Practice SNT-TC 1A). Only level II or III personnel shall interpret test results.

Record of qualified radiographers shall be kept by the Engineer. Requirements of clause 5.4.2 of API STD 1104 shall be observed in this respect.

15.14.1.9 Where gamma rays are used, the film shall be fine grained class two type as specified in ASTM E-94. Shooting, development, identification and reading of the film shall be carried out by the contractor in accordance with ASTM E 94 and under the supervision of the Engineer. Final interpretation will be made by the Engineer or his nominated interpreter. Even after final verdict on radiograph, no cut-out or repair is to be made without the Engineer's instruction.

The Engineer or his nominated interpreter will check films every day.

15.14.1.10 Standard of acceptability for determination of the type and size of weld defects by non-destructive testing is described in section 6 API STD 1104 which shall be strictly adhered to.

15.14.1.11 The frequency of the radiographic inspection shall be determined by the Engineer; However, the following is recommended as a basic rule.

CATEGORY 1

For special cases in production welds:

One hundred percent

a) For tie-ins, similar welds and welds performed in bellholes.

b) For complete or partial repair welds (excluding of cap repair).

c) For welds performed on pipeline sections intended for crossings (Freeways, rail, road and river crossing)

d) For welds between pipes of different grades and for joints of pipes having same outside diameter and different wall thickness.

e) For welds performed on insertion of fittings into line.

f) When there is a change in welding team.

g) When the Engineer considers that performance conditions have changed, either because of the location or because of climatic conditions (for example wind or sand storm).

CATEGORY 2

For normal production weld:

a) One hundred percent

During the initial start-up period and until the rate of progress envisaged in the work schedule is reached and maintained for at least two consecutive days, and as long as the percentage of rejected welds on the two days of welding exceeds six percent of the total number of welds performed during these two days, or if any rejected weld is due to a crack.

b) Minimum thirty percent

b.1) For welds performed in line, after the initial period provided the conditions described in the above paragraph (a) do not exist.

b.2) As long as no unacceptable defect entailing the complete remaking of the weld, in the opinion of the Engineer, is revealed.

b.3) As long as the daily number of weld repairs, except those due to crack, after the radiographic inspection is less than the value given below:

ns/10

Where:

"n" being the number of welds performed daily by one spread.
"s" being the percentage of welds inspected at random ("s" is expressed in hundredths).

b.4) As long as, during the last ten days, not including the initial period when one hundred percent inspection is carried out, the number of welds showing defects beyond the tolerance does not exceed eight percent of the welds performed.

c) One hundred percent

For welds performed in line after the initial period, as soon as one of the conditions in paragraph (b) above is not met for at least two consecutive days and as long as the percentage of defects beyond the tolerance limits calculated during the last two days of welding of this one hundred percent inspection period exceeds six percent of the total number of welds performed during these two days.

15.14.1.12 Film processing shall be carried out so as to produce radiographs free of all artifacts which could interfere with the interpretation. Fixing and washing of the film shall be carried out in such a way that they can be stored for at least five years without discoloring. All films shall be washed in clear running water at temperature not exceeding thirty centigrade.

The developing laboratory, dark room, shall be large enough, properly equipped and always kept extremely clean. It shall be supplied with electric power and clean running water. The dark room shall be air-conditioned, if needed, and be provided with film washing water.

The contractor may utilize automatic radiograph processor.

15.14.1.13 Radiation protection

The radiation hazards associated with the use of x-ray equipment or gamma source shall be minimized by adherence to "Iranian Atomic Energy" regulations. Operators of the equipment or sources shall be aware of the aforesaid regulation and the hazards of penetrating radiation. Careful attention must be given to personnel monitoring. All personnel involved in handling and operation of radiographic source are required to be equipped with film badge and pocket dosimeters for recording accumulated doses of radiation exposure.

The maximum permissible accumulated dose for every person involved in radiography is as follows:

5 rem in any one year (50 msv)
3 rem over any calendar quarter (30 msv)
100 millirem per week (one msv)
20 millirem per day (0.2 msv)

Note:

Rem is symbol for roentgens equivalent mean whereas msv is symbol for millisievert which is si unit.

For personnel not directly involved in radiography the maximum radiation received shall not exceed 1.5 rem per year warning signs installed for public shall be made to prevent people entering area with radiation expecting 0.75 millirem (0.0075 msv) per hour.

Radiation surveys are an integral part of the safe operation of x-ray machines or radioactive sources which must be conducted by contractor.

These surveys which are conducted to determine the extent of radiation hazard in any given area is vitally important when working in a populated area. The survey meter is a rate instrument which indicates the exposure received per unit time. The most commonly used instruments are the geiger muller counter (G-M) and chamber meters. The effect of distance on the intensity of radiation is calculated by the inverse square law, represented by the following equation.

$$\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$$

where:

I = intensity of radiation.
D = distance from the source of radiation.

Film badges shall be sent to Iranian Atomic Energy on monthly basis to measure radiation exposure of each person involved in radiography. Record of the result shall be kept in the relevant file.

15.14.2 Ultrasonic inspection of production welds

All fillet welds (e.g. branch connections, weldolet, threadolet, split-tee and saddle connection) shall be examined by ultrasonic method.

When automatic welding or semi-automatic welding under shielding atmosphere is employed, all welds shall be inspected by radiographic or ultrasonic testing.

Equipment and material shall conform to the requirements of ASTM E317. For the calibration equipment, the contractor shall conform to the requirements of calibration block according to the requirements of Norm ISO 2400 and calibrate the equipment under operation twice a day.

Qualification of NDT personnel shall conform to requirement set out in par. 15.14 of this Standard.

15.15 Time Lapse between Weld Completion and Weld Inspection

Contractor shall complete radiography of pipeline production welds within 24 hours of weld completion except for double joint welds and tie-in welds. Tie-in welds shall be radiographed within two days of completion.

Double joint welds shall be tested ultrasonically or by radiography (if made by automatic or semi-automatic) or with radiography (if made by manual shield arc) continuously during the production of double jointing.

15.16 Radiographic Test Record

The weld radiographs shall be recorded according to an appropriate identification number. Their position on the weld shall clearly be indicated by means of convenient markings so as to locate defects on weldment.

The joint position shall be indicated on the pipe record book or on proper drawings or sketches, making reference to the above mentioned identification number.

In addition to pipe record book a radiograph record book shall be prepared. The following radiographic records shall be maintained in the radiograph record book.

a) Techniques used
b) Weld repair
c) Film
d) Film interpretation record. This record shall contain as a minimum the following information .

d.1) Disposition of each radiograph (acceptable or rejectable).
d.2) If rejectable, the opinion issued by the interpreter for cause of rejection (e.g crack, slag, porosity, etc.).
d.3) Surface indication verified by visual examination (grinding marks, weld ripple, splatter, etc.).
d.4) Name of the film interpreter, including certification level.
d.5) The radiograph record book shall be signed by the interpreter. It shall be duly countersigned by the Engineer and by the contractor.

The contractor shall keep at the site a copy of the pipe record book as well as the radiograph record book. The contractor shall file the radiographs, pipe record book with relevant drawings or sketches, radiograph record book until work is completed and they are handed over to the company together with as built drawings and other documents.

15.17 Identification of Radiographs

All radiographs shall be identified by numbering them in sequence in the same order in which they were exposed by the contractor.

The identification of each radiograph shall be tied to known pipeline locations, as described in procedure.

Repaired or new welds at cut-outs shall retain the original radiographic number with the suffix R for repair, N1 for new weld, N2 for second new weld if N1 was rejected and required cut-out.

Example:

Original weld No. AIII (Rejected)
Repair weld No. AIII R (Rejected)
New weld No. AIII RN1 (Accepted)

The original weld was rejected for repair. The repair failed and required cut-out.

The new weld was acceptable.

The record of the radiographs made by the contractor shall be verified by the Engineer for authentication.

15.18 Interpretation of Radiographs

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 API STD 1104. The radiographer shall describe to the Engineer those weld defects that he considers cause for rejection of the weld. The Engineer will make final interpretation on all welds.

15.19 Radiographed Film Storage

The contractor shall supply and store film in boxes with a number of sections which is agreed upon between the contractor and the Engineer.

The film of welds considered acceptable shall be stored in numbered sequence with the records of those considered unacceptable and required repair or replacement.

The film of those welds considered unacceptable (required repair or cut-out) shall be tagged, listing the weld number, the date, the position and type of defect. The film will then be placed into the storage box with proper dimensions in numbered sequential order with the acceptable weld films.

The contractor shall keep each film box until all sections of the box are filled with films of acceptable welds, or films (suitably tagged) of unacceptable welds. When the box is filled, it shall be transmitted to the Engineer.

All storage boxes shall contain a record of the film numbers stored within showing orientation of each film by number. Each box shall be marked with the beginning and ending film numbers in the box, including kilometer post number, referred to locations of welds represented by the films.

After receipt of films of repair or replacement welds from the contractor, the Engineer shall remove the rejected films of the same welds and their film tags from the respective storage boxes and shall insert both the original and new films rolled together in their proper section. The tags may then be destroyed if the Engineer is satisfied that the original and new films are of the same weld.

15.20 Procedure for Transfer of Radiograph

Each storage box with spaces filled shall be transferred to the Engineer with a written transmittal containing the following information :

i) Box number.
ii) Date of transfer.
iii) Film interpretation sheets of all welds (acceptable or reject) contained in the storage box.

Following the repair or replacement of all reject welds, the contractor shall transfer the film of repaired or replacement weld to the Engineer daily, with a written transmittal containing the following information:

a) Date of transfer.
b) Film interpretation sheets of all repair or replacement welds represented.

15.21 Procedure for Identification, Numbering and Records of Films of String Welds

Welds made in strings (between tie-ins) shall be identified with consecutive letter/number series. These numbers will appear on the radiographic film. When welds are made to repair or replace the original welds, the radiographic crew shall maintain the original film numbers and add N1 or R as applicable.

If x-Ray panoramic technique is used whenever the x-Ray crawler is removed from a string of pipe or introduced into it, the radiographic crew shall legibly print the last (or first) x-Ray number with a felt-pen, on the outside surface of pipe facing the ditch.

The survey station of each end of all strings shall be recorded by the contractor's as built survey crew. The as built survey station for the tie-in weld shall be written inside each of the ends of the strings which are to be tied together.

15.22 Procedure for Identification of Films of Tie-in Welds

The identification letters to be placed on the tie-in films shall appear on each quadrant film and shall be supplied in writing by the tie-in inspector in the following form:

Tie-in weld films shall retain the consecutive number listed in Appendix D.

Replacement welds or repairs shall be identified by R or N1 added to the original film number.

15.23 Repairs and Rewelding in Detail

15.23.1 The contractor shall not repair or cut-out any weld without the Engineer's instruction and presence. The contractor shall cut non-repairable defects from the pipeline as cylinders and replace with good pipe. The length of cylinder to be cut shall be a minimum of 1.5 time diameter of the line. In no case the length of cutting shall be less than 15 cm.

Cracks and arc burns shall be removed by the contractor as nonrepairable defects. Defects in the root, hot and filler beads consisting of slag inclusion, porosity and gas pockets, may be repaired with the approval of the Engineer and in accordance with section 7 of API STD 1104 if the following apply (correction of an individual bead prior to the laying of a succeeding bead is not considered repair of a defect).

15.23.2 The repair procedure to be used is fully qualified in accordance with API STD 1104.

15.23.3 Incompleted penetration resulting from Hi-Lo internal undercut may be repaired by back welding. Repair of incomplete penetration shall extend beyond the ends of the defects. The distance for repair extension shall be 50 mm on either side of the defects. Remedy of other defects may require back welding.

Maximum length of back welding for any single repair area shall meet approval of the Engineer provided that:

a) Adjacent defect areas shall be separated by a minimum of 100 mm of sound weld metal.
b) For any repair 100 mm or longer, a new rod shall be used for each bead.
c) Before such repairs are made, such defects shall be entirely removed to clean metal by grinding and all slag, scale rust, paint, dirt or other forign substances shall be removed.

15.23.4 An area covering a minimum of 50 mm (or 5 times wall thickness of pipe whichever is greater) on each side of the weld at the repair area shall be uniformly preheated to a minimum temperature of ninety-five degrees centigrade and maintained during repair welding. The temperature shall be checked by the use of temperature indicating crayons approved by the Engineer.

15.23.5 All repair cavities shall not be less than 50 mm. in length. The start and stop of additional repair passes shall not be superimposed over the start and stop of the proceeding repair passes. Ends of the completed repair shall be ground to a smooth contour blending into the surface.

Any notches resulting from back welding shall be removed by grinding, including those occurring along the edge of the bead. The completed back weld shall be cleaned.

15.23.6 A given repair area may consist of one or more defects.

15.23.7 Each repair bead shall begin and end outside the repair area.

15.23.8 Visual inspection by the Engineer shall be mandatory and no further repairs shall be made in these areas.

15.23.9 Repair procedure shall be prepared by the contractor for the Engineer's review and approval. The procedure shall include:

a) The method of gouging out defective areas.
b) Pre-heating.
c) Post weld heat treatment, if required.
d) Electrode to be used (classification and sizes).
e) Applied welding procedure and NDT method used for inspection of repair weld.

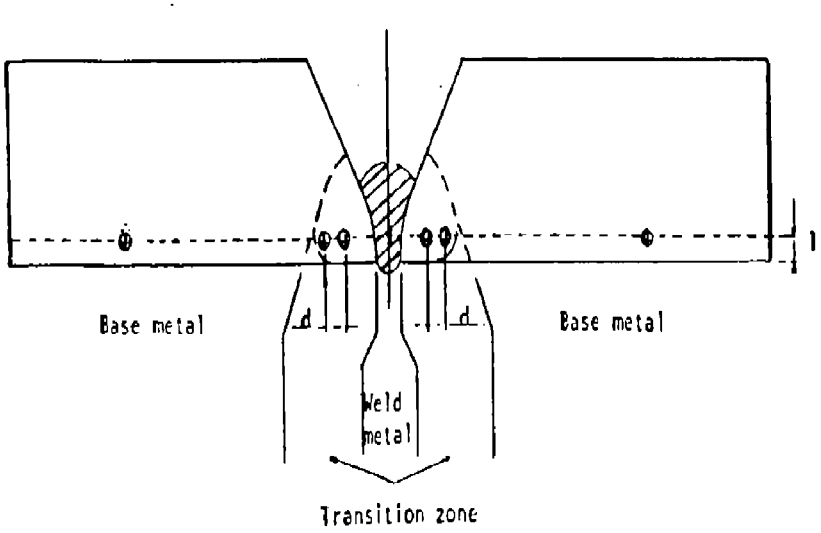
15.23.10 Defects shall be removed by chipping and grinding. Thermal gouging is not permitted without obtaining the Engineer's approval. The contractor shall submit schedule of repair so as the Engineer can plan for supervision.

15.23.11 The contractor shall maintain record of all repairs and rewelding together with location of such repair or rewelding. Length of cutting and replaced piece of pipe inserted shall not be less than 1.5 time diameter of the line. In no case the length of cutting shall be less than 15 cm.

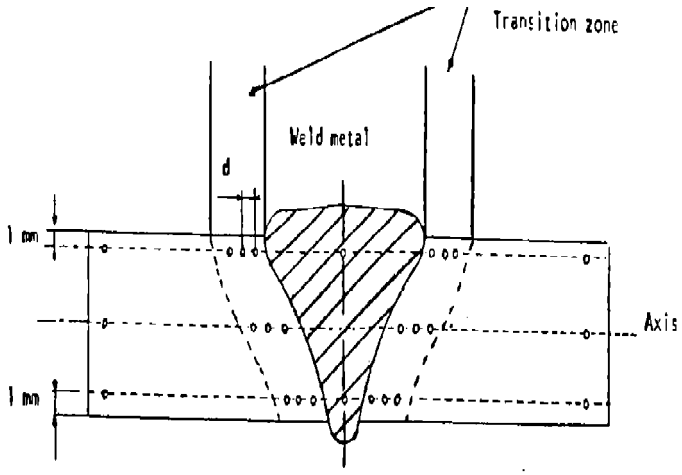
APPENDICES

APPENDIX A
VICKER HARDNESS TESTS

1) ROOT BEAD TEST



2) FINISHED WELD TEST



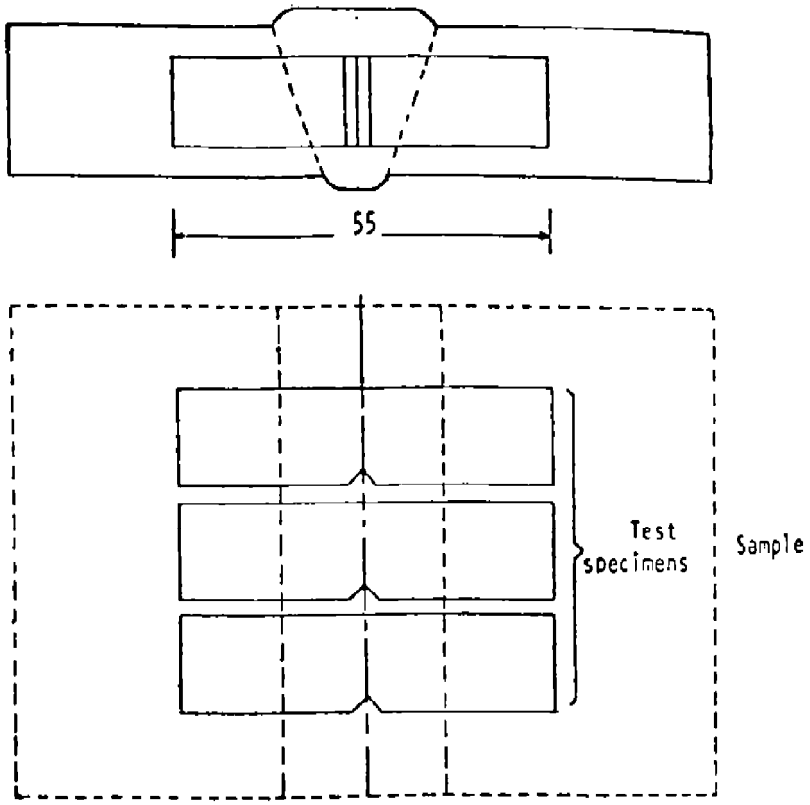
Notes:

1) Indicate print locations.

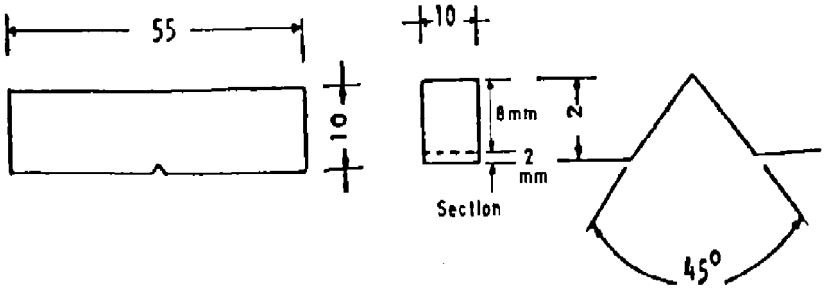
2) d In transition zone shall be less than 0.5 mm or 2.5 times the diameter of the print whichever is shorter.

APPENDIX B
CHARPY V-IMPACT TESTS

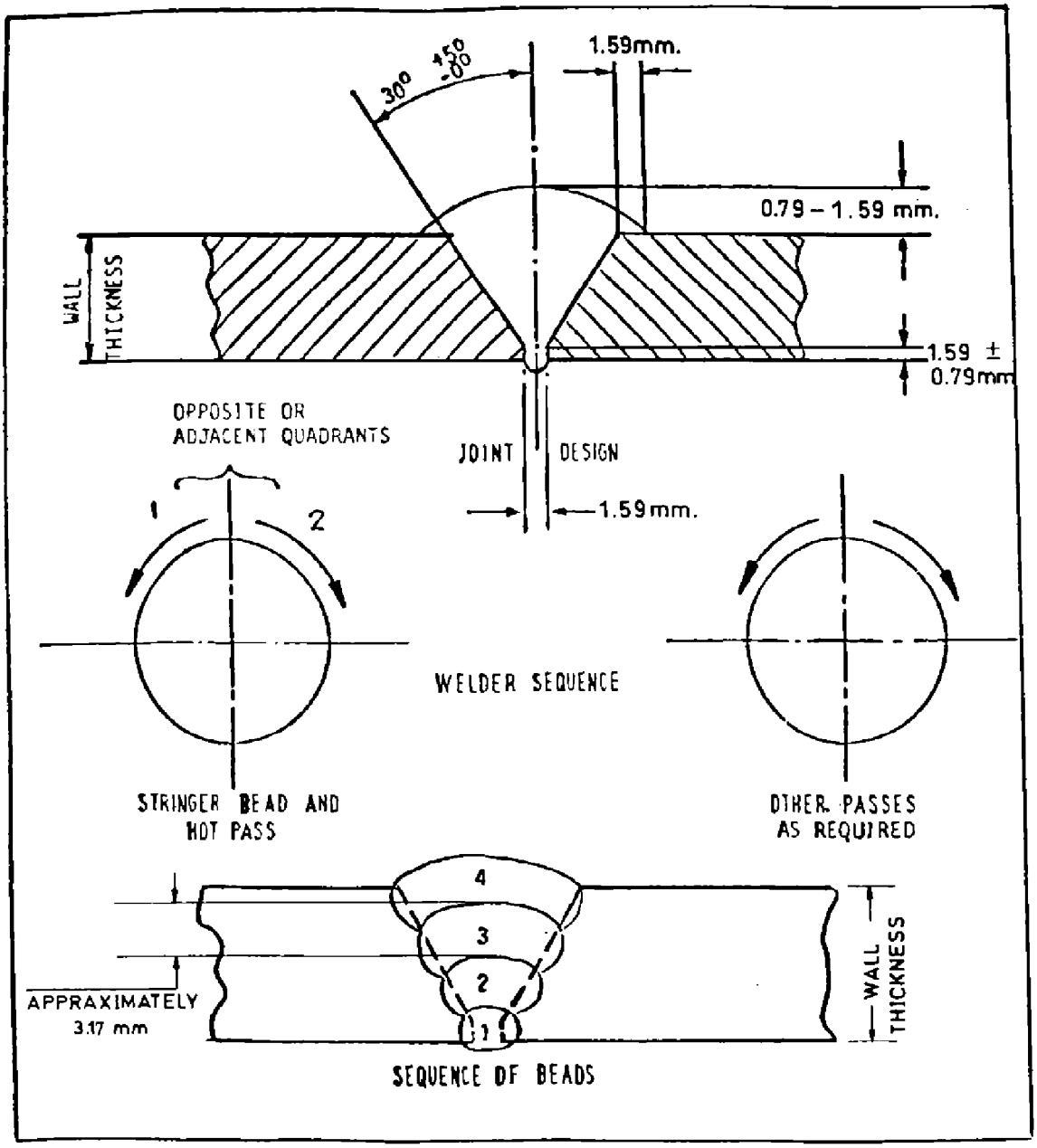
1) SAMPLING



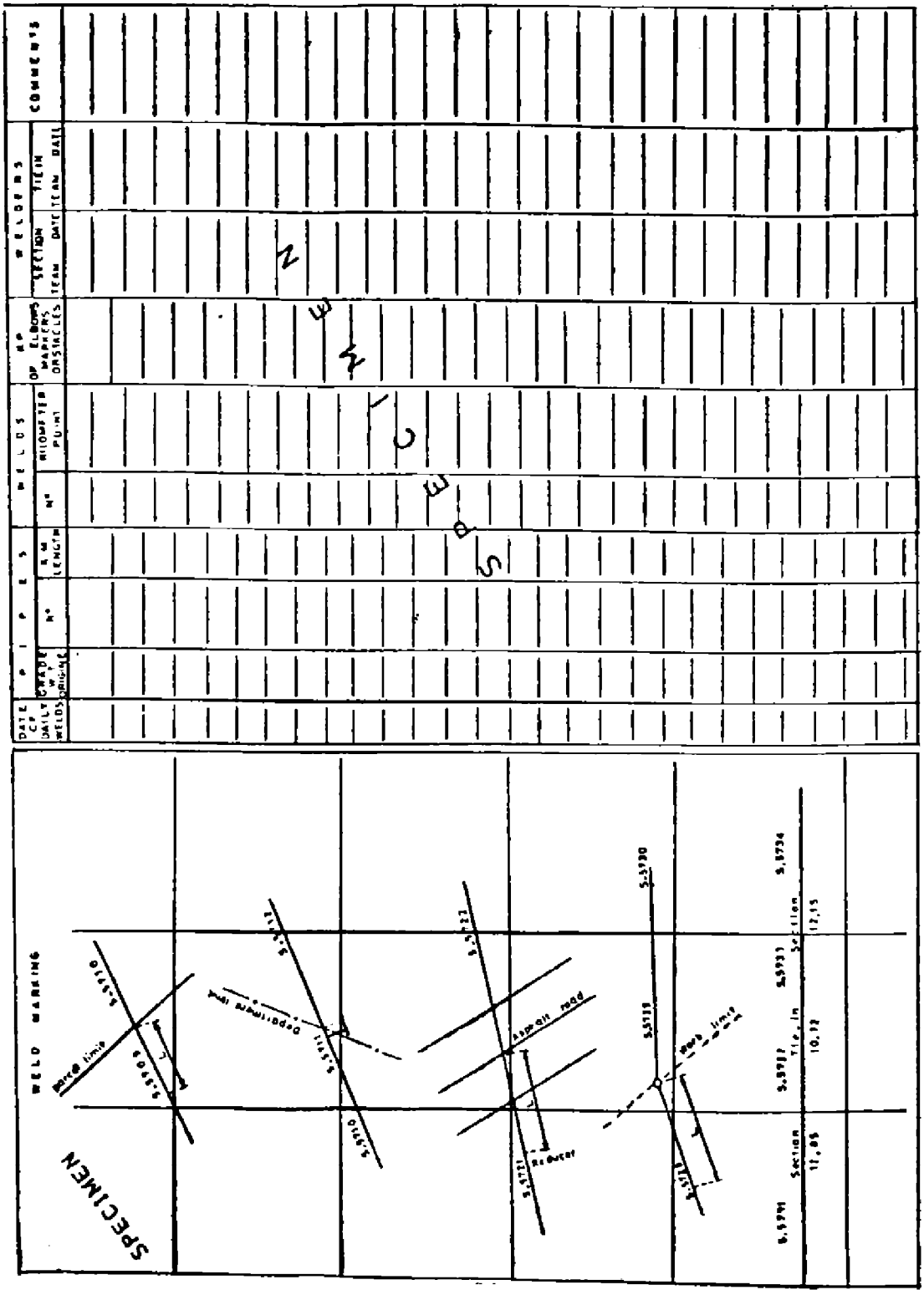
2) TEST SPECIMEN DIMENSIONS (in mm)

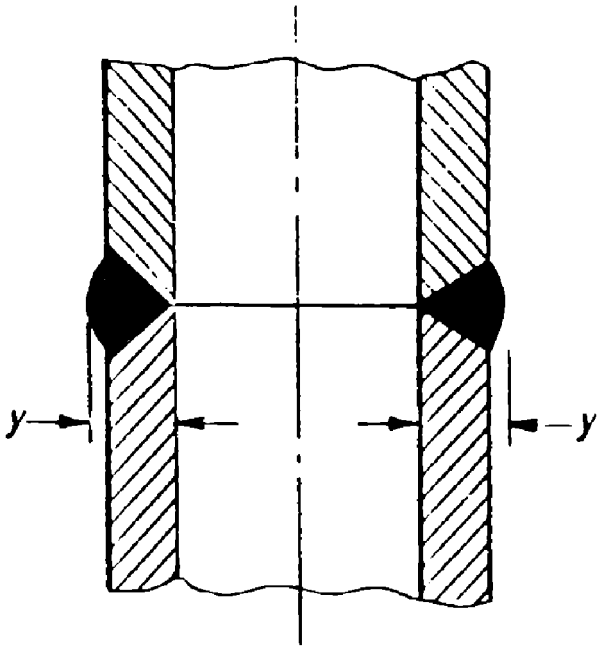


APPENDIX C
TYPICAL JOINT DESIGN "V" GROOVE



APPENDIX D
WELD RECORD SPECIMEN



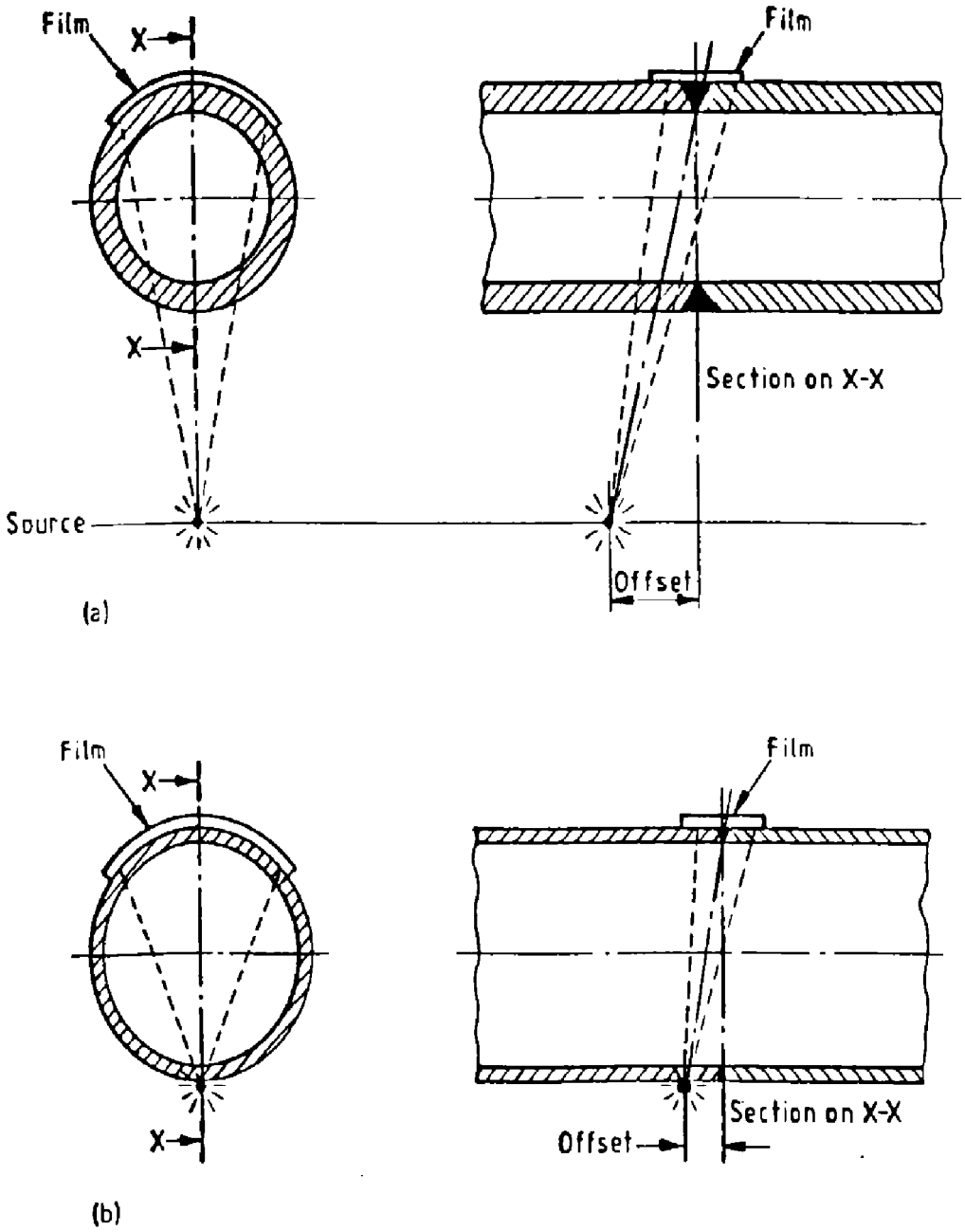


Y is the thickness of metal immediately adjacent to film where there is no backing ring.

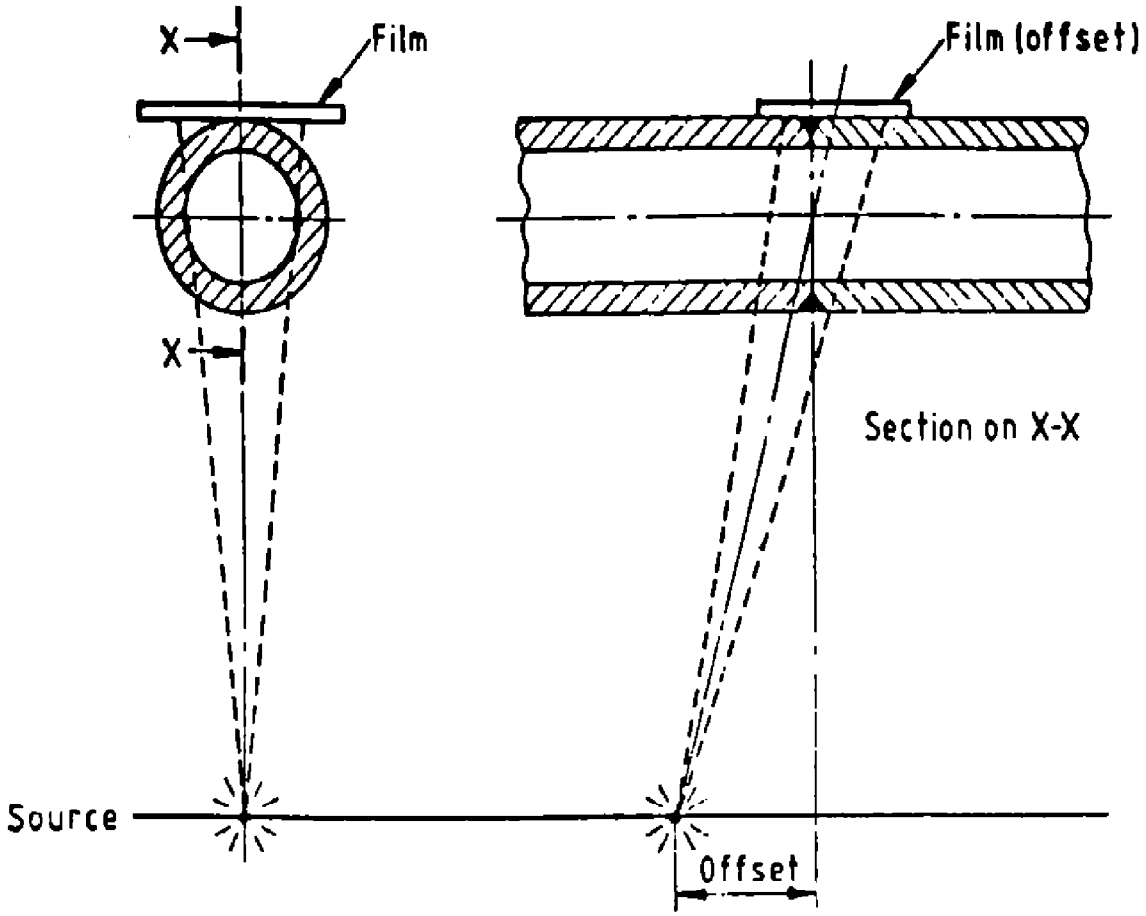
For single wall method, penetrated thickness is Y.

For double wall method, penetrated thickness is 2Y.

PENETRATED THICKNESSES (RADIOGRAPHIC METHODS)
Fig. 1



DOUBLE WALL, SINGLE IMAGE METHOD (RADIOGRAPHIC METHODS)
Fig. 2



Note:

For clarity the offset distance has been drawn larger than required.

DOUBLE WALL, DOUBLE IMAGE METHOD (RADIOGRAPHIC METHODS)
Fig. 3