طرح نگهداشت و افزایش تولید 27 مخزن

NDT PROCEDURE

نگهداشت و افزایش تولید میدان نفتی بینک

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IDC: Inter-Discipline Check
IFC: Issued For Comment
IFA: Issued For Approval
AFD: Approved For Design
AFC: Approved For Construction
AFP: Approved For Purchase
AFQ: Approved For Quotation
IFI: Issued For Information
AB-R: As-Built for CLIENT Review
AB-A: As-Built –Approved

REVISION RECORD SHEET

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CONTENTS

1. INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – General Facilities
EPD/EPC CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection(D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
HOLD POINT: (abbreviated: H)	Means that a hold shall be applied to the production schedule.TheClient must be invited for the inspection / test and the inspection / test must be carried out with the named person in attendance. For drawings / documents: Vendor must receive approved drawings / documents, stamped by /Client.

Review (abbreviated R)	Means that documents shall be submitted after inspection for review as part of the Vendor data book.
Review & Approve (abbreviated: R/A)	Means that documents shall be submitted after inspection for review & be approved as part of the Vendor data book.
Witness (abbreviated: W)	Means that the TPI/Client requires notification of the inspection timing. However, if the Client is not present, Vendor will carry out the test and proceed with the work.
Spot Witness (abbreviated :S.W)	Means random Inspection during visits.
Monitoring (abbreviated: M)	Means that the Client requires monitoring during the Manufacturing of goods. However, if the work is performed as scheduled and if the Client is not present, Vendor will proceed with the work.
MOM	Minutes of meeting
PIM	Pre Inspection Meeting

2. SCOPE

This specification covers the minimum requirements for the NDT Bank project equipment, and the use of the above document in the development project of Binak oil field.

It shall be used in conjunction with data/requisition sheets for present document subject.

3. NORMATIVE REFERENCES

3.1 Local Codes and Standards

- IPS-C-PI-270 — Construction Standard for Welding of Transportation Pipeline
- IPS-C-PI-290 — Construction Standard for Welding of Plant Piping system
- IPS-C-PI-370 — Construction Standard for Transportation Pipeline (onshore) Pressure Testing

3.2 International Codes and Standards

- ASME BPVC Sec.V (2021) — Nondestructive Examination
- ASME BPVC sec.VIII Div.I (2021) — Construction of Pressure Vessels Division 1
- API 1104 (2021) — Welding of Pipeline and Related Facilities
- ASME B31.3 (2020) — Process Piping
- ASNT/SNT-TC-1A(2020) — Personnel Qualification and Certification in Nondestructive Testing

3.3 Order of Precedence

In case of any conflict between the contents of this document or any discrepancy between this document and other project documents or reference standards, this issue must be reported to the CLIENT. The final decision in this situation will be made by CLIENT

4. PERSONNEL QUALIFICATION

Radiographers shall be qualified to ASNT Level II in accordance with recommended practice in compliance with SNT – TC – 1A (personnel qualification and certification in Nondestructive testing)

5. RADIOGRAPHIC TESTING (RT)

Radiographic testing of weldments employs X-ray or gamma ray to penetrate an object and detect any discontinuities by the resulting on a recording or a viewing medium. The medium can be a photographic film, sensitive paper a fluorescent screen, or an electronic detector. Photographic film is normally used to obtain a permanent record of test. when a test object or welded joint is exposed to penetrating radiation, some of the radiation will be absorbed, some scattered and some transmitted through the metal to a record medium .the variation in the amount of radiation transmitted through the weld depend upon, the relative density of the metal and any inclusions, through thickness variations, and the characteristics of the radiation itself. Nonmetallic, inclusions, pores, aligning cracks and other discontinuities result in more or less radiation reaching the record or viewing medium. The variations in transmitted radiation produce optically contrasting areas on the record medium.

5.1 RT PROCEDURE

- Surface preparation.
- The specify location of weld.
- Apply film that is included, I.Q.I, welder stamp, weld location, thickness and required information according to Attachment 3. (IQI with the essential wire for materials (welds) being radio graphed.)
- Use of tray equines and radiator shooting on film
- Apply suitable fixer and developer (Film processing) to achieve high quality film.
- Interpretation
- If unacceptable defects are detected, an approved repair procedure shall be applied to the weld. Then RT shall be done for second time to show if we have achieved the acceptable size of defects.

SURFACE PREPARATION

All welded joints before radiography examination shall be subjected to 100% visually inspected. Spatter and other surface irregularities that cause difficulty in detecting defects shall be remove.

5.2 ESSENTIAL ELEMENTS OF RT

- A source of penetrating radiation, such as an X-ray machine or a radioactive isotope.
- The object to be radiographed, such as a weldment.
- A record or viewing device, usually photographic (X-ray) film enclosed in a light-tight holder.
- A qualified radiographer, trained to produce a satisfactory exposure.
- A means to process exposed film or operate other recording means.
- A person skilled in the interpretation of radiograph.
- Films shall be fine grain, high definition, high contrast film (ASTM type 2)

RADIATION SOURCE

The following Gamma-ray source shall be used:
Iridium 192.

TECHNIQUE

A single-Wall exposure technique shall be used for radiography whenever practical. When it is not practical to use a single-wall technique, a double-wall technique shall be used. An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained.

Single-wall technique
In the single-wall technique, the radiation passes through only one wall of the weld, which is viewed for acceptance on the radiograph.

Double-wall technique
When it is not practical to use a single-wall technique one of the following double-wall techniques shall be used.

Single-wall viewing
For material and for welds in components, a technique may be used in which the radiation passes through two walls and only the weld on the film side wall is viewed for acceptance on the radiograph. When complete coverage is required for circumferential welds, a minimum of three exposures taken 120 deg to each other shall be made.

Double-wall viewing
For material and for welds in components 3½ in or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld in both walls is viewed for acceptance on the same radiograph. For double-wall viewing, only a source side IQI shall be used. Care should be exercised to ensure that required geometric unsharpness is not exceeded. If the geometric unsharpness requirement cannot be met, then single-wall viewing shall be used.

For welds, the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source side and film side portions of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90 deg to each other shall be made for each joint.

As an alternate, the weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed. When complete coverage is required, a minimum of three exposures taken at either 60 deg. or 120 deg to each other shall be made for each joint.

BACK SCATTERED RADIATION
Back scattered radiation may be reduced by placing a lead screen with suitable thickness to the back of the holder. In any case a lead letter“B”(dimensions 13×6×1.6 mm) shall be attached to the back of the film holder. If a light image of letter “B” appears on a darker back ground of the radiograph, protection from back scatter is insufficient and the radiography shall be retaken providing for a stronger protection with thicker protection screen. A dark image of the “B” on a lighter background is not cause for rejection.

5.3 EQUIPMENT
All of the equipment shall be used · Gamma-ray source.
- Manual processing dark room equipment & accessories.
- Radiation survey meter.
- Related safety equipment.

5.3.1 FILM TYPE
Ready packed films, fine grain contracts fine (ASTM film type 2) strip type, with width 100 mm. It shall be free from any kind of damage and artifact.

5.3.2 IQI
IQI wire type shall be used. Wire IQI shall be determined by a set of wires conforming to the following requirements.

SELECTION OF THE IQI

MATERIAL
IQIs shall be selected from either the same alloy material group or grade or from an alloy material group or grade with less radiation absorption than the material being radio graphed.

SIZE
The designated essential wire diameter shall be selected so that code requirement is obtained. (According table T-276 ASME Sec.V, Article II) (Attachment 1)
For welds with reinforcements the thickness on which the IQI is based is the nominal single-wall thickness plus the estimated weld reinforcement by the referencing code section. For welds without reinforcement the thickness on which the IQI is based is the nominal single-wall thickness. Backing rings or strips are not to be considered as part of the weld thickness in IQI selection.

WELDS JOINING DISSIMILAR MATERIALS OR WELDS WITH DISSIMILAR FILLER METAL.
When the weld metal is of an alloy group or grade that has a radiation attenuation that differs from the base material, the IQI material selection shall be based on the weld metal and be in accordance with selection of the IQI paragraph. When the density limits of PLACEMENT OF IQI cannot be met with one IQI, and the exceptional density area(s) is at the interface of the weld metal and the base metal, the material selection for the additional IQIs shall be based on the base material and be in accordance with SELECTION OF THE IQI paragraph.

PLACEMENT OF IQI
The IQI(s) shall be placed on the source side of the part being examined.
Where inaccessibility prevents hand placing the IQI(s) on the source side, the IQI(s) shall be placed on the film side in contact with the part being examined. A lead letter “F” shall be placed adjacent to or on the IQI(s).
The IQI(s) shall be placed on the weld so that the length of the wires is perpendicular to the length of the weld.
The identification numbers and, when used, the lead letter “F,” shall not be in the area of interest, except when geometric configuration makes it impractical.

NUMBER OF IQI
When one or more film holders are used for an exposure, at least one IQI image shall appear on each radiograph except as outlined in Special Cases below.

Multiple IQIs. If the requirements of T-282 are met by using more than one IQI, one shall be representative of the lightest area of interest and the other the darkest area of interest; the intervening densities on the radiograph shall be considered as having acceptable density.

Special Cases
For cylindrical components where the source is placed on the axis of the component for a single exposure, at least three IQIs, spaced approximately 120 deg apart, are required under the following conditions:

When the complete circumference is radio graphed using one or more film holders, or; When a section or sections of the circumference, where the length between the ends of the outermost sections span 240 or more deg, is radio graphed using one or more film holders. Additional film locations may be required to obtain necessary IQI spacing.

For cylindrical components where the source is placed on the axis of the component for a single exposure, at least three IQIs, with one placed at each end of the span of the circumference radio graphed and one in the approximate center of the span, are required under the following conditions:

When a section of the circumference, the length of which is greater than 120 deg and less than 240 deg, is radio graphed using just one film holder, or; When a section or sections of the circumference, where the length between the ends of the outermost sections span less than 240 deg, is radio graphed using more than one film holder.

where sections of longitudinal welds adjoining the circumferential weld are radio graphed simultaneously with the circumferential weld, an additional IQI shall be placed on each longitudinal weld at the end of the section most remote from the junction with the circumferential weld being radio graphed.

For segments of a flat or curved (i.e., ellipsoidal, torispherical, toriconical, elliptical, etc.) component where the source is placed perpendicular to the center of a length of weld for a single exposure when using more than three film holders, at least three IQIs, one placed at each end of the radio graphed span and one in the approximate center of the span, are required.

When an array of components in a circle is radio graphed, at least one IQI shall show on each component image.

5.4 RADIOGRAPHIC DENSITY

Density Limitations
The transmitted film density through the radiographic image of the adjacent to the designated wire of a wire IQI and the area of interest shall be 2.0 minimum for single film viewing for radiographs made with a gamma ray source. The maximum density shall be 4.0.
A tolerance of 0.05 in density is allowed for variations between densitometer readings.

Density Variation
If the density of the radiograph anywhere through the area of interest varies by more than minus 15% or plus 30% from the density through the adjacent to the designated wire of a wire IQI, within the minimum/maximum allowable density ranges specified in SELECTION OF THE IQI paragraph, then an additional IQI shall be used for each exceptional area or areas and the radiograph retaken.

When calculating the allowable variation in density, the calculation may be rounded to the nearest 0.1 within the range specified in SELECTION OF THE IQI paragraph.

FILM PROCESSING

Manual film processing consist five steps as follow:

DEVELOPING

Film will be placed in hangers and immersed in developer solution with constant agitation for even development. Developing time shall be in accordance to that recommended by film manufacture. It shall normally be 5 minute at 20°C. If developer temperature varies, development time should be adjusted according to manufactures recommended time.

STOP BATH RINSE

When development is finished, the film shall be immersed in stop bath or rinsed in clean running water to stop the activity of the developer.

FIXING

After development is completed, the unexposed silver halide crystals remaining in the emulsion must be removed. This is accomplished by immersing the film in fixer solution.

Fixing time shall be at least twice the cleaning time.

WASHING

Washing shall be done with constant of clean fresh water. Rate of water flow shall be approximately 5 to 6 times the volume of water tank per hour. Filters should be used unnecessary. Minimum time is as per manufactures recommendation.

DRYING

The final processing stage is drying. Drying has an important bearing on the quality of the finished radiograph. The X-ray film shall be dried without any mechanical damage to the emulsion, and without exposing the moist emulsion to dust or dirt.

After the final water wash the film should be given a few seconds immersion in a static water rinse containing a wetting agent to promote even drying marks and reduces drying times by up to 25%. The film shall be hung up to dry in a dust-free atmosphere. Heat can be used to fasten drying when there is provision for a rapid flow of clean, dry air across the emulsion surface, as in a drying cabinet. The temperature of the air impinging on the film is governed be a thermostat that controls the dryer heater. The actual temperature of the air blowing on the film shall not vary more than +50°C set point.

5.6 QUALITY OF RADIOGRAPHS

All radiographs shall be free from mechanical, chemical or other blemishes to the extent that they do not mask and are not mask and confused with the image of any discontinuity in the area of interest of the object being radio graphed. Such blemishes include, but are not limited to:

- Fogging
- Processing defects such as streaks, watermarks, or chemical stains.
- Scratches, finger marks, crimps, dirt, static marks, or tears.
- False indication due to defective screens

IQI SENSITIVITY

Radiography shall be performed with a technique of sufficient sensitivity to display the designated wire of a wire IQI, which are essential indications of the image quality of the radiograph. The radiographs shall also display the I.Q.I identifying numbers and letters. The I.Q.I sensitivity in percent shall be calculated by formula:

I.Q.I sensitivity percent = thickness of thinness wire visible/ Specimen thicknessThe sensitivity shall not be less than %2 of the specimen thickness.

GEOMETRIC UNSHARPNESS

Geometric unsharpness of the radiograph shall be determined in accordance with the formula:

Ug = F×d /D Where:

Ug = geometric unsharpness

F = source size: the maximum projected dimension of the radiation source (or effective focal spot) in the plane perpendicular to the distance D form the weld or object being radio graphed.

D = distance from source of radiation to weld or object being radio graphed.

d = distance form object being radio graphed to the film.

Geometric unsharpness of the radiograph shall not exceed the following (according to T-274.2 ASME Sec.V, articleII)

Mat. Thk. (mm) Under 50 50 through 75 Over 75 through 100 Greater than 100 **Max Ug** 0.51 0.76 1.02 1.78

5.7 IDENTIFICATION MARK

Following information shall be included in the film as a minimum:

Identification, job no.

Material type and thickness

Welder stamp

Joint No. or (W.L. No.)

Film No.

I.Q.I. designation

Exposure date

Location marker (leaden meter or leaden word).

Fabricator name (manufacturer)

Repair & Reshooting marker (R1, R2...)

Equipment or Tower No.

Markings Sketch

The information mentioned on IQI SENSITIVITY paragraph shall be arranged as Marking Sketch (Attachment 3).

Abbreviations for Markings

Some Applicable abbreviations are as follow:

PTF: Penalty Film

EXF: Extension Film

RSH: Re Shoot Film

RTK: Retake Film

RPW: Repaired welds

RWW: Rewelded Welds

LOCATION MARK

The lead location markers, that shall be appears on the film, shall be placed on the corresponding stamping areas of the weld. Joint being radio graphed and shall be positioned as follows:

SINGLE – WALL VIEWING

- On Source Side
- Joints in flat components or longitudinal joint in cylindrical or conical components.
- Joints in curved components whose concave side is toward the source and when the source to material distance less than the inside radius the components.
- Joint in curved components, whose convex side is toward the source.
- On film side
- Joint in curved components whose concave side is toward the source and when the source to material distance is greater than the inside radius.
- Either side marker

Location markers may be placed on either the source or film side joints in curved or spherical components side is toward the source and the source to material distance equals the inside radius of the component.

DOUBLE – WALL VIEWING

In this case at least one location marker shall be placed on the outside surface adjacent to the weld (or on the material in the area of interest) for each radiograph.

5.8 FACILITIES FOR VIEWING OF RADIOGRAPHS

Viewing facilities shall provide subdued background lighting of an intensity that will not cause reflections, shadows, or glare on the radiograph that interferes with the interpretation process. Equipment used to view radiographs for interpretation shall provide a variable light source sufficient for the essential IQI hole or designated wire to be visible for the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

5.9 ACCEPTANCE CRITERIA

All radiographs For Pressure vessel shall be interpreted in accordance with the acceptance standard Of ASME, Sec VIII, Div.1. (ASME, Sec VIII, Div.1. Appendix 4 is attached to this document) (Attachment 2).

All radiographs For Pipeline shall be interpreted in accordance with the acceptance standard Of API 1104 2021 Welding of Pipeline and Related Facilities Paragraf 8 & 9.

All radiographs For Piping shall be interpreted in accordance with the acceptance standard Of ASME B31.3 2020 Process Piping Paragraf

Note: Case of spot radiographs. IF weld shows one unacceptable defect at the end of a radiograph

One or several radiographs must be re-taken to determine the exact limits of the unacceptable defect.

DEFECT REMOVAL

All discontinuities in excess to acceptance standard shall be removed by suitable means and repaired according to approved procedure.

The repaired area shall be radio graphed after repair accordance with this specification; the repeated film shall be identified with lead letter “R”.

5.10 REPORTING

All examination that mentioned above must be reported in the related forms and signed by RT qualified personnel (level II) and manufacturer authorized inspector. Those documents are maintained in archive.

5.11 RADIATION PROTECTION

All radiography performance shall be followed under the laws of Iran atomic organization.

5.12 FILM STORAGE

Un-exposed films shall be stored in accordance with ASME standard, exposed film’s of project shall be stored and in case of requirement dispatch to client.

5.13 SAFETY

Before performing radiography the personnel must be trained for using Gamma-Ray. They will be obliged to wear the dosimeter film badge.

5.14 ATTACHMENTS

ATTACHMENT 1

TABLE T-276
IQI SELECTION

Nominal Single-Wall Material Thickness Range		IQI			
		Source Side		Film Side	
in.	mm	Hole-Type Designation	Wire-Type Essential Wire	Hole-Type Designation	Wire-Type Essential Wire
Up to 0.25, incl.	Up to 6.4, incl.	12	5	10	4
Over 0.25 through 0.375	Over 6.4 through 9.5	15	6	12	5
Over 0.375 through 0.50	Over 9.5 through 12.7	17	7	15	6
Over 0.50 through 0.75	Over 12.7 through 19.0	20	8	17	7
Over 0.75 through 1.00	Over 19.0 through 25.4	25	9	20	8
Over 1.00 through 1.50	Over 25.4 through 38.1	30	10	25	9
Over 1.50 through 2.00	Over 38.1 through 50.8	35	11	30	10
Over 2.00 through 2.50	Over 50.8 through 63.5	40	12	35	11
Over 2.50 through 4.00	Over 63.5 through 101.6	50	13	40	12
Over 4.00 through 6.00	Over 101.6 through 152.4	60	14	50	13
Over 6.00 through 8.00	Over 152.4 through 203.2	80	16	60	14
Over 8.00 through 10.00	Over 203.2 through 254.0	100	17	80	16
Over 10.00 through 12.00	Over 254.0 through 304.8	120	18	100	17
Over 12.00 through 16.00	Over 304.8 through 406.4	160	20	120	18
Over 16.00 through 20.00	Over 406.4 through 508.0	200	21	160	20

ATTACHMENT 2

TABLE 4-1

Customary Units

Thickness t, in.	Maximum Size of Acceptable Rounded Indications, in.		Maximum Size of Nonrelevant Indication, in.
	Random	Isolated	
Less than $\frac{1}{8}$	$\frac{1}{4}t$	$\frac{3}{4}t$	$\frac{3}{10}t$
$\frac{1}{8}$	0.031	0.042	0.015
$\frac{5}{32}$	0.047	0.063	0.015
$\frac{1}{4}$	0.063	0.083	0.015
$\frac{5}{16}$	0.078	0.104	0.031
$\frac{3}{8}$	0.094	0.125	0.031
$\frac{7}{16}$	0.109	0.146	0.031
$\frac{1}{2}$	0.125	0.166	0.031
$\frac{9}{16}$	0.142	0.188	0.031
$\frac{5}{8}$	0.156	0.210	0.031
$\frac{11}{16}$	0.156	0.230	0.031
$\frac{3}{4}$ to 2, incl.	0.156	0.250	0.031
Over 2	0.156	0.375	0.063

SI Units

Thickness t, mm	Maximum Size of Acceptable Rounded Indications, mm		Maximum Size of Nonrelevant Indication, mm
	Random	Isolated	
Less than 3	$\frac{1}{4}t$	$\frac{3}{4}t$	$\frac{3}{10}t$
3	0.79	1.07	0.38
5	1.19	1.60	0.38
6	1.60	2.11	0.38
8	1.98	2.64	0.79
10	2.51	3.18	0.79
11	2.77	3.71	0.79
13	3.18	4.27	0.79
14	3.61	4.78	0.79
16	3.96	5.33	0.79
17	3.96	5.84	0.79
19.0 to 50, incl.	3.96	6.35	0.79
Over 50	3.96	9.53	1.60

GENERAL NOTE: This Table contains examples only.

be permitted in welds less than 6 in. (150 mm) in length.

(b) Clustered Indications. The illustrations for clustered indications show up to four times as many indications in a local area, as that shown in the illustrations for random indications. The length of an acceptable cluster shall not exceed the lesser of 1 in. (25 mm) or $2t$. Where more than one cluster is present, the sum of the lengths of the clusters shall not exceed 1 in. (25 mm) in a 6 in. (150 mm) length weld.

پیوست 1 حدود پذیرش بازرسی جوش بر اساس استانداردهای ASME Sec VIII و API 650

1-محدوده پذیرش :

اثرات ناشی از ناپیوستگی ها مطابق محدوده زیر تفسیر و ارزیابی میشوند.

1-1- هرگونه عیب ترک ، عدم نفوذ و عدم ذوب مجاز نمی باشد .

1-2- حداکثر طول مجاز هرگونه اثر کشیده :

-برای قطعات تا ضخامت ۱۹ میلیمتر حداکثر ۶ میلیمتر
-برای قطعات از ضخامت ۱۹ تا ۵۷ میلیمتر حداکثر یک سوم ضخامت
-برای قطعات با ضخامت بیشتر از ۵۷ میلیمتر حداکثر ۱۹ میلیمتر

1-3- هر گروه از علائم طولی که در یک راستا باشند، مجموع طول آنها نباید از ضخامت قطعه بیشتر باشد (در هر طول جوشی معادل ۱۲ برابر ضخامت) مگر اینکه فاصله بین آنها بیشتر از ۶ برابر طول بزرگترین عیب کشیده باشد.

1-4- حداکثر طول مجاز هرگونه اثر گرد :

-حداکثر اندازهٔ مجاز برابر یک اثر گرد برابر یک چهارم ضخامت یا ۴ میلیمتر می باشد (هر کدام که کمتر است)
-در صورتیکه علائم گرد بصورت منفرد باشد (حداقل ۲۵ میلیمتر با علائم دیگر فاصله داشته باشد) حداکثر اندازه مجاز علائم گرد منفرد یک سوم ضخامت یا ۶ میلیمتر می باشد. (هر کدام که کمتر است)
-حداکثر اندازهٔ مجاز علائم منفرد برای ضخامت بیشتر از ۲۵ میلیمتر برابر ۱۰ میلیمتر می باشد.

1-5- حداکثر طول مجاز هرگونه اثر گرد ردیفی:

-بدنبال قرار گرفتن چهار عیب گرد و یا بیشتر بصورتیکه دو علامت بیرونی مجموعه بر روی خطی موازی محور طولی جوش قرار گرفته باشند.)
- مجموع ابعاد این علائم نبایستی از اندازهٔ ضخامت در هر طول جوشی معادل ۱۲ برابر ضخامت بیشتر باشد.
- حداقل فاصله بین هر کدام از گروه علائم ردیفی می بایست ۳ برابر اندازهٔ بزرگترین گروه مجاور باشد.

1-6- حداکثر طول مجاز هرگونه اثر خوشه ای:

- تصاویر علائم خوشه ای شکل، چهار برابر تصویر علائم اتفاقی در یک محل می باشد.
- طول عیب های خوشه ای نباید از ۲۵ میلیمتر یا ۲ برابر ضخامت بیشتر باشد (هرکدام کمتر است).
- در صورت وجود بیش از یک مجموعه علائم خوشه ای مجموع طول آنها نباید از بیشتر از ۲۵ میلیمتر در هر ۱۵۲ میلیمتر طول جوش باشد

RT Acceptance criteria according to ASME B31.3 2020

(18)

Table 341.3.2 Acceptance Criteria for Welds — Visual and Radiographic Examination

Criteria (A to M) for Types of Welds and for Service Conditions [Note (1)]											Examination Methods	
Normal and Category M Fluid Service			Severe Cyclic Conditions			Category D Fluid Service						
Girth, Miter Groove, and Branch Connection Welds [Note (2)]	Longitudinal Groove Weld [Note (3)]	Fillet Weld [Note (4)]	Girth, Miter Groove, and Branch Connection Welds [Note (2)]	Longitudinal Groove Weld [Note (3)]	Fillet Weld [Note (4)]	Girth and Miter Groove Welds	Longitudinal Groove Weld [Note (3)]	Fillet Weld [Note (4)]	Branch Connection Weld [Note (2)]	Weld Imperfection	Visual	Radiography
A	A	A	A	A	A	A	A	A	A	Crack	✓	✓
A	A	A	A	A	A	C	A	N/A	A	Lack of fusion	✓	✓
B	A	N/A	A	A	N/A	C	A	N/A	B	Incomplete penetration	✓	✓
E	E	N/A	D	D	N/A	N/A	N/A	N/A	N/A	Rounded Indications	...	✓
G	G	N/A	F	F	N/A	N/A	N/A	N/A	N/A	Linear indications	...	✓
H	A	H	A	A	A	I	A	H	H	Undercutting	✓	✓
A	A	A	A	A	A	A	A	A	A	Surface porosity or exposed slag inclusion [Note (5)]	✓	...
N/A	N/A	N/A	J	J	J	N/A	N/A	N/A	N/A	Surface finish	✓	...
K	K	N/A	K	K	N/A	K	K	N/A	K	Concave surface, concave root, or burn-through	✓	✓
L	L	L	L	L	L	M	M	M	M	Weld reinforcement or internal protrusion	✓	...

GENERAL NOTES:
(a) Weld imperfections are evaluated by one or more of the types of examination methods given, as specified in paras. 341.4.1, 341.4.2, 341.4.3, and M341.4, or by the engineering design.
(b) "N/A" indicates the Code does not establish acceptance criteria or does not require evaluation of this kind of imperfection for this type of weld.
(c) Check (✓) indicates examination method generally used for evaluating this kind of weld imperfection.
(d) Ellipsis (...) indicates examination method not generally used for evaluating this kind of weld imperfection.

NOTES:
(1) Criteria given are for required examination. More-stringent criteria may be specified in the engineering design. See also paras. 341.5 and 341.5.3.
(2) Branch connection weld includes pressure containing welds in branches and fabricated laps.
(3) Longitudinal groove weld includes straight and spiral (helical) seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1, Table A-1M, or Table 326.1. Alternative Leak Test requires examination of these welds; see para. 345.9.
(4) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports.
(5) These imperfections are evaluated only for welds ≤5 mm ($^3/_{16}$ in.) in nominal thickness.

(18)

Criterion Value Notes for Table 341.3.2

Criterion Symbol	Criterion Measure	Acceptable Value Limits [Note (1)]	
A	Extent of imperfection	Zero (no evident imperfection)	
B	Cumulative length of incomplete penetration	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less	
C	Cumulative length of lack of fusion and incomplete penetration	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less	
D	Size and distribution of rounded indications	See ASME BPVC, Section VIII, Division 1, Appendix 4 [Note (2)]	
E	Size and distribution of rounded indications	For $T_w \le 6$ mm (¼ in.), limit is same as D [Note (2)] For $T_w > 6$ mm (¼ in.), limit is 1.5 × D [Note (2)]	
F	Linear indications		
	Individual length	$\le T_w/3$	
	Individual width	≤2.5 mm (3/32 in.) and $\le T_w/3$	
	Cumulative length	$\le T_w$ in any 12 T_w weld length [Note (2)]	
G	Linear indications		
	Individual length	$\le 2T_w$	
	Individual width	≤3 mm (⅛ in.) and $\le T_w/2$	
	Cumulative length	$\le 4T_w$ in any 150 mm (6 in.) weld length [Note (2)]	
H	Depth of undercut	≤1 mm (1/32 in.) and $\le T_w/4$	
	Cumulative length of internal and external undercut	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less	
I	Depth of undercut	≤1.5 mm (1/16 in.) and $\le [T_w/4$ or 1 mm (1/32 in.)]	
	Cumulative length of internal and external undercut	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less	
J	Surface roughness	≤12.5 μm (500 μin.) R_a in accordance with ASME B46.1	
K	Depth of surface concavity, root concavity, or burn-through	Total joint thickness, including weld reinforcement, $\ge T_w$ [Notes (3) and (4)]	
L	Height of reinforcement or internal protrusion [Note (5)] in any plane through the weld shall be within limits of the applicable height value in the tabulation at right, except as provided in Note (6). Weld metal shall merge smoothly into the component surfaces.	For T_w, mm (in.)	Height, mm (in.)
		≤6 (¼)	≤1.5 (1/16)
		>6 (¼), ≤13 (½)	≤3 (⅛)
		>13 (½), ≤25 (1)	≤4 (5/32)
		>25 (1)	≤5 (3/16)
M	Height of reinforcement or internal protrusion [Note (5)] as described in L. Note (6) does not apply.	Limit is twice the value applicable for L above	

NOTES:

(1) Where two limiting values are separated by "and," the lesser of the values determines acceptance. Where two sets of values are separated by "or," the larger value is acceptable. T_w is the nominal wall thickness of the thinner of two components joined by a butt weld.

Criterion Value Notes for Table 341.3.2 (Cont'd)

NOTES: (Cont'd)

(2) Porosity and inclusions such as slag or tungsten are defined as rounded indications where the maximum length is three times the width or less. These indications may be circular, elliptical, or irregular in shape; may have tails; and may vary in density. Indications where the length is greater than three times the width are defined as linear indications and may also be slag, porosity, or tungsten.

(3) For circumferential groove welded joints in pipe, tube, and headers made entirely without the addition of filler metal, external concavity shall not exceed the lesser of 1 mm (1/32 in.) or 10% of the joint nominal thickness. The contour of the concavity shall blend smoothly with the base metal. The total joint thickness, including any reinforcement, shall not be less than the minimum wall thickness, t_m.

(4) For radiography, acceptability may be determined by comparing the density of the image through the affected area to the density through the adjacent base metal (T_w). If digital radiography is used, brightness comparison may be utilized. A density or brightness darker than the adjacent base metal is cause for rejection.

(5) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat, Figure 328.5.2A; internal protrusion does not apply.

(6) For welds in aluminum alloy only, internal protrusion shall not exceed the following values:
(a) 1.5 mm (1/16 in.) for thickness ≤2 mm (5/64 in.)
(b) 2.5 mm (3/32 in.) for thickness >2 mm and ≤6 mm (¼ in.)
For external reinforcement and for greater thicknesses, see the tabulation for symbol L.

RT Acceptance criteria according to AWS D1.1-2020

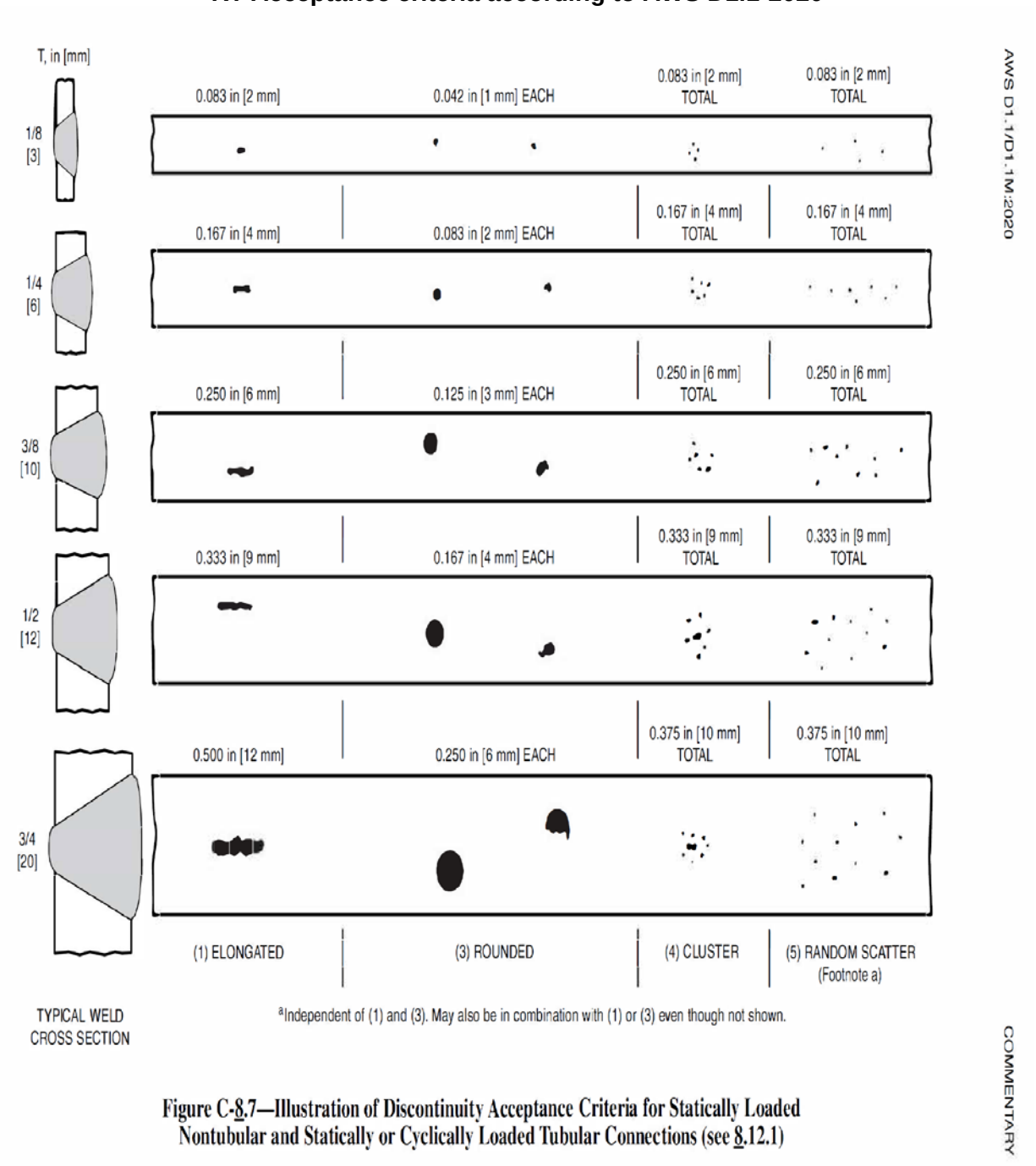
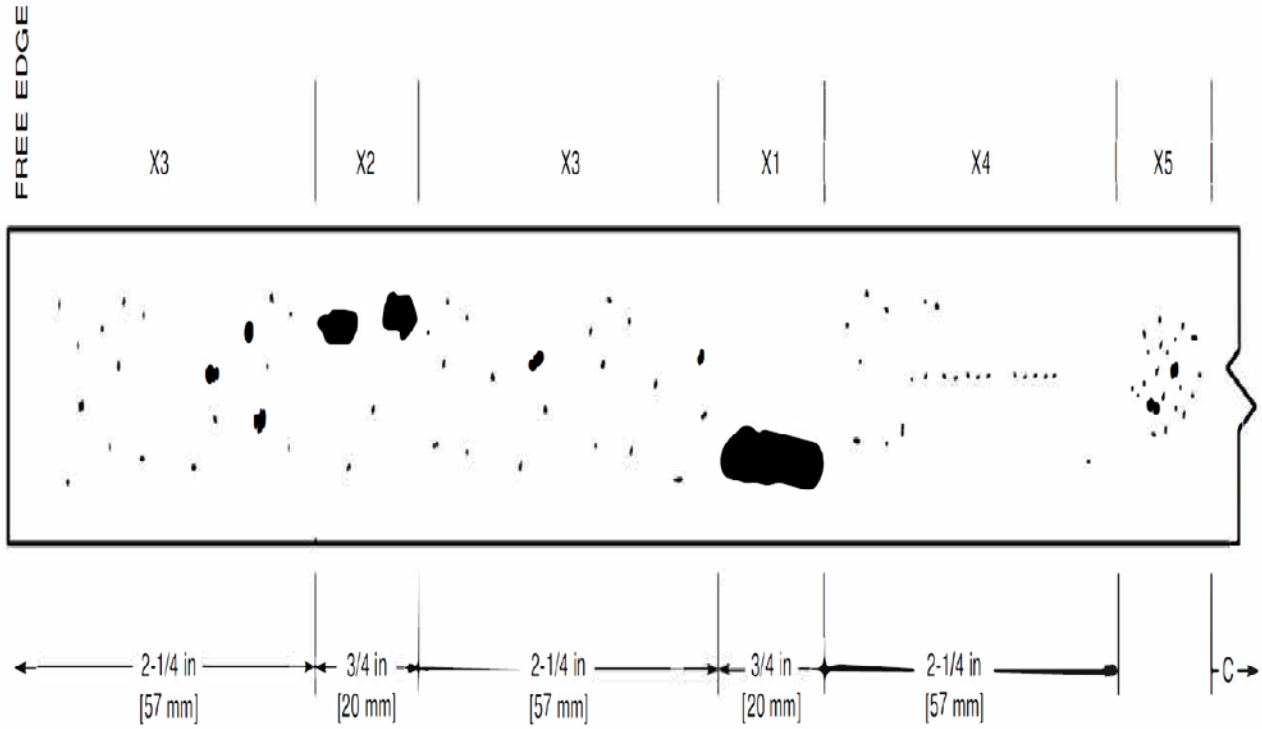


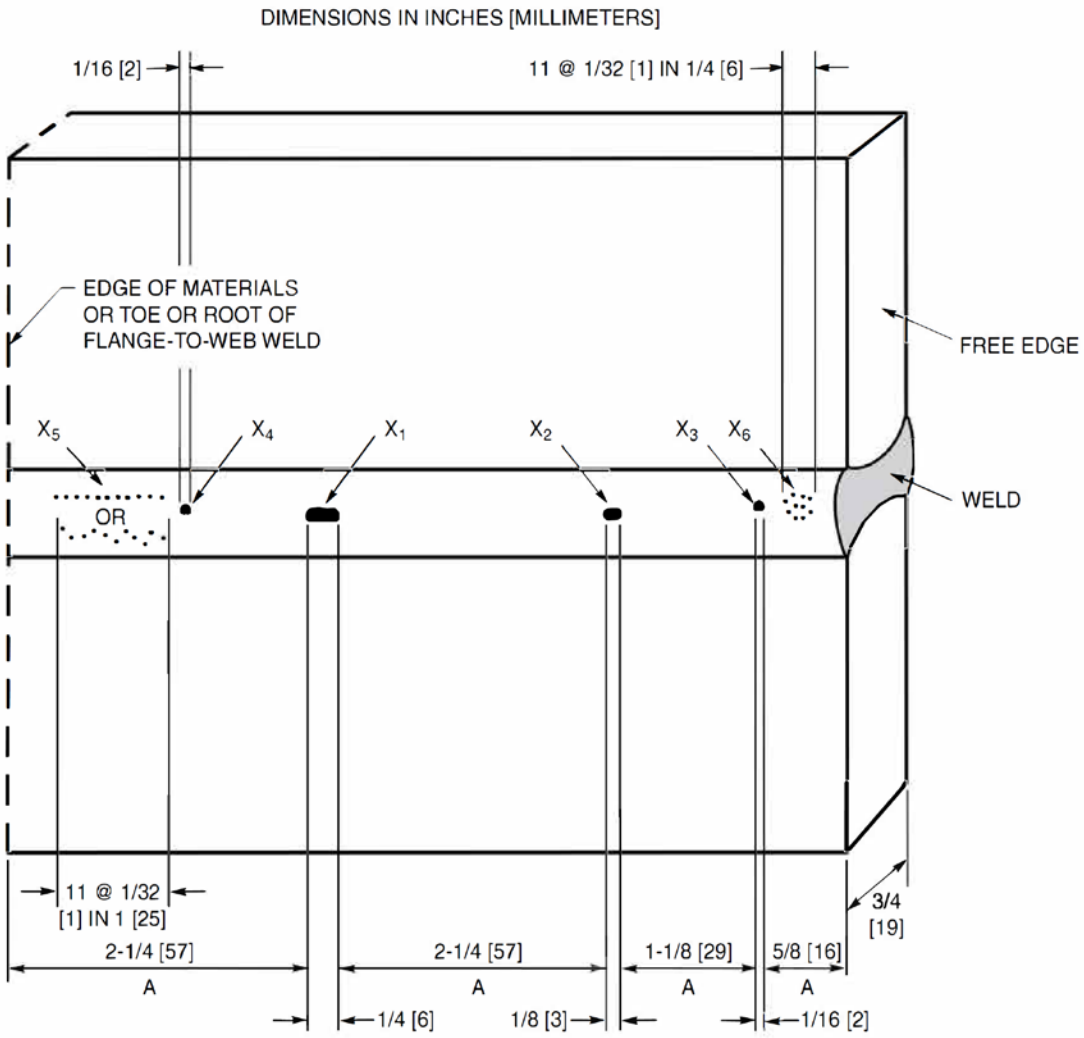
Figure C-8.7—Illustration of Discontinuity Acceptance Criteria for Statically Loaded Nontubular and Statically or Cyclically Loaded Tubular Connections (see 8.12.1)



Notes:

1. C—Minimum clearance allowed between edges of discontinuities 3/32 in [2.5 mm] or larger (per Figure 8.1). Larger of adjacent discontinuities governs.
2. X1—Largest permissible elongated discontinuity for 1-1/8 in [30 mm] joint thickness (see Figure 8.1).
3. X2—Multiple discontinuities within a length allowed by Figure 8.1 may be handled as a single discontinuity.
4. X3-X4—Rounded-type discontinuity less than 3/32 in [2.5 mm].
5. X5—Rounded-type discontinuities in a cluster. Such a cluster having a maximum of 3/4 in [20 mm] for all pores in the cluster is treated as requiring the same clearance as a 3/4 in [20 mm] long discontinuity of Figure 8.1.
6. Interpretation: Rounded and elongated discontinuities are acceptable as shown. All are within the size limits and the minimum clearance allowed between discontinuities or the end of a weld joint.

Figure C-8.8—Illustration of Discontinuity Acceptance Criteria for Statically Loaded Nontubular and Statically or Cyclically Loaded Tubular Connections 1-1/8 in [30 mm] and Greater, Typical of Random Acceptable Discontinuities (see 8.12.1)



Notes:

1. A—Minimum clearance allowed between edges of porosity or fusion-type discontinuities 1/16 in [2 mm] or larger. Larger of adjacent discontinuities governs.
2. X1—Largest allowable porosity or fusion-type discontinuity for 3/4 in [20 mm] joint thickness (see Figure 8.2).
3. X_2, X_3, X_4—Porosity or fusion-type discontinuity 1/16 in [2 mm] or larger, but less than maximum allowable for 3/4 in [20 mm] joint thickness.
4. X_5, X_6—Porosity or fusion-type discontinuity less than 1/16 in [2 mm].
5. Porosity or fusion-type discontinuity X4 is not acceptable because it is within the minimum clearance allowed between edges of such discontinuities (see 8.12.2.1 and Figure 8.2). Remainder of weld is acceptable.
6. Discontinuity size indicated is assumed to be its greatest dimension.

Figure C-8.9—Illustration of Discontinuity Acceptance Criteria for Cyclically Loaded Nontubular Connections in Tension (see 8.12.2.1)

RT Acceptance criteria according to API 1104-2020

API 1104 - Butt Weld RT/Visual Workmanship Defect Acceptance Criteria	
Indication	Acceptance Criteria · Length or Dimension Allowed
Inadequate Penetration (IP)	Without high-low: individual Of cumulative 25mm In 300mm weld or 8% <300mm weld With high-low: Individual 50 mm, cumulative 75 mm in any 300 mm of weld
Fusion (IF)	Individual 50 mm, cumulative 150 mm in any 300 mm of weld or 8% < 300 mm welds
Internal Concavity (IC)	Any, if density > thinnest adjacent WT. If < burn-through criteria applies
Burn-through (BT)	< 60.3 OD, 1 indication 6 mm and density > adjacent WT ≥ 60.3 OD, same with cumulative 12 mm in 300 mm of weld
Internal Undercut (IUC)	Cumulative 1/6 weld or 50 mm in 300 mm weld
Hollow Bead Porosity (HB)	Individual12 mm or 6 mm when separation < 50 mm, cumulative 50 mm or 8% weld
Porosity (P)	Individual/scattered - 3.2 mm or 25% Thk.; Dist. per Figure below. Cluster-Individual > 1.6 mm or Dia. > 12 mm; cumulative > 12 mm in 300 mm weld
Elongated or Isolated Slag Inclusions (ESI or ISI)	Elongated < 60.3 mm OD- 3xWT, width > 1.6 mm, cumulative 8% WT Elongated ≥ 60.3 mm OD- 2 in, width > 1.6 mm, cumulative 8% WT Isolated < 60.3 mm 0D - cumulative 2xWT, width > 0.5x WT or > 8% weld Isolated ≥ 60.3 mm 0D - > 3.2 mm width or > 4 at 3.2 mm width in 12 in. weld or cumulative 8% WT
Cracks (CR)	Zero
Arc Burns (AB)	API disposition by repair or removal at Company discretion
Weld Crown (Reinforcement)	Min. outside surface of base metal; Max. 1.6 mm
Accumulation of Imperfections	50 mm in 300 mm weld or > 8% of weld length
Definition: Thk. = thickness WT= wall thickness	

9.3 Radiographic Testing

NOTE All densities referred to in 9.3.1 through 9.3.13 are based on negative images.

9.3.1 Inadequate Penetration Without High-low (IP)

IP is defined as the incomplete filling of the weld root. This condition is shown schematically in Figure 13. IP shall be considered a defect should any of the following conditions exist:

a) the length of an individual indication of IP exceeds 1 in. (25 mm),

b) the aggregate length of indications of IP in any continuous 12 in. (300 mm) length of weld exceeds 1 in. (25 mm),

c) the aggregate length of indications of IP exceeds 8 % of the weld length in any weld less than 12 in. (300 mm) in length.

NOTE One or both root faces may be inadequately filled at the inside surface.

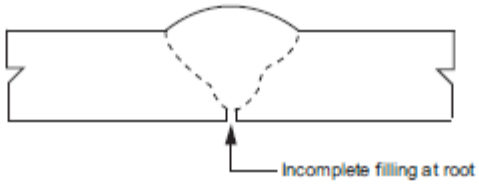


Figure 13—Inadequate Penetration Without High-low

9.3.2 Inadequate Penetration Due to High-low (IPD)

IPD is defined as the condition that exists when one edge of the root is exposed (or unbonded) because adjacent pipe or fitting joints are misaligned. This condition is shown schematically in Figure 14. IPD shall be considered a defect should any of the following conditions exist:

a) the length of an individual indication of IPD exceeds 2 in. (50 mm),

b) the aggregate length of indications of IPD in any continuous 12 in. (300 mm) length of weld exceeds 3 in. (75 mm).

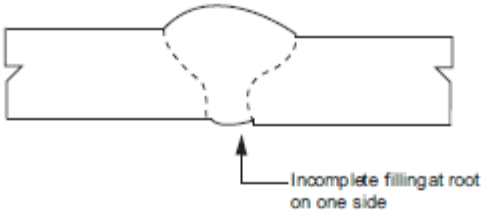


Figure 14—Inadequate Penetration Due to High-low

9.3.3 Inadequate Cross Penetration (ICP)

ICP is defined as a subsurface imperfection between the first inside pass and the first outside pass that is caused by inadequately penetrating the vertical land faces. This condition is shown schematically in Figure 15. ICP shall be considered a defect should any of the following conditions exist:

a) the length of an individual indication of ICP exceeds 2 in. (50 mm),

b) the aggregate length of indications of ICP in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).

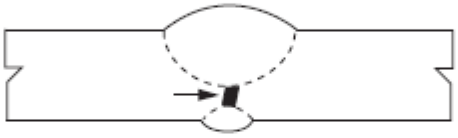


Figure 15—Inadequate Cross Penetration

9.3.4 Incomplete Fusion (IF)

IF is defined as a surface imperfection between the weld metal and the base material that is open to the surface. This condition is shown schematically in Figure 16. IF shall be considered a defect should any of the following conditions exist:

a) the length of an individual indication of IF exceeds 1 in. (25 mm),

b) the aggregate length of indications of IF in any continuous 12 in. (300 mm) length of weld exceeds 1 in. (25 mm),

c) the aggregate length of indications of IF exceeds 8 % of the weld length in any weld less than 12 in. (300 mm) in length.

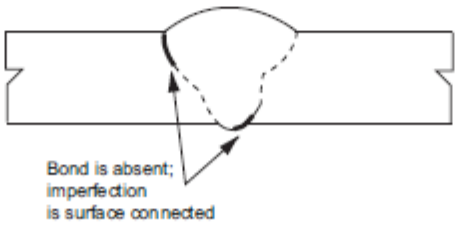


Figure 16—Incomplete Fusion at Root of Bead or Top of Joint

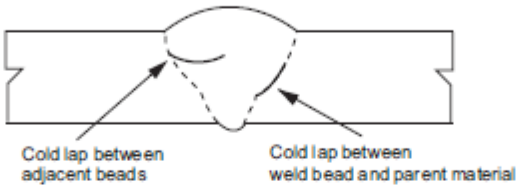
9.3.5 Incomplete Fusion Due to Cold Lap (IFD)

IFD is defined as an imperfection between two adjacent weld beads or between the weld metal and the base metal that is not open to the surface. This condition is shown schematically in Figure 17. IFD shall be considered a defect should any of the following conditions exist:

a) the length of an individual indication of IFD exceeds 2 in. (50 mm),

b) the aggregate length of indications of IFD in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm),

c) the aggregate length of indications of IFD exceeds 8 % of the weld length.



NOTE The cold lap shown is not surface connected.

Figure 17—Incomplete Fusion Due to Cold Lap

9.3.6 Internal Concavity (IC)

IC is defined in 3.1.13 and is shown schematically in Figure 18. Any length of IC is acceptable, provided the density of the radiographic image of the IC does not exceed that of the thinnest adjacent parent material. For areas that exceed the density of the thinnest adjacent parent material, the criteria for BT (see 9.3.7) are applicable.

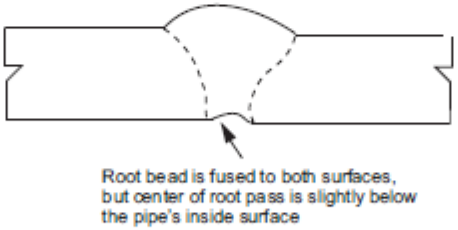


Figure 18—Internal Concavity

9.3.7 Burn-through (BT)

9.3.7.1 General

A BT is defined as a portion of the root bead where excessive penetration has caused the weld puddle to be blown into the pipe.

9.3.7.2 Large Diameter Pipe

For pipe with a specified OD greater than or equal to 2.375 in. (60.3 mm), a BT shall be considered a defect should any of the following conditions exist:

a) the maximum dimension exceeds 1/4 in. (6 mm) and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material;

b) the maximum dimension exceeds the thinner of the specified wall thicknesses joined and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material;

c) the sum of the maximum dimensions of separate BTs whose image density for any portion of the BTs exceeds that of the thinnest adjacent parent material and exceeds 1/2 in. (13 mm) in any continuous 12 in. (300 mm) length of weld or the total weld length, whichever is less.

9.3.7.3 Small Diameter Pipe

For pipe with a specified OD less than 2.375 in. (60.3 mm), a BT shall be considered a defect when any of the following conditions exists:

a) the maximum dimension exceeds 1/4 in. (6 mm) and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material;

b) the maximum dimension exceeds the thinner of the specified wall thicknesses joined and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material;

c) more than one BT of any size is present and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material.

9.3.8 Slag Inclusions

9.3.8.1 General

A slag inclusion is defined as a nonmetallic solid entrapped in the weld metal or between the weld metal and the parent material. Elongated slag inclusions (ESIs)—for example, continuous or broken slag lines or wagon tracks—are usually found at the fusion zone. Isolated slag inclusions (ISIs) are irregularly shaped and may be located anywhere in the weld. For evaluation purposes, when the size of a radiographic indication of slag is measured, the indication's maximum dimension shall be considered its length.

9.3.8.2 Large Diameter Pipe

For pipe with a specified OD greater than or equal to 2.375 in. (60.3 mm), slag inclusions shall be considered a defect should any of the following conditions exist:

a) the length of an ESI indication exceeds 2 in. (50 mm),

NOTE Parallel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single indication unless the width of either of them exceeds 1/32 in. (0.8 mm). In that event, they shall be considered separate indications.

b) the aggregate length of ESI indications in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm),

c) the width of an ESI indication exceeds 1/16 in. (1.6 mm),

d) the aggregate length of ISI indications in any continuous 12 in. (300 mm) length of weld exceeds 1/2 in. (13 mm),

e) the width of an ISI indication exceeds 1/8 in. (3 mm),

f) more than four ISI indications with the maximum width of 1/8 in. (3 mm) are present in any continuous 12 in. (300 mm) length of weld,

g) the aggregate length of ESI and ISI indications exceeds 8 % of the weld length.

9.3.8.3 Small Diameter Pipe

For pipe with a specified OD less than 2.375 in. (60.3 mm), slag inclusions shall be considered a defect should any of the following conditions exist:

a) the length of an ESI indication exceeds three times the thinner of the specified wall thicknesses joined,

NOTE Parallel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single indication unless the width of either of them exceeds 1/32 in. (0.8 mm). In that event, they shall be considered separate indications.

b) the width of an ESI indication exceeds 1/16 in. (1.6 mm),

c) the aggregate length of ISI indications exceeds two times the thinner of the specified wall thicknesses joined and the width exceeds one-half the thinner of the specified wall thicknesses joined,

d) the aggregate length of ESI and ISI indications exceeds 8 % of the weld length.

9.3.9 Porosity

9.3.9.1 General

Porosity is defined as gas trapped by solidifying weld metal before the gas has a chance to rise to the surface of the molten puddle and escape. Porosity is generally spherical but may be elongated or irregular in shape, such as piping (wormhole) porosity. When the size of the radiographic indication produced by a pore is measured, the maximum dimension of the indication shall apply to the criteria given in 9.3.9.2 through 9.3.9.4.

9.3.9.2 Individual or Scattered Porosity

Individual or scattered porosity shall be considered a defect should any of the following conditions exist:

a) the size of an individual pore exceeds 1/8 in. (3 mm) in diameter or 25 % of the specified wall thickness, whichever is less;

b) the size of an individual pore exceeds 25 % of the thinner of the specified wall thicknesses joined, but no more than 1/8 in. (3 mm) in diameter;

c) the distribution of scattered porosity exceeds the concentration permitted by Figure 19 or Figure 20.

9.3.9.3 Cluster Porosity (CP)

CP that occurs in any pass except the finish pass shall comply with the criteria of 9.3.9.2. CP that occurs in the finish pass shall be considered a defect should any of the following conditions exist:

a) the diameter of the cluster exceeds 1/2 in. (13 mm);

b) the aggregate length of CP in any continuous 12 in. (300 mm) length of weld exceeds 1/2 in. (13 mm).

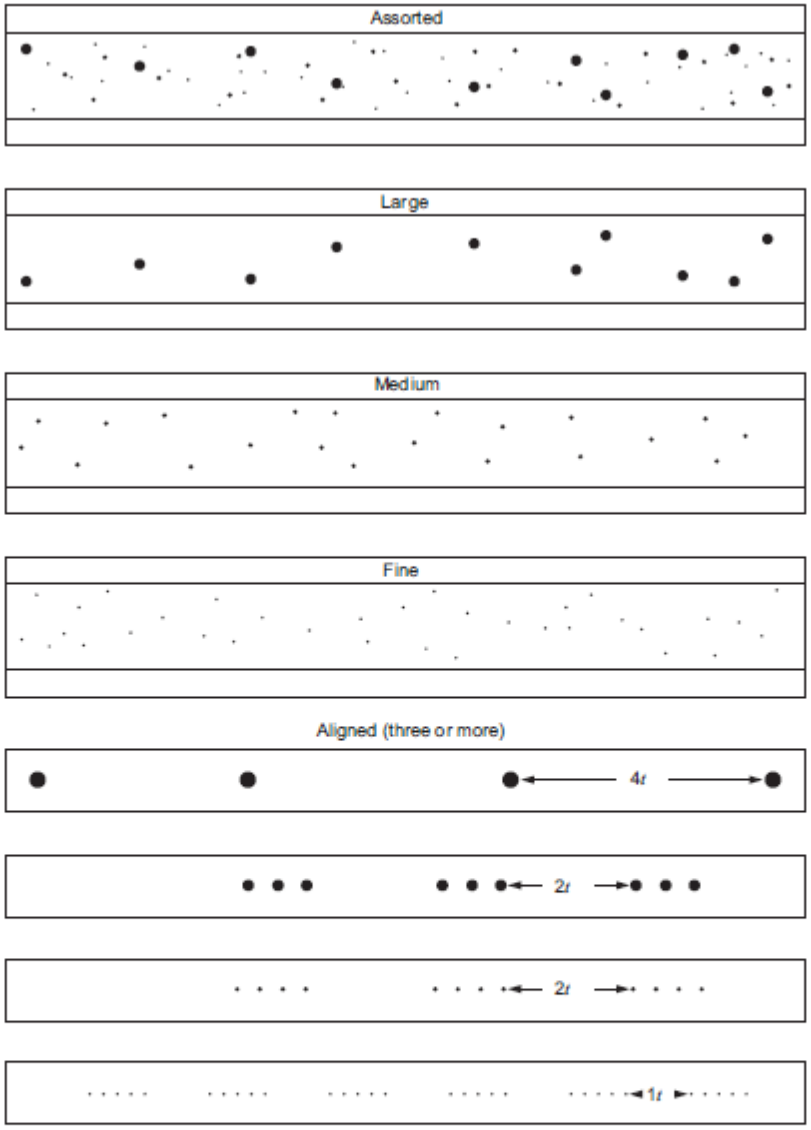


Figure 19—Maximum Distribution of Gas Pockets: Wall Thickness (*t*) Less Than or Equal to 0.500 in. (12.7 mm)

9.3.9.4 Hollow Bead (HB) Porosity

Hollow bead porosity is defined as elongated linear porosity that occurs in the root pass. HB shall be considered a defect should any of the following conditions exist:

a) the length of an individual indication of HB exceeds 1/2 in. (13 mm);

b) the aggregate length of indications of HB in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm);

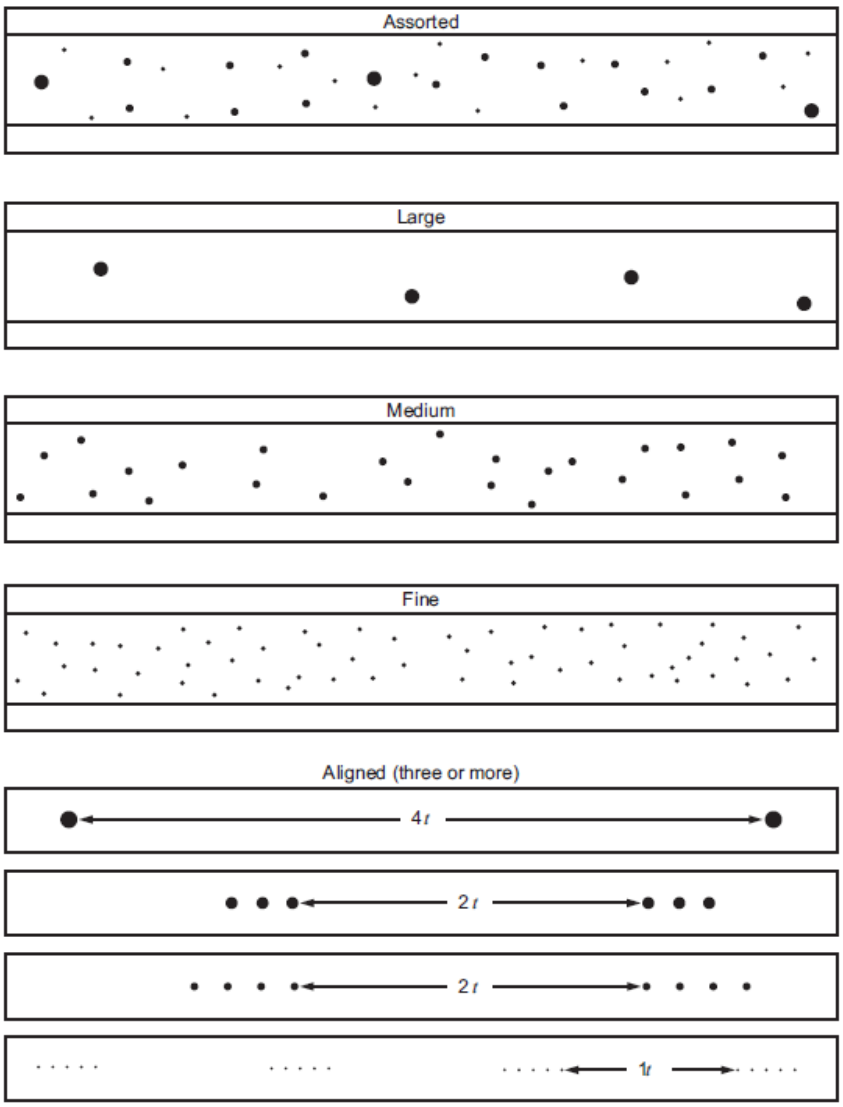


Figure 20—Maximum Distribution of Gas Pockets: Wall Thickness (*t*) Greater Than 0.500 in. (12.7 mm)

c) individual indications of HB, each greater than 1/4 in. (6 mm) in length, are separated by less than 2 in. (50 mm);

d) the aggregate length of all indications of HB exceeds 8 % of the weld length.

9.3.10 Cracks

Cracks shall be considered a defect should any of the following conditions exists:

a) the crack, of any size or location in the weld, is not a shallow crater crack or star crack;

b) the crack is a shallow crater crack or star crack with a length that exceeds 5/32 in. (4 mm).

NOTE Shallow crater cracks or star cracks are located at the stopping point of weld beads and are the result of weld metal contractions during solidification.

9.3.11 Undercutting

Undercutting is defined as a groove melted into the parent material adjacent to the toe or root of the weld and left unfilled by weld metal. Undercutting adjacent to the cover pass (EU) or undercutting adjacent to root pass (IU) shall be considered a defect should any of the following conditions exists:

a) the aggregate length of indications of EU and IU, in any combination, in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm);

b) the aggregate length of indications of EU and IU, in any combination, exceeds one-sixth of the weld length.

NOTE See 9.7 for acceptance standards for undercutting when visual and mechanical measurements are employed.

9.3.12 Accumulation of Imperfections

Excluding incomplete penetration due to high-low and undercutting, any accumulation of imperfections shall be considered a defect should any of the following conditions exist:

a) the aggregate length of indications in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm),

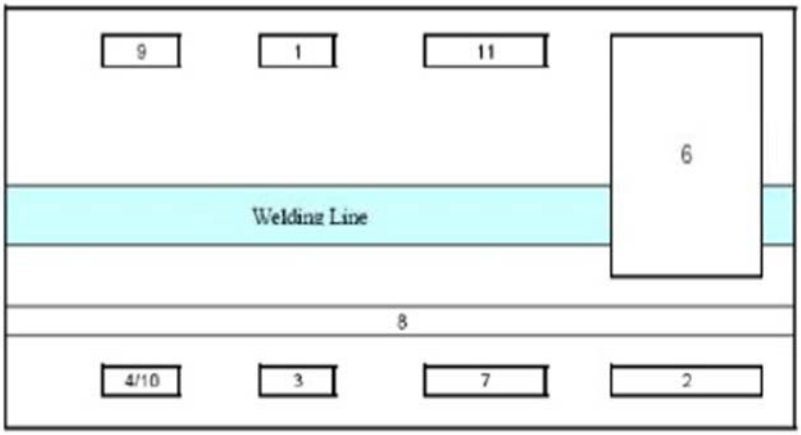
b) the aggregate length of indications exceeds 8 % of the weld length.

9.3.13 Base Material Imperfections

Imperfections in the base material detected by radiographic testing shall be reported to the company. The disposition of these imperfections shall be as directed by the company.

Attachment 3 - Markings Sketch

(Related to 18.2)



Following information shall be included in the film as a minimum :

1. Identification , job no.
2. Material type and thickness
3. Welder stamp
4. Joint No. or (Wl No .)
5. Film no.
6. IQI designation
7. Exposure data
8. Location marker (leaden meter or leaden word).
9. Fabricator name (manufacture)
10. Repair & reshooting marker (R1,R2,....)
11. Equipment or Tower No .:

Radiographic Test Report

Request No.	Examination Date :	Inspection Procedure No.	Report No.
Client:	Contractor:	Project:	Location:
Component Code:	Parent Material:		Acceptance criteria reference :

Test Condition

Joint design: Tee○ Lap○ Butt○ Corrner○ Edge○ Other○		Welding Process:
		Performance Std:
I.Q.I :	Visible IQI :	Test length:

Procedure:

Source type:	Source size:	Source strength:	SFD:	U_g :
EXP. Time:	Tech:	Film Type:	Density:	Sensitivity:

No	Weld Id	Thickness (mm)		Film No	Tested length (cm)	Film Size (cm)	Discontinuity & Evaluation			Result			
		1	2				Location						
							X (mm)	Y (mm)	Length (mm)	Defect	Accept	Repair	Accept After Repair
1													
2													
3													
4													
5													

Explanation:

Sketch:

Weld Identification:
BP: Bottom Plate, TP: Top Plate, BC: Box Corner, WF: Web fo Flange, SP: Splice Plate, CP:Cover Plate, S:Stiffener, CB: Column to Base Plate, GP:Gusset Plate, LW: longitudinal weld CW: circular weld

Type of weld defect :
UC: under cut **CP: cluster porosity** **SL: slag line.isolated** **LOF: lack of fusion** **TI: Tungesten inclusion**
LOP: lack of penetration **PO: porosity** **CR: crack** **EP: excess penetration** **RC: root concavity**

Name & Sign of Inspector: Date:	Name & Sign of corrector: Date:	Name & Sign of Client: Date:

6. ULTRASONIC TESTING (UT)

6.1 SURFACE PREPARATION

Base Metal

The base metal on the each side of weld shall be free of weld spatter, surface irregularities, or foreign matter that might interfere with the ultrasonic wave transmission.

Surface Condition:

All surfaces shall be clean and free of scale, dirt, or other foreign material that could interfere with interpretation of test results. The methods used for cleaning and preparing the surfaces for inspection shall not be detrimental to the base metal or the surface finish. If needed, surfaces may be ground, sanded, wire brushed, scraped or otherwise prepared for examining purposes. Excessive surface roughness or scratches can produce signal that interfere with the test.

Weld Metal

The weld surface may be in as welded condition. Where the weld surface interferes with the examination, the weld shall be conditioned as needed to permit examination.

Surface preparation for Butt-weld joint with thickness up to 80mm.

- The finished weld surface and adjacent area for a as required width on one side of plate and surface be adequately smoothed in order to obtain a sufficient coupling with the search unit.
- The weld surface may be as welded condition if the coupling with the search unit is assured.

Surface preparation for Butt-weld joint with thickness over 80mm.

- The finished weld surface and adjacent area for as required width on both sides of plate and surfaces shall be adequately smoothed in order to obtain a sufficient coupling with the search unit.
- The weld surface may be as welded condition if the coupling with the search unit is assured.
- When the examination of the weld joint is impractical from both surfaces, the surface preparation shall be according to par weld metal (Up).

Nozzle welds SET-IN and SET-ON

The weld surfaces shall be conditioned as required.

Examination Coverage:

Each pass of the search shall overlap a minimum 10% of the transducer dimension perpendicular to the direction of scanning.

6.2 EQUIPMENT

FLAW DETECTOR

Pulse-echo, A scan presentation type Ultrasonic equipment shall be used. All equipments shall be equipped with gain or attenuation control.

The equipment shall be capable of generating at test frequency within the range 2 MHZ to 4 MHZ and equipped with a stepped gain control calibration in units of 2.0 DB or less.

The equipment used shall be calibration at least 3 months for linear vertical presentation (screen height linearity) and amplitude control linearity and recorded.

SEARCH UNITS

Frequency

This examination shall be conducted with a pulse – echo ultrasonic instrument capable of generating frequencies over the range of at least 1 MHz to 5 MHz .instruments operating at other frequencies may be used if equal or better if equal or better sensitivity can be demonstrated and documented.

Screen Height Linearity

The ultrasonic instrument shall provide linear vertical presentation within +5% of the full screen height for 20% to 80% of the calibrated screen height. The procedure for evaluating screen height linearity shall be performed at the beginning of each period of extended use.

Amplitude Control Linearity

The ultrasonic instrument shall utilize an amplitude control accurate over its useful range to +20% of the nominal amplitude ratio, to allow measurement of indications beyond the linear range of the vertical display on the screen. The procedure for evaluating amplitude control linearity shall be performed at the beginning of each period of extended use.

Checking and Calibration of Equipment

The proper functioning of the examination equipment shall be checked and the equipment shall be calibrated by the use of the calibration standard at the beginning and end of each examination. If during any check it is determined that the testing equipment is not functioning properly, all of the product that has been tested since the last valid equipment calibration shall be reexamined.

The search units to be used shall have the following characteristics:

ROW	MODEL	SIZE (mm)	FEREQUENCY	THICKNESS (mm)
1	a =70°	1 8×9 or 20×22	2 ~ 4 MHZ	UP TO 35
2	a =60°	8×9 or 20×22	2 ~ 4 MHZ	35 TO 90
3	a = 45°	8×9 or 20×22 2	2 ~ 4 MHZ	OVER 35mm

RATE OF SCANING

The rate of scanning for examination shall not exceed 150mm/sec. unless calibration is verified at the scanning speed.

In accordance ASME Sec.V paragrafe T-460: The equipment used must be calibrated at least each 3 months for linear vertical presentation (Screen high linearity) and amplitude control linearity according to manufacturer recommendation.

The scanning positions of search units are shown in the **Figures 2 to 5 (Attachment 2)**

COUPLING MEDIUM

A Couplant, usually a liquid or semi-liquid, is required between the face of the search unit and the examination surface to permit or improve the transmittance of ultrasound from the search unit into the material under test. Typical couplants include water, cellulose gel, oil, and grease, corrosion inhibitors or wetting agents or both may be used.

BASIC CALIBRATION BLOCK

This basic calibration reflectors shall be used to establish a primary reference response of the equipment. The dimensions of basic calibration blocks shall be met the article 4 of ASME sec. V, Fig T434.2.1 (Attachment - 4).

Where the block thickness ±1 in. spans two of the weld thickness ranges shown in article 4. The block's use shall be acceptable in those portions of each thickness range covered by 1 in.

Where two or more base material thicknesses are involved, the calibration block thickness shall be determined by average thickness of the weld.

Basic calibration block material

The material from which the block is fabricated shall be of the same product form, and material specification or equivalent p-number grouping and grade, production, heat treatment and thicknesses as one of the materials being examined. For calibration blocks for dissimilar metal welds, the material selection shall be based on the material on the side of the weld from which the examination will be conducted: if the examination will be conducted from both sides, calibration reflectors shall be provided in both materials. For the purposes of this paragraph, P-Nos. 1, 3, 4, and 5 materials are considered equivalent.

Surface finish

The surface finish of the calibration blocks will be as representative of the surface finish of the components as far as possible with suitable surface preparation or treatment as practical, to simulate testing conditions.

Block quality

The calibration block material shall be completely examined with a straight beam search unit. Areas that contain an indication exceeding the remaining back reflection shall be excluding from the beam paths required to reach the various calibration reflectors.

Cladding

When the component material is clad, the block shall be clad by the same welding procedure as the production part. It is desirable to have component materials which have been clad before the drop outs

or prolongations are removed. When the cladding is deposited using an automatic welding process, and, if due to block size, the automatic welding process is impractical, deposition of clad may be by the manual method.

CURVATURE OF SURFACES

For examination of circumferential welds in vessels with contact surface diameter smaller than 20in (508 mm) the basic calibration block contact surface shall be curved. A single curved basic calibration block may be used to calibrate the examination of vessel contact surfaces in the range of curvature from 0.9 to 1.5 time basic calibration block diameter. For example, an 8 in (203 mm) diameter block may be used to calibrate for examinations on surfaces in the range of curvature from 7.2 in. to 12 in. (183 mm to 305mm) in diameter. The curvature range from 0.94 to 20 in (24 to 508mm) diameter requires six blocks as indicated in (fig T-434.1.7.2. Attachment 4)

For examination of welds in vessels with contact surface curvature having diameter greater than 20in (508mm) flat basic calibration block or a block of essentially a same curvature shall be used. 6.5.2.1.

When examining a welded joint by straight beam contact technique from convex side of contact surface having diameter greater than 20in (508 mm) and the flat block is used for calibration, it is required to increase the examination gain by a gain correction factor. The gain correction shall apply to the far field portion of the sound beam.

The determination of gain correction must be evaluated as follows:

- When the ratio of R/Rc, the radius of curvature of the material (R) divided by critical Radians of the transducer (RC) from table A-10 and diagram of fig A-10 (a)(Article 5), is equal to or greater than 1.0, no gain correction is required.

- When the ratio of R/Rc is less than 1.0 the gain correction must be obtained from fig A-10 (b) of article 5.

- Example: material with a 10in. (254mm) radius (R) will be examined with a 1 in. (25mm) diameter

  2.25MHz, boron carbide faced search unit, using glycerin as a couplant.
  I. Determine the appropriate transducer factor, F1 from A-10: F1=93.
  II. Determine the RC from fig A-10 (b), RC =100 in
  III. Calculate the R/Rc ratio; 10in / 100in = 0.1.
  IV. Using fig A-10 (b); obtain the gain increase required 12 db. This gain increase calibrates the examination on the curved surface after establishing calibration sensitivity on a flat calibration block.

6.3 SYSTEM CALIBRATION

General requirements:

Calibration shall include the complete ultrasonic Examination system. The original calibration must be performed on the basic calibration block. In all Calibrations, it is important that maximum indications be obtained with the sound beam oriented perpendicular to the axis of the side-drilled holes and notches. The centerline of the search unit shall be at least 1½ in. (38mm) from the nearest side of the block. (Rotation of the beam into the corner formed by the hole and the side of

the block may produce high amplitude at a long beam path; this beam path shall not be used for calibration). For contact examination, the temperature of the examination and basic calibration block surfaces shall be within 25ºF (14ºC). Each calibration shall be performed from the surface (clad or unclad) corresponding to the surface of the component from which the examination will be performed.

Angle beam calibration
The following calibrations shall be performed:

- Angle beam search unit checking
- Sweep range calibration
- Distance amplitude correction
- Position calibration
- Echo amplitude measurement from the surface notch in the basic calibration block.

Angle beam search unit checking
Prior to start with its use each angle beam search unit has to be checked on the international institute of welding block type V1 as per fig.1.

Exact location of beam point the location of the beam exit point is checked by placing the search unit over the check mark and positioning for maximum response. The check mark on the block then coincides with the true point of exit of the central beam ray into the search unit.

The angle of incident is checked by placing the search unit on the angle scale and using the large hole with Perspex insert. In position of maximum response the true point of beam centerline shall concide with the true mark of angle scale.

Sweep range calibration (see fig B-10 – Attachment 5) T=1½ in (38.1mm)

- Position the search unit for the maximum first indication from the ¼ T side drilled hole. Adjust the left edge of this indication to line 2 on the screen with delay control.
- Position the search unit for the maximum indication from the ¾ T hole. Adjust the left edge of this indication to line 6 on the screen with the range control.
- Repeat delay and range control adjustments until the ¼ T and ¾ T hole reflections start at sweep line 2 and 6.
- Position the search unit for maximum response from the square notch on the opposite surface. The indication will appear near sweep line 8.
- Two divisions on the sweep equal ¼ T.

Distance-amplitude correction (primary reference level see fig B-20 on article 4).
Calibration from the clad side

- Position the search unit for maximum response from hole which gives the highest amplitude.
- Adjust the sensitivity controls to provide an 80% (±5% of full screen height) of full screen indication from the hole. Mark the peak of the indication on the screen.
- Position the search unit for maximum response from another hole indication.
- Mark the peak of the indication on the screen.

- Position the search unit for maximum amplitude from the third hole indication and mark the peak on the screen.
- Position the search unit for maximum amplitude from the ¾ T hole indication after the beam has bounced from the opposite surface. The indication should appear at sweep line 10. Mark the peak on the screen for the 5/4 T position.
- Connect the screen marks for the side drilled holes to provide the distance amplitude curve DAC.

Calibration from the unclad side

- From the clad side of the block, determine the db change in amplitude between the ¾ T and 5/4 T position.
- From the unclad side; perform calibration as noted
- Position the search unit for maximum amplitude from the 3/4T hole, to determine the amplitude for the 5/4 T hole. Decrease the signal amplitude by the number of db determined in. Mark the height of this signal amplitude at sweep line 10 (5/4 T).
- Connect the screen marks to provide the distance-amplitude curve. This will permit evaluation of indications down to the clad surface (near sweep line 8).
- For calibration correction for perpendicular planar reflectors near the opposite surface refer to par 6.

Distance-amplitude correction (DAC) exemption

- A DAC is not required where the examination is limited to one-half V path in a material less than 1 in thick, in which case the amplitude level from a single calibration shall be used.

Position calibration (see fig. B-40 in Article 4)

The following measurements may be made with a ruler, scale, or marked on an indexing strip.

- Position the search unit for maximum response from the ¼ T hole. Place one end of the extending in the direction of the beam. Mark the number 2 on the indexing strip at the scribe line, which is directly above the hole. (If the search unit covers the scribe line, the marks may be made on the side of the search unit).
- Position the search unit for the maximum indications from the ½ T and ¾ T holes. Keep the same end of the indexing strip against the front of the search unit. Mark the numbers 4, 6 and 10 on the indexing strip at the scribe line.
- Position the search unit for maximum opposite surface notch indication. Mark the numbers 8 on the indexing strip at the scribe line.
- The calibration numbers on the indexing strip indicate the position directly over the reflector in sixteenths of the V-path.
- The depth from the examination surface to the reflector is T at 8, ¾T at 6 and 10, ½T at 4 and 12, ¼T at 2 and 14 and 0 at 0. Interpolation is possible for smaller increments of depth. This measurement may be corrected by the radius of hole if the radius is considered significant to the accuracy of reflector's location.

Calibration correction for planar reflectors perpendicular to the examination surface at or near opposite surface (see fig B-50 in article 4 - Attachment 5).

- Position the search unit for maximum amplitude from the square notch on the opposite surface. 'X' marks the peak of the indication of the screen near sweep line 8.

• The opposite surface square notch may give an indication 2 to1 above DAC at 45 deg. And ½ DAC at 60deg. Therefore, the indications from the square notch must be considered when evaluating reflectors at the opposite surface.

Straight beam calibration

• The calibration shall provide the following measurements:
• Sweep range calibration

Distance-amplitude correction

Sweep range calibration (see fig. C-10 in article 4 - Attachment 5)

• Position the search unit for the maximum first indication from the ¼ T side drilled hole. Adjust the left edge of this indication to line 2 on the screen with the delay control.
• Position the search unit for the maximum indication from the 3/4 T hole. Adjust the left edge of this indication to line 6 on the screen with the range control.
• Repeat delay and range control adjustments until the ¼ T and ¾ T hole reflections start at sweep lines 2 and 6.

Distance-amplitude correction (see fig.C-20 in article 4 - Attachment 6)

• Position for maximum response from the hole, which gives the highest amplitude.

• Adjust the sensitivity controls to provide an 80% (±5% of full screen height) of full screen indication on the screen with a grease pencil or other suitable marker.
• Position the search unit for maximum response from another hole indication.
• Mark the peak of the indication on the screen.
• Position the search unit for maximum amplitude from the third hole indication and mark the peak on the screen.
• Connect the screen marks and extend through the thickness to provide the distance-amplitude curve for the side drilled holes.
• When examining curved surface from convex side having diameter greater than 508 mm and calibration performed on flat basic reference block, the sensitivity level of DAC shall be increased of gain correction value.

6.4 CALIBRATION CHECKS

Calibration confirmation:

Calibration shall be performed prior to use of the system in the thickness range under examination. Before start of examination, calibration check shall verify the sweep angle calibration; as applicable and every 4 hour during the examination. The check must satisfy the requirements of par. 6.3

Calibration check

The calibration check during production welds examination must be performed on basic calibration block according to par.6.3 to verify that ¼, ½ and ¾ T points on the sweep and DAC are correct.

Calibration checks shall be performed:

- When an element of the examination system is changed (cable, transducer, or equipment)
- When examination personnel is changed during examination.

- After each hour of examination.
- At the finish of each examination or series of similar examination the check shall satisfy the requirements of par. Sweep range correction and DAC correction.

Sweep range correction

If a point on the DAC curve has moved on the sweep line more than 10% of the sweep reading or 5% of full sweep, whichever is greater, correct the sweep range calibration and note the correction in the examination record. If reflectors are recorded on the data sheets, those data sheets shall be voided; a new calibration shall be recorded. All recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

DAC correction

If a point on the distance-amplitude correction (DAC) curve has decreased 20% or 2 db of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new Calibration shall be made and recorded and the area covered by the voided data shall be reexamined. If any point of the distance-amplitude correction (DAC) curve is increased more than 20% or 2 db of its amplitude, all recorded indications since the last valid calibration or corrected calibration and their values shall be changed on the data sheets.

6.5 SCANING PROCEDURE

- The weld joint plus 10 mm of base material adjacent to H.A.Z shall be 100% examined which straight and angle beam search unit.

- During the scanning the response from basic calibration block hole shall be magnified increasing the gain setting value of 6 db. The gain setting shall be placed at true value of reference response for the evaluation of the indications.

- The search unit shall be moved as so to obtain a complete exploration of the weld. Each pass of the search unit shall overlay a minimum of 10% of transducer width. The rate of manual scanning shall not exceed 6 in. per second.

- Butt weld joints shall be examined basically according to **fig .2 and 3** (**Attachment 2)**.

- Nozzle weld joints shall be examined basically according to **fig.4 and 5 (Attachment 2).**

Angle beam scanning

- Angle beam scanning for reflectors oriented parallel to the weld angle beam shall be directed at approximate right angles to the weld axis from two directions, where possible.

- Weld joints with thickness up to 35 mm shall be covered by path from both sides and surface of weld **(see fig.2** - **Attachment 2**)

- Weld joints with thickness over 35 mm shall be covered by path from both sides and surface of weld, when both sides and surface of weld **(see fig.3 Attachment 2)** are accessible.

- Angle beam scanning for reflectors oriented transverse to the weld. The angle beam shall be directed essentially parallel to the weld axis. The search unit shall be rotated 180 deg. and the examination repeated.

Longitudinal beam scanning

- The scanning shall be performed on weld and base metal.

- The scanning of the adjacent base metal shall be performed to detect reflectors that might affect interpretation of angle beam results, and is not to be used as an acceptance rejection examination. Location and areas of such reflectors shall be recorded.

6.6 REPORTABLE INDICATIONS AND EVALUATION

- All indications, which produce a response greater than 20% of reference level, shall be investigated to the extent, the operator can evaluate the shape, identity and location of all such reflectors in terms of acceptance standards of par.11.
- All indications in excess 50% of primary reference level shall be recorded.
- Doubtful indications may be confirmed by radiographic examination.
- The length of discontinuities shall be determined placing the search unit at two border points, in which the response is half the maximum value given by the local discontinuity.

6.7 ACCEPTANCE CRITERIA

Acceptance criteria should be according to appendix 12 of ASME sec.VIII, DIV.1 as mentioned as follow: “These standards shall apply unless other standards are specified for specific applications within Division I.
Imperfections which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such imperfections and evaluate them in terms of the acceptance standards given in (a) and (b) below.

a) Indications characterized as cracks, lack of fusion, or incomplete penetrations are unacceptable regardless of length.
b) Other imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths, which exceed:
1) ¼ in. (6mm) for t up to ¾ in. (19mm).
2) 1/3 t for t from ¾ in. to 2 ¼ in. (19mm to 57mm) 3) 3/4 in. (19.05mm) for t over 2 ¼ in. (57mm).

Here t is the thickness of the weld excluding any allowable reinforcement; for a butt weld joining two members having different thicknesses at the weld. T is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.”

6.8 REMOVAL OF DEFECTS

Indications or discontinuities in excess to standards shall be removed by mechanical means and repaired by qualified welding procedure, where necessary.

The repaired area shall be reinspected using the ultrasonic examination procedure according to this specification.

6.9 CLEANING AFTER EXAMINATION

After examination the coupling medium, used for the ultrasonic examination, shall be removed.

6.10 CERTIFICATION

After inspection an "UT" certificate (ultrasonic examination report) shall be filled out.

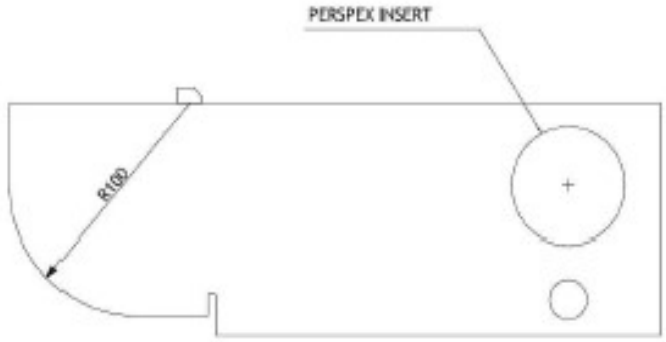
6.11 PERSONNEL QUALIFICATION

All nondestructive examination shall be performed by personnel certificate in accordance with level II of ASNT-SNTTC- IA

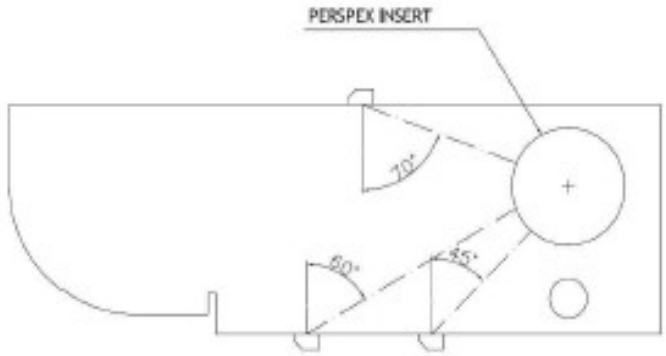
6.12 RECORD

- The record of ultrasonic examination shall be signed by qualified personnel and shall be submitted to CONTRACTOR / COMPANY.
- The record shall include the welds or volume examined, the location of each record reflector, and the identification of the operator, such as detailed in ASME Sec. V, T-593.
- The record shall be included in the QC Dossier for the field construction work.

Attachment 1- Angle beam checking (Related with item “6.3 & 6.4” of this procedure)



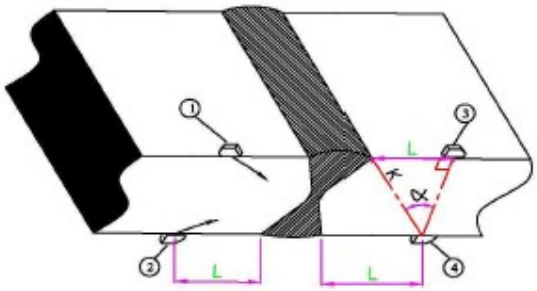
BEAM EXIT POINT CHECKING



BEAM INCIDENCE ANGLE CHECKING

FIG. 1

Attachment 2- Scanning positions
(Related with item "4.5" of this procedure)

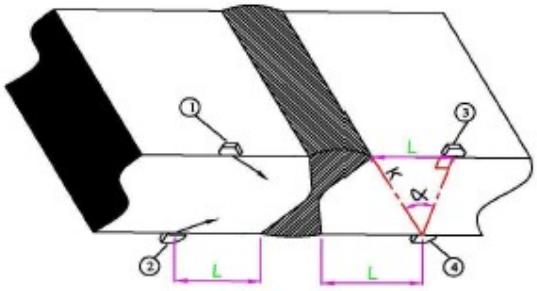


20mm≤T≤35mm
Scannining Position 1&2 or 3&4
Angle beam search unit of 70°
FIG.2

$$K=\frac{T}{\cos\alpha}$$

$$L=\sqrt{K^2-T}$$

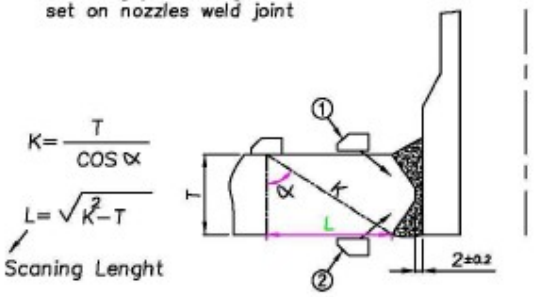
Scaning Lenght



35mm≤T≤90mm
Scannining Position 1&2&3&4
Angle beam search unit of 45° or 60°
FIG.3

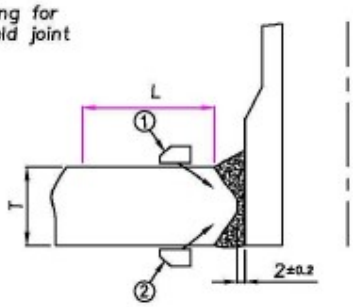
Attachment 2- Scanning positions **Page 2 of 2**
(Related with item "4.5 and 9" of this procedure)

FIG.4
Scaning positioning for
set on nozzles weld joint



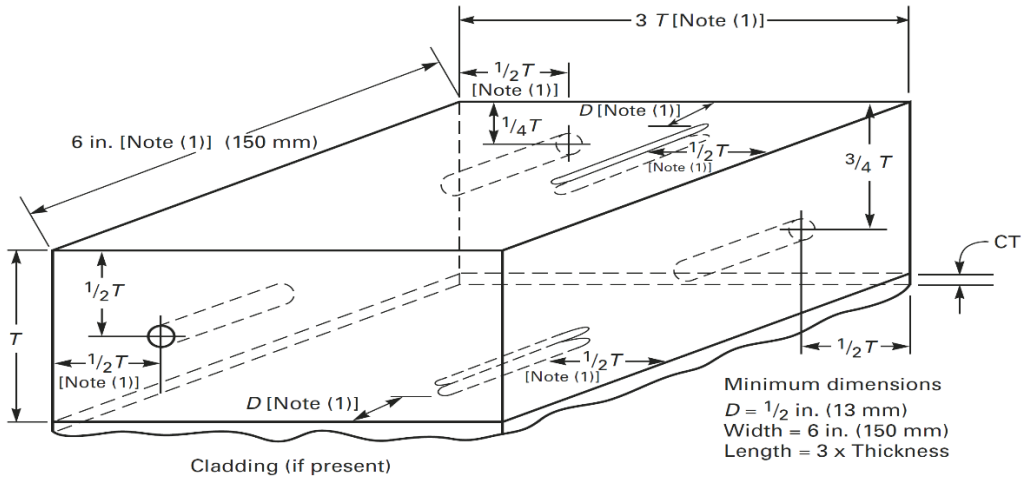
20mm≤T≤35mm
Scannining Position 1&2
Angle beam search unit of 70°

FIG.5
Scaning positioning for
set on nozzles weld joint



35mm≤T≤90mm
Scannining Position 1&2
Angle beam search unit of 45° or 60°

Figure T-434.2.1
Nonpiping Calibration Blocks



Notch Dimensions, in. (mm)
Notch depth = 1.6% T to 2.2% T
Notch width = 1/4 (6) max.
Notch length = 1 (25) min.

Weld Thickness (t), in. (mm)	Calibration Block Thickness (T), in. (mm)	Hole Diameter, in. (mm)
Up to 1 (25)	3/4 (19) or t	3/32 (2.5)
Over 1 (25) through 2 (50)	1 1/2 (38) or t	1/8 (3)
Over 2 (50) through 4 (100)	3 (75) or t	3/16 (5)
Over 4 (100)	t ±1 (25)	[Note (2)]

GENERAL NOTES:
(a) Holes shall be drilled and reamed 1.5 in. (38 mm) deep minimum, essentially parallel to the examination surface.
(b) For components equal to or less than 20 in. (500 mm) in diameter, calibration block diameter shall meet the requirements of T-434.1.7.2. Two sets of calibration reflectors (holes, notches) oriented 90 deg from each other shall be used. Alternatively, two curved calibration blocks may be used.
(c) The tolerance for hole diameter shall be ±1/32 in. (0.8 mm). The tolerance for hole location through the calibration block thickness (i.e., distance from the examination surface) shall be ±1/8 in. (3 mm).
(d) For blocks less than 3/4 in. (19 mm) in thickness, only the 1/2T side-drilled hole and surface notches are required.
(e) All holes may be located on the same face (side) of the calibration block, provided care is exercised to locate all the reflectors (holes, notches) to prevent one reflector from affecting the indication from another reflector during calibration. Notches may also be in the same plane as the inline holes (see Nonmandatory Appendix J, Figure J-431). As in Figure J-431, a sufficient number of holes shall be provided for both angle and straight beam calibrations at the 1/4T, 1/2T, and 3/4T depths.
(f) When cladding is present, notch depth on the cladding side of the block shall be increased by the cladding thickness, CT (i.e., 1.6% T + CT minimum to 2.2% T + CT maximum).
(g) Maximum notch width is not critical. Notches may be made by EDM or with end mills up to 1/4 in. (6.4 mm) in diameter.
(h) Weld thickness, t, is the nominal material thickness for welds without reinforcement or, for welds with reinforcement, the nominal material thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing Code Section. When two or more base material thicknesses are involved, the calibration block thickness, T, shall be determined by the average thickness of the weld; alternatively, a calibration block based on the greater base material thickness may be used provided the reference reflector size is based upon the average weld thickness.

NOTES:
(1) Minimum dimension.
(2) For each increase in weld thickness of 2 in. (50 mm) or fraction thereof over 4 in. (100 mm), the hole diameter shall increase 1/16 in. (1.5 mm).

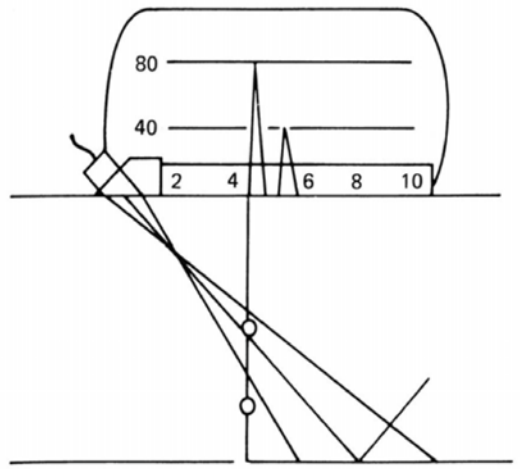
I-410 SCOPE

This Mandatory Appendix provides requirements for checking screen height linearity and is applicable to ultrasonic instruments with A-scan displays.

I-440 MISCELLANEOUS REQUIREMENTS

Position an angle beam search unit on a calibration block, as shown in Figure I-440 so that indications from both the $\frac{1}{2}T$ and $\frac{3}{4}T$ holes give a 2:1 ratio of amplitudes between the two indications. Adjust the sensitivity (gain) so that the larger indication is set at 80% of full screen height (FSH). Without moving the search unit, adjust sensitivity (gain) to successively set the larger indication from 100% to 20% of full screen height, in 10% increments (or 2 dB steps if a fine control is not available), and read the smaller indication at each setting. The reading shall be 50% of the larger amplitude, within 5% of FSH. The settings and readings shall be estimated to the nearest 1% of full screen. Alternatively, a straight beam search unit may be used on any calibration block that provides amplitude differences, with sufficient signal separation to prevent overlapping of the two signals.

Figure I-440
Linearity



II-410 SCOPE

This Mandatory Appendix provides requirements for checking amplitude control linearity and is applicable to ultrasonic instruments with A-scan displays.

II-440 MISCELLANEOUS REQUIREMENTS

Position an angle beam search unit on a basic calibration block, as shown in Figure I-440 so that the indication from the $\frac{1}{2}T$ side-drilled hole is peaked on the screen. Adjust the sensitivity (gain) as shown in the following table. The indication shall fall within the specified limits. Alternatively, any other convenient reflector from any calibration block may be used with angle or straight beam search units.

Indication Set at % of Full Screen	dB Control Change	Indication Limits % of Full Screen
80%	−6 dB	35% to 45%
80%	−12 dB	15% to 25%
40%	+6 dB	65% to 95%
20%	+12 dB	65% to 95%

The settings and readings shall be estimated to the nearest 1% of full screen.

Attachment 4 – Ratio limits for curved surfaces
(Related with item "6.5.1" of this procedure)

T-441 ARTICLE 4 — ULTRASONIC EXAMINATION METHODS FOR WELDS T-450

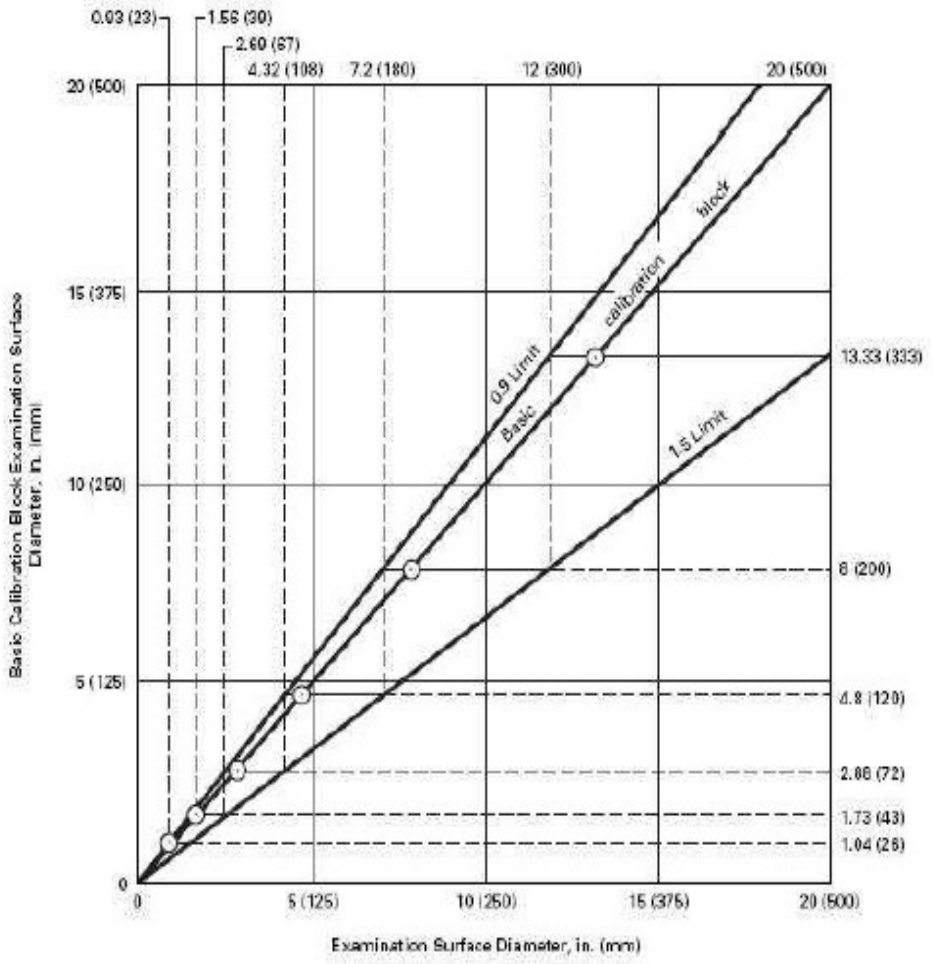


FIG. T-434.1.7.2 RATIO LIMITS FOR CURVED SURFACES

Attachment 5 – sweep range, calibration correction
(Related with item "7.2.2, 7.3.1 and 7.2.5" of this procedure)

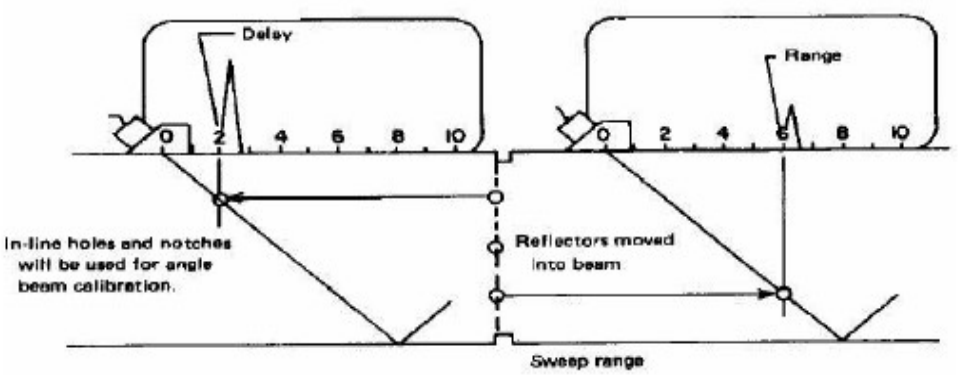


FIG. B-10 SWEEP RANGE

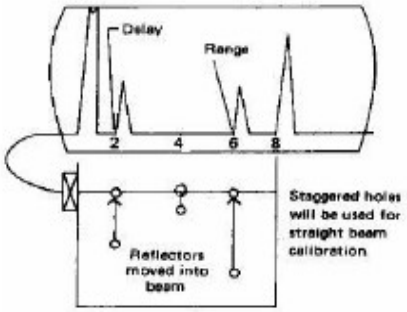


FIG. C-10 SWEEP RANGE

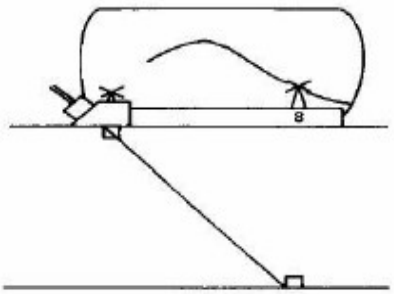


FIG. B-50 PLANAR REFLECTIONS

Attachment 6 – Distance-amplitude correction
(Related with item "7.3.2" of this procedure)

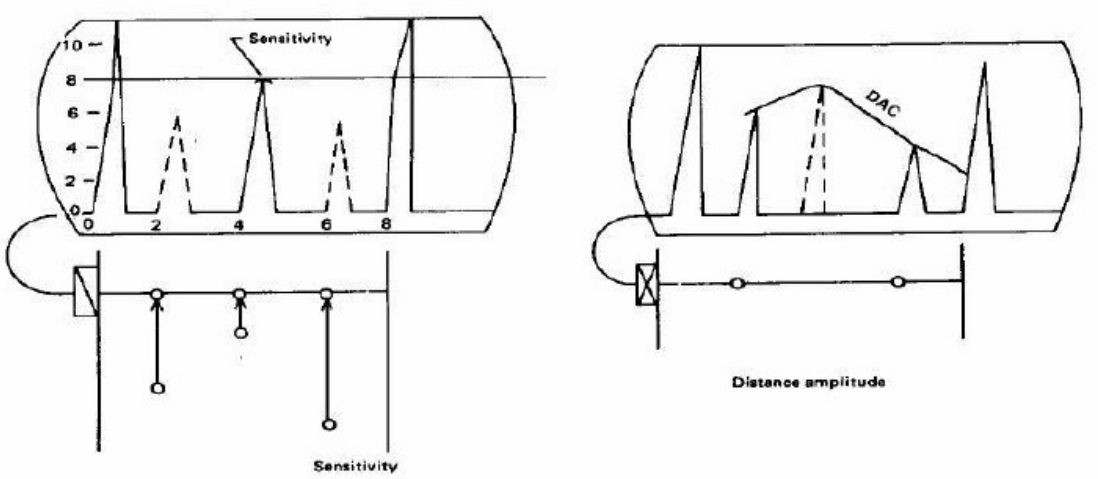


FIG. C-20 SENSITIVITY AND DISTANCE–AMPLITUDE CORRECTION

ASME

Request No.	**Examination Date:**	**Inspection Procedure No.**	**Report No.**
Client:	**Contractor:**	**Project:**	**Location:**
Component Code:	**Parent Material:**		

Test Condition

Surface cleaning: Brushing○ Grinding ○ Solvent○ Other○			**Welding Process:**
Joint design: Tee○ Lap○ Butt○ Corrner○ Edge○ Other○			**Performance Std:**
Equipment:	**Model:**	**Ser No:**	**Test length:**
Probe:	Angle○ Angle: Size: Freq:		**Acceptance Criteriare reference :**
	striaght○ Freq: Size:		**Reference dB:**
Sensivity evaluation method: RI○ Rh○ DAC○			**Scanning dB:** / **Couplant:**
Calibration Block : V1○ V2○ Others○			

No	Weld Id	Prob angel	Thickness (mm)		Tested length (cm)	A (mm)	Discontinuity & Evaluation				Result			
			1	2			Location							
							X (mm)	Y (mm)	Length (mm)	Depth (mm)	Defect	Accept	Repair	Accept After Repair
1														
2														
3														
4														
5														

Explanation:

Sketch:

Weld Identification:
BP: Bottom Plate, TP: Top Plate, BC: Box Corner, WF: Web fo Flange, SP: Splice Plate, CP:Cover Plate, S:Stiffener, CB: Column to Base Plate, GP:Gusset Plate, LW: longitudinal weld CW: circular weld

Name & Sign of Inspector: **Date:**	**Name & Sign of corrector:** **Date:**	**Name & Sign of Client :** **Date:**

AWS

Request No.	Examination Date:	Inspection Procedure No.	Report No.
Client:	Contractor:	Project:	Location:
Component Code:	Parent Material:		

Test Condition

Surface cleaning: Brushing○ Grinding ○ Solvent○ Other○	**Welding Process:**
Joint design: Tee○ Lap○ Butt○ Corrner○ Edge○ Other○	**Performance Std:**
Equipment: **Model:** **Ser No:**	**Test length:**
Probe: Angle○ Angle: Size: Freq:	**Acceptance Criteriare reference :**
striaght○ Freq: Size:	**Reference dB:**
Sensivity evaluation method: RI○ Rh○ DAC○	**Scanning dB:** **Couplant:**
Calibration Block : V1○ V2○ Others○	

No	Weld Id	Prob angel	Thickness (mm) 1	Thickness (mm) 2	Tested length (cm)	Desibels: Indication Level a	Desibels: Reference level b	Desibels: Attenuation Factor c	Desibels: Indication Rating d	Discontinuity & Evaluation: Location X (mm)	Y (mm)	Length (mm)	Depth (mm)	Result: Defect	Accept	Repair	Accept After Repair
1																	
2																	
3																	
4																	
5																	

Explanation:

Sketch:

Weld Identification:
BP: Bottom Plate, TP: Top Plate, BC: Box Corner, WF: Web fo Flange, SP: Splice Plate, CP:Cover Plate, S:Stiffener, CB: Column to Base Plate, GP:Gusset Plate, LW: longitudinal weld CW: circular weld

Name & Sign of Inspector: Date:	Name & Sign of corrector: Date:	Name & Sign of Client : Date:

7. LIQUID PENETRANT TEST

GENERAL

The liquid penetrant examination method is an effective means for detecting discontinuities which are open to the surface of nonporous metals and other materials. Typical discontinuities detectable by this method are cracks, seams, laps, cold shuts, laminations, and porosity. In principle, a liquid penetrant is applied to the surface to be examined and allowed to enter discontinuities. All excess penetrant is then removed, the part is dried, and a developer is applied. The developer functions both as a blotter to absorb penetrant that has been trapped in discontinuities, and as a contrasting background to enhance the visibility of penetrant indications. The dyes in penetrants are either color contrast (visible under white light) or fluorescent (visible under ultraviolet light).

SURFACE PREPARATION

Prior to each liquid penetrant examination, the surface to be examined and all adjacent areas within at least 1 in. (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux, weld spatter, paint, oil, and other extraneous matter that could obscure surface openings or otherwise interfere with the examination.

TECHNIQUE

A color contrast (visible) penetrant will be used with water washable penetrant process.
The following mediums and / or similar will be used for finding discontinuities:

- Magnaflux – (cleaner) SKC – S
- Magnaflux – (penetrant red) SKL – SP1
- Magnaflux – (developer) SKD – S2
- Irrespective of the method or system selected for use by the CONTRACTOR, all component materials (penetrant, cleaner, developer) shall be materials from the same brand or manufacturer's system. Interchanging or use of penetrant, cleaner, or developer from different manufacturers or brands shall not be permitted.

TEMPERATURE

The temperature of the penetrant and the surface of the part to be processed shall not be below 10°C nor above 52°C throughout the examination period. Local heating or cooling is permitted provided the part temperature remains in the range of 10°C to 52°C during the examination.

METHOD OF EXAMINATION

The following sequence shall be used for penetration test:

PRECLEANING

The success of any penetrant examination procedure is greatly dependent upon the surface and discontinuity being free of any contaminant (solid or liquid) that might interfere with the penetrant process.
All part of area of parts to be examined must be clean and dry before the penetrant is applied. If only a section of a part , and all adjacent areas at least 1 in (25 mm) to be examined remove all contaminants from the area being examined. Clean is intended to mean that the surface must be from of rust, scale, welding flux, spatter, grease, paint, oily films, dirt, etc., that might interfere with penetration. All of these contaminations can prevent the penetrant from entering discontinuities.

DRYING AFTER CLEANING

It is essential that the surfaces be thoroughly dry after cleaning, since any liquid residue will hinder the entrance of the penetrant. Drying may be accomplished by warming or by exposure to ambient temperature.

PENETRANT APPLICATION

The penetrant shall be applied by spraying. If necessary, the material surface to be examined, shall be shaded or cooled to maintain the surface temperature between 16° C and 52° C during the examination. The liquid penetrant shall remain on the weld for at least five 5 minutes. If the liquid penetrant dries out completely before the duration of the penetration time, additional penetrant shall applied ad required.

After the area to be examined has been cleaned, dried and is within the temperature range, apply the penetrant to the surface to be examined so that the entire part or area under examination is completely covered with penetrant.

PENETRANT DWELL TIME

After application, allow excess penetrant to drain from the part (care should be taken to prevent pools of penetrant of the part), while allowing for proper penetrant dwell time. The length of time the penetrant must remain on the part to allow proper penetration should be as recommended by the penetrant manufacturer.

REMOVAL OF EXCESS PENETRANT

After the specified penetration (dwell) time has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from discontinuities Excess water washable penetrant shall be removed with a water spray. The water pressure shall not exceed 50 psi (350 kPa), and the water temperature shall not exceed 43°C.

DRYING AFTER EXCESS PENETRANT REMOVAL

For the water washable or post-emulsifying technique, the surfaces may be dried by blotting with clean materials or by using circulating air, provided the temperature of the surface is not raised above 52°C.

DEVELOPING

The developer shall be applied as soon as possible after penetrant removal; the time interval shall not exceed that established in the procedure. Insufficient coating thickness may not draw the penetrant out of discontinuities; conversely, excessive coating thickness may mask indications. With color contrast penetrants, only a wet developer shall be used.

WET DEVELOPER APPLICATION

Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

AQUEOUS DEVELOPER APPLICATION

Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, brushing, spraying, or other means, provided a thin coating is obtained over the entire surface being examined.

Drying time may be decreased by using warm air, provided the surface temperature of the part is not raised above 52°C. Blotting is not permitted.

NONAQUEOUS DEVELOPER APPLICATION

Nonaqueous developer shall be applied only to a dry surface. It shall be applied by spraying, except where safety or restricted access precludes it. Under such conditions, developer may be applied by brushing.
Drying shall be by normal evaporation.

Developing time for final interpretation begins immediately after the application of a dry developer or as soon as a wet developer coating is dry. The minimum developing time is 10 minutes.

EVALUATION

- All indications shall be evaluated in terms of the acceptance standards of ASME Sec. VIII Div.1 Appendix 8.
- Discontinuities at the surface will be indicated by bleed-out of penetrant; however, localized surface irregularities due to machining marks or other surface conditions may produce false indications.
- Broad areas of fluorescence or pigmentation which could mask indications of discontinuities are unacceptable, and such areas shall be cleaned and reexamined.

LIGHT INTENSITY

A minimum light intensity of 100 fc (1000 lx) is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications.

POST-EXAMINATION CLEANING

Post-examination cleaning should be conducted as soon as practical after evaluation and documentation**.**

REPAIR AND TEST

Unacceptable defects, shall be processed as follows:

- Remove by light grinding.
- Re-examination; repeat previous steps above as necessary until an acceptable test result is confirmed. (This means grinding and examining until confirmed that the defect has been completely removed).
- Thickness verification after the removal of the defects (without repair welding). Either by a visual assessment, or by direct measurement by Ultra-sonic gauging or pit gauge. - Repair weld, if below minimum thickness
- Re-examination (if a repair weld has been performed)

CERTIFICATION

After inspection a liquid penetrant examination report shall be filled out in the attached related form.

PERSONNEL QUALIFICATION

All personnel performing liquid penetrant examination according to this specification shall be qualified Level I, II, III of ASNT –TC-1A or equivalent. Interpretation shall be performed only by level II or III.

DYE PENETRANT INSPECTION REPORT

Request No.	**Examination Date:**	**Inspection Procedure No.**	**Report No.**
Client:	**Contractor:**	**Project:**	**Location:**
Component Code:	**Parent Material:**	**Acceptance criteria reference:**	

Test Condition

Surface cleaning: Brushing○ Grinding ○ Solvent○ Other○	**Welding Process:**	
Joint design: Tee○ Lap○ Butt○ Corrner○ Edge○ Other○	**Performance Std:**	
Removal Method : Water Washable ○ Post Emulsifiable ○ Solvent ○	**Test length:**	Temp Test :
Developer Type : Wet ○ Dry ○ **Developer Brand and Code**:	**Penetrant Type:** Visible ○ florescent ○	
Penetrant Applay: spray○ brushing○ **Penetrant Brand and Code**:	**Development Time:**	**Penetrant time:**

No	Weld Id	Thickness (mm)		Tested length (cm)	Discontinuity & Evaluation			Result			
		1	2		Location						
					X (mm)	Y (mm)	Length (mm)	Defect	Accept	Repair	Accept After Repair
1											
2											
3											
4											
5											

Explanation:

Sketch:

Name & Sign of Inspector: Date:	**Name & Sign of corrector:** Date:	**Name & Sign of Client:** Date:

8. VISUAL INSPECTION (VT)

A nondestructive examination method used to evaluate an item by observation, such as: the correct assembly, surface conditions, alignment of mating surfaces, shape and cleanliness of materials, parts, and components used in the fabrication and construction.
In addition, visual examination is used to determine a composite materials (translucent laminate) subsurface condition.
Visual examination shall be performed before, during and after welding operation to detect discontinuities.

PRIOR TO WELDING

Examination of the base metal prior to fabrication can detect conditions which to cause weld defects.
Scabs, seams, scale can be detected with VT. Plate lamination may be observed on cut edges.
Dimensions should be confirmed by measurements. Base metal shall be identified type and grade.
After the parts are assembled for welding, the weld joint root opening, edge preparation and other features shall be checked that might affect the quality of the weld.

Here is a list of check points:

- Joint preparation, dimensions and cleanness
- Clearance dimension of backing strips, rings or consumable inserts.
- Alignment and fit up (according to UW-33 of ASME code) · Cleaning of edge (according to UW-32 of ASME code) · Welding process and consumables.
- Welding procedures and machine settings.
- Specific preheat temp.
- Tack welds quality.

LOWEST PERMISSIBLE TEMPERATURES FOR WELDING

It is recommended that no welding of any kind be done when the temperature of the base metal is lower than −20°C.
At temperatures between 0°C and −20°C, the surface of all are as within 3in. (75mm) of the point where a weld is to be started shall be heated to a temperature at least warm to the hand [estimated to be above 15°C] before welding is started. It is recommended also that no welding be done when surfaces are wet or covered with ice, when snow is falling on the surfaces to be welded, or during periods of high wind, unless the welders or welding operators and the work are properly protected.

CLEANING OF EDGE

When plates are shaped by oxygen or arc cutting, the edges to be welded shall be uniform and smooth and shall be freed of all loose scale and slag accumulations before welding.

TACK WELDS QUALITY

Tack welds used to secure alignment shall either be removed completely when they have served their purpose, or their stopping and starting ends shall be properly prepared by grinding or other suitable means so that they may be satisfactorily incorporated into the final weld. Tack welds, whether removed or left in place, shall be made using a fillet weld or butt weld procedure qualified in accordance with Section IX. Tack welds to be left in place shall be made by welders qualified in

accordance with Section IX, and shall be examined visually for defects, and if found to be defective shall be removed.

CLEANING OF SURFACES TO BE WELDED

The surfaces to be welded shall be clean and free of scale, rust, oil, grease, slag, detrimental oxides, and other deleterious foreign material. The method and extent of cleaning shall be determined based on the material to be welded and the contaminants to be removed. When weld metal is to be deposited over a previously welded surface, all slag shall be removed by a roughing tool, chisel, chipping hammer, or other suitable means so as to prevent inclusion of impurities in the weld metal.

ALIGNMENT TOLERANCE

(a) Alignment of sections at edges to be butt welded shall be such that the maximum offset is not greater than the applicable amount for the welded joint category (see UW-3-Attachment 2) under consideration, as listed in Table UW-33 (Attachment 1). The section thickness t is the nominal thickness of the thinner section at the joint.

(b) Any offset within the allowable tolerance provided above shall be faired at a three to one taper over the width of the finished weld, or if necessary, by adding additional weld metal beyond what would otherwise be the edge of the weld.

DURING WELDING

During welding VT is the primary method of the quality control. Here is some check points of this phase:

- Treatment of tack welds.
- Quality of root pass and succeeding weld layers.
- Proper preheat and inter pass temp.
- Sequence of weld passes.
- Inter pass cleaning
- Root condition prior to welding second side.
- Distortion

The most critical part of a weld is the root pass. Complete VT of root pass may detect conditions which cause a defect in the completed weld. The root opening shall be monitored as the welding progresses. The tack welds, clamps, or braces shall be designed to maintain specific root opens to assure proper joint penetration and alignment.

Inspection of successive layers of weld metal is concentrated on the bead shape and cleaning. When specified, preheat and inter pass temperatures shall be monitored at the proper times with a suitable temperature measuring device.

The amount of heat input and also welding sequence and placement of each weld pass may be specified to maintain mechanical properties or limit distortion or both. Each weld pass shall be evaluated before the next bead is applied.

AFTER WELDING

After completion of welding and dimensional inspection, final visual inspection shall be performed to conform to the requirements of applicable code and project specification. These Items shall be checked after welding:

- Final weld appearance
- Final weld size (maximum reinforcement of weld shall be according to UW-35 of code-Attachment
- Amount of distortion

Many of the following discontinuities on the surface can be found by VT:

- Cracks
- Undercut
- Overlap
- Exposed porosity and slag inclusions
- Spatter
- Arc strick
- Unacceptable weld profile
- Roughness of the weld

For detection and accurate evaluation of discontinuities, the weld surface shall be thoroughly cleaned of oxide and slag. Dimensional accuracy of weldments is determined by conventional methods. The conformity of the weld size and shape may be detected by using suitable weld gauges. The size of a fillet weld in joints, whose members are at right angles, or near, is defined in terms of the length of legs. The gauge shall determine if the leg size is within the allowable limits, and whether there is excessive cavity or convexity. For groove welds, the height of reinforcement shall be consistent with requirements. The weld surface appearance shall meet the requirements of the standard.

Cracks, incomplete fusion and penetration are not accepted. VT can't detect subsurface discontinuities but proper VT procedures before and during fabrication can increase product reliability.

ATTACHMENTS

Attachment 1

TABLE UW-33

Customary Units

Section Thickness, in.	Joint Categories A	Joint Categories B, C, & D
Up to ½, Incl.	¼t	¼t
Over ½ to ¾, Incl.	⅛ in.	¼t
Over ¾ to 1½, Incl.	⅛ in.	3/16 in.
Over 1½ to 2, Incl.	⅛ in.	⅛t
Over 2	Lesser of 1/16t or ⅜ in.	Lesser of ⅛t or ¾ in.

SI Units

Section Thickness, mm	Joint Categories A	Joint Categories B, C, & D
Up to 13, Incl.	¼t	¼t
Over 13 to 19, Incl.	3 mm	¼t
Over 19 to 38, Incl.	3 mm	5 mm
Over 38 to 51, Incl.	3 mm	⅛t
Over 51	Lesser of 1/16t or 10 mm	Lesser of ⅛t or 19 mm

Attachment 2

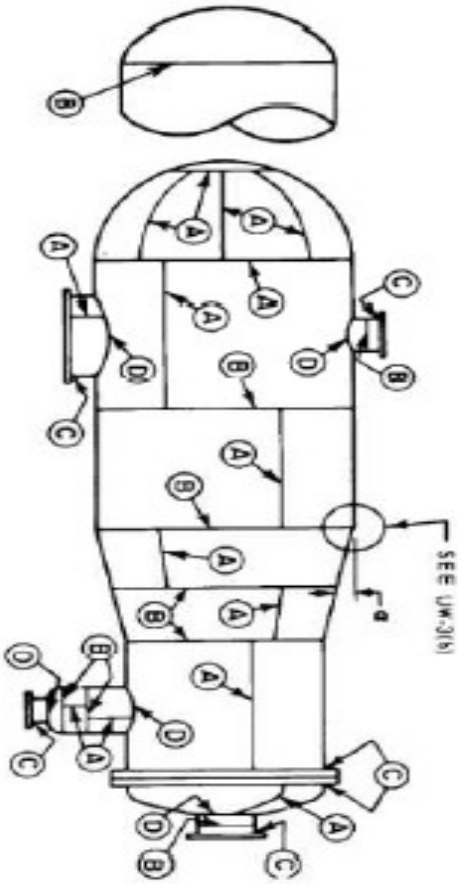


FIG. UW-3 ILLUSTRATION OF WELDED JOINT LOCATIONS TYPICAL OF CATEGORIES A, B, C, AND D

Attachment 3

Customary Units

Material Nominal Thickness, in.	Maximum Reinforcement, in. Category B & C Butt Welds	Other Welds
Less than 3/32	3/32	1/32
3/32 to 3/16, incl.	1/8	1/16
Over 3/16 to 1/2, incl.	5/32	3/32
Over 1/2 to 1, incl.	3/16	3/32
Over 1 to 2, incl.	1/4	1/8
Over 2 to 3, incl.	1/4	5/32
Over 3 to 4, incl.	1/4	7/32
Over 4 to 5, incl.	1/4	1/4
Over 5	5/16	5/16

SI Units

Material Nominal Thickness, mm	Maximum Reinforcement, mm. Category B & C Butt Welds	Other Welds
Less than 2.4	2.4	0.8
2.4 to 4.8, incl.	3.2	1.6
Over 4.8 to 13, incl.	4.0	2.4
Over 13 to 25, incl.	4.8	2.4
Over 25 to 51, incl.	5	3.2
Over 51 to 76, incl.	6	4
Over 76 to 102, incl.	6	6
Over 102 to 127, incl.	6	6
Over 127	8	8

VISUAL INSPECTION REPORT

Request No.	**Examination Date:**	**Inspection Procedure No.**	**Report No.**
Client:	**Contractor:**	**Project:**	**Location:**
Component Code:	**Parent Material:**		**Acceptance criteria reference:**

Test Condition

Surface cleaning:
Brushing○ Grinding ○ Solvent○ Other○

Welding Process:

Joint design:
Tee○ Lap○ Butt○ Corner○ Edge○ Other○

Performance Std:

No	Weld Id	Thickness (mm)		Tested length (cm)	Discontinuity & Evaluation			Result			
		1	2		Location						
					X (mm)	Y (mm)	Length (mm)	Defect	Accept	Repair	Accept After Repair
1											
2											
3											
4											
5											

Explanation:

Sketch:

Weld Identification:
BP: Bottom Plate, TP: Top Plate, BC: Box Corner, WF: Web fo Flange, SP: Splice Plate, CP:Cover Plate, S:Stiffener, CB: Column to Base Plate, GP:Gusset Plate, LW: longitudinal weld CW: circular weld

Name & Sign of Inspector: **Date:**	**Name & Sign of corrector:** **Date:**	**Name & Sign of Client :** **Date:**