Southern Area Corrosion Control

&

Inspection Division

INSPECTOR'S HANDBOOK

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Compiled by D. Boult ~ SAPED/TSU (Tel: 576-6147)

Approved

_____ _____
A.F. Al Shammari Date
General Supervisor SACCID

This handbook is designed to give the field Inspector useful information to carry out his work safely and efficiently. If a conflict exists between this handbook and any National code or Saudi Aramco standard, then the SAES or SAEP must be deemed correct.

The information contained was taken from various sources and publication and is as accurate as possible. It is the responsibility of the User to check any information used for official purposes.

Any inaccuracies or discrepancies should be reported to the Unit Supervisor as soon as possible.

If there are any omissions or areas not covered give the details to the Unit Supervisor for inclusion in the next revision.

The Handbook Team.

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PAINTS & COATINGS

Inspection Methods And Acceptance Criteria

8.1 General

This section gives the mandatory inspection methods and acceptance criteria that shall be met before the FBE-coated welds can be put into service.

8.2 Visual Inspection

The Inspector shall verify that the surface preparation requirements of paragraph 7.2 are met prior to the commencement of preheating.

8.2.2 Thickness checks shall be made on each coated weld joint using an approved, correctly calibrated magnetic dry film thickness gauge (e.g. Microtest, Elcometer or equivalent). The instrument shall be calibrated in accordance with SSPC PA-2.

A minimum number of 6 readings shall be taken on each field joint coating to verify compliance with the thickness requirement in paragraph 7.3.5.1. The readings shall include the weld seam.

8.2.3 On the first 5 joints of the job and twice each day thereafter, the quality of cure shall be checked by maintaining a MEK soaked pad in contact with the coating surface for one minute and then rubbing vigorously for 15 seconds. There shall be no softening of the coating or substantial color removal from the coating.

8.2.4 The finished coating shall have a uniform, glossy appearance and be free of defects such as holidays, fish eyes, lumps, dry spray, sags and runs.

100% of the coated girth weld surface area shall be holiday detected, inspected, and repaired in accordance with the procedures and equipment specified in SAES-H-200 for the mill-applied FBE coating on the pipe. Holiday detection shall not be

conducted if the surface temperature of the coated girth weld area exceeds 88°C.

Patch Coating

The material for patch coating shall be supplied or approved by the manufacturer of the powder epoxy coating. The patch coating shall not be applied when the pipe surface temperature is less than 3 deg C above the dew point.

6.3 Repairs

6.3.1 Damaged FBE coating shall be repaired as follows:

6.3.1.1 Areas smaller than 1450 sq mm - use thermal melt sticks or an epoxy-patching compound approved by the RSA.

6.3.1.2 Areas larger than 1450 sq mm and smaller than 0.2 sq m - use an epoxy-patching compound approved by the RSA.

6.3.1.3 Areas larger than 0.2 sq m - use APCS-113.

6.3.1.4 The repair coating shall overlap the adjacent sound coating by at least 13 mm. Coating application shall be according to the Manufacturer's recommendations.

6.3.2 Damaged PE coating shall be repaired as follows:

6.3.2.1 Isolated holidays less than 150 mm in any direction - Use a heat shrink patch approved by the RSA. An average of no more than 1 field patch per 12 meter joint shall be acceptable for any consecutive 100 meters. Damage in excess of this shall be sleeved in accordance with paragraph 6.3.2.2 or cut out in accordance with paragraph 6.3.2.3. The patches shall overlap the adjacent, sound coating by at least 50 mm.

6.3.2.2 Holidays larger than 150 mm in any direction (including close spaced, individual holidays that cannot be covered by a single patch

per paragraph 6.3.2.1) - Use a full encirclement heat shrink sleeve approved by the RSA. The sleeve shall overlap the adjacent sound coating by at least 50 mm. Where more than one sleeve is required, the sleeves shall be overlapped by at least 50%. A total of no more than 3 meters shall be sleeved in the field in any consecutive 100 meters in mountain terrain or 1000 meters in other terrain.

5.2.5 Internal coatings in dead-leg areas shall be holiday free.

5.3 Internal Coatings, Various Services

Categories	Appr'd Coatings Syst		Area to be Coated/ Other Remarks
	New Constr.	Maint.	
5.3.1 Water Potable	APCS-103 APCS-100 APCS-101 APCS-102 APCS-2B	APCS-103 APCS-102 APCS-2B	APCS-100, 101, & 102 must be certified suitable for potable water services.
5.3.2. Water Oil or Gas	APCS-100 APCS-101 APCS-102 APCS-103	APCS-103 APCS-2A	For APCS-2A the allowable pH range is 5.0 to 12.0, the maximum allowable service pressure is 3445 KPa (ga) (500 psig), and the maximum allowable partial pressures of H (2) S and CO (2) are each 345 KPa (abs) (50 psia).

Categories	Appr'd Coatings Syst		Area to be Coated/ Other Remarks
	New Constr.	Maint.	
5.4.1 Buried (Pipe Body)	APCS-104 APCS-105 APCS-106	APCS-109 APCS-113	APCS-106 may only be used in cases where subsequent field bending will not be required, e.g., cement-lined pipe. APCS-113 may be used on new construction to repair damaged FBE, to coat already cement-lined pipe, and on short runs of pipe (60 meters or less) that will not require subsequent bending.
5. 4. 2 Buried (Field Girth Welds)	APCS-104 APCS-110 APCS-111 APCS-112	APCS-113 APCS-107 APCS-109 APCS-22	Use APCS-22 if the surface is slightly damp or has oil/salt contamination. APCS-113 may be used on new construction for tie-in welds and for girth welds on thrust-bored pipe.
5. 4. 3 Buried Fittings, Appurtenances, And Spool Pieces	APCS-104 APCS-113 APCS-19B	APCS-113 APCS-19B APCS-22 APCS-10 APCS-23	Use APCS-22 if the surface is slightly damp or has oil/salt contamination. Tapewrap (APCS-107 or APCS-109) is acceptable for maintenance on tapewrapped or P2-coated lines.

5. 4. 4 Buried Road Crossings	APCS-104 APCS-105 APCS-113 APCS-19B	APCS-113 APCS-19B APCS-107 APCS-109	On sleeved crossings, the carrier pipe shall be coated with APCS-104, APCS-105, APCS-19B, or APCS-113. The casing shall be externally coated with any of these systems or with APCS-3.
5. 4. 5 Above Ground	Not Required	Not Required	
5. 4. 6 Buried Anchors	See Comments	See Comments	Coat concrete anchors in accordance with standard drawing L-AA-036531. Steel anchors shall be coated with APCS-113, APCS-22, or APCS-19B.

5.6 External Pipe Coatings, In-Plant

Categories	Appr'd Coatings Syst		Area to be Coated/
	New Constr.	Maint.	Other Remarks
5. 6. 1 Buried (All services except insulated)	See Remarks	See Remarks	Same as for cross-country pipe. Exceptions: APCS-107 and APCS-109 shall not be used on buried hydrocarbon lines on plot.

5. 6. 2 Insulated (Cold System)	APCS-104 APCS-2A APCS-10 APCS-105 APCS-108	Same as new Construction	Applies to pipe that will be operated continuously or intermiiently below atmopheric dew point. Cover with polyurethane or foam glass insulation. For APCS-2A, contact RSA if applied onto cold surfaces. Use APCS17A or APCS-17B for temperatures less than minus 40 ^{0}C.
5. 6. 3 Insulated (Hot System)	See Remarks	See Remarks	No coating needed where continuous operating temperatiures exceed 65 ^{0}C and the facility is in service at least 90% of the time. Otherwise, obtain coating requirements from responsible Technical Orgaanization.
5. 6. 4 Mild Atmospheric Exposure	APCS-4 APCS-6 APCS-26B		
5. 6. 5 Industrial and/or High Humidity Atmospheric Exposure	APCS-1A APCS-1B APCS-22 APCS-26B	APCS-26A APCS-26B APCS-1B APCS-1C APCS-22	

5.2 Materials

5.2.1 Abrasive shall be kept dry and clean. Regardless of the type of abrasive, the sulphate, chloride, and calcium carbonate content (if any) shall not exceed the levels given in Appendix I of this standard.

5.2.2 The use of reclaimed slag abrasives is prohibited. The use of reclaimed garnet is permitted provided it meets the requirements of para, 5.2.1 and an approved recycling system is utilized.

5.2.3 The use of sand as a blasting abrasive shall be permitted only as follows:

5.2.3.1 The sand shall meet the requirements given in Appendix I of this standard.

5.2.3.2 New construction, exterior surfaces. Sand meeting the requirements of para. 5.2.3.1 shall be permitted for APCS-4, APCS-6 and APCS-26. It is also permitted as a pre-blasting medium for exterior surfaces to be subsequently re-blasted with abrasive grit.

5.2.3.3 Spot repairs (Maintenance and New Construction) exterior surfaces: Sand-meeting requirements of para. 5.2.3.1 shall be permitted for maintenance/repairs to isolated areas not exceeding 0.1 sq. meters and no more than 5% of the total area of the structure is involved.

5.2.3.4 Sand shall not be used as a blasting abrasive for immersion coatings. Exception: spot removal of existing coatings for inspection purpose. The affected areas shall be re-blasted with abrasive grit prior to recoating.

Appendix I - Qualification Procedure For Sand For Abrasive Blasting

Prior to use, the Responsible Technical Organization shall certify in writing that the sand meets the requirements below:

1. Physical characteristics: The sand shall be clean, dry, and free of contaminants.
2. Composition: the sand shall contain more than 90% by weight silicon dioxide and less than 2.3% by weight calcium carbonate.
3. Loss on ignition in accordance with ASTM C146: at 1000 deg C the sand shall not lose more than 1% by weight.
4. Water solubles (1:1 extract): The abrasive shall be less than 250 ppm sulfates and less than 250 ppm chlorides, in accordance with ASTM D516 Method B and D512 Method A respectively.
5. Profile: The anchor pattern created on mild steel plate at 620 kPa (90psi) nozzle pressure during abrasive flow must be in accordance with the specified requirements of the applicable APCS Data Sheet.
6. Appearance: No discernable contaminants shall remain on the steel substrate when viewed through a5X Data Sheet.
A separate, new certification is required for each job. The Inspector may require additional checks during the course of the job if, in his opinion, conditions warrant it.

Table II - Calculating Dft, Wft, And Theoretical Coverage

Dry Film Thickness (DFT)

No solvent added: $DFT = WFT \times \%\ Solids\ by\ Volume$

Solvent added $DFT = WFT \times \dfrac{\%\ Solids\ by\ volume}{1 + \%\ thinner\ by\ volume}$

Theoretical Coverage

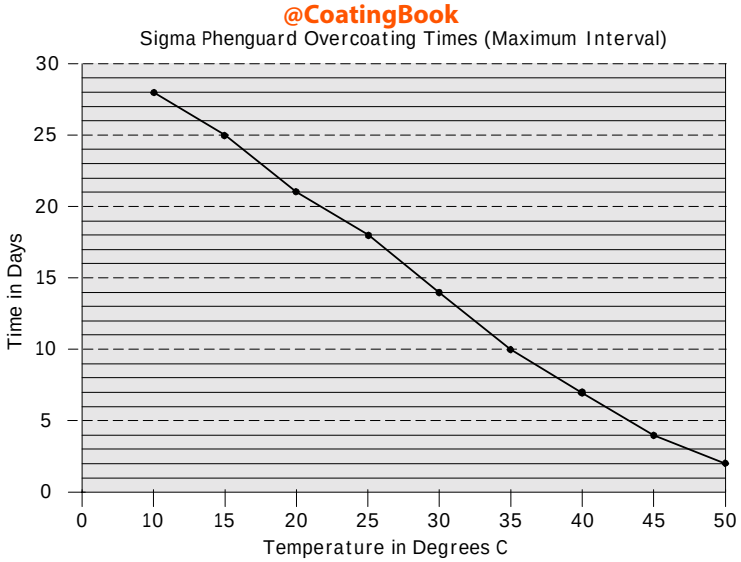
Coverage (sq. m) = No. L $\times$ % Solids per L $\times \dfrac{1000}{DFT\ (micrometers)}$

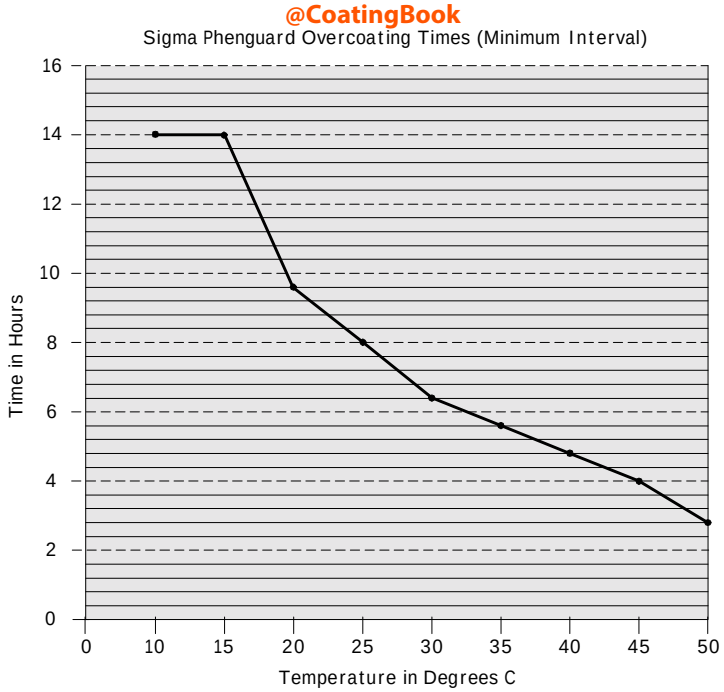
Coverage (sq. ft) = No. Gal coating $\times$ % Solids per L $\times \dfrac{1604}{DFT\ (mils)}$

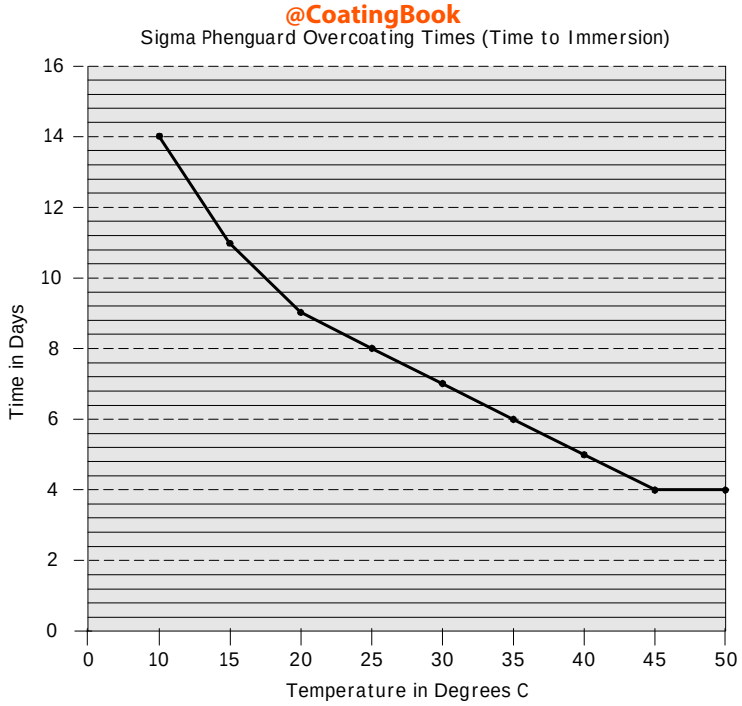
Table I – Dew Point Calculation Chart Ambient Air Temperature (Degrees Celsius)

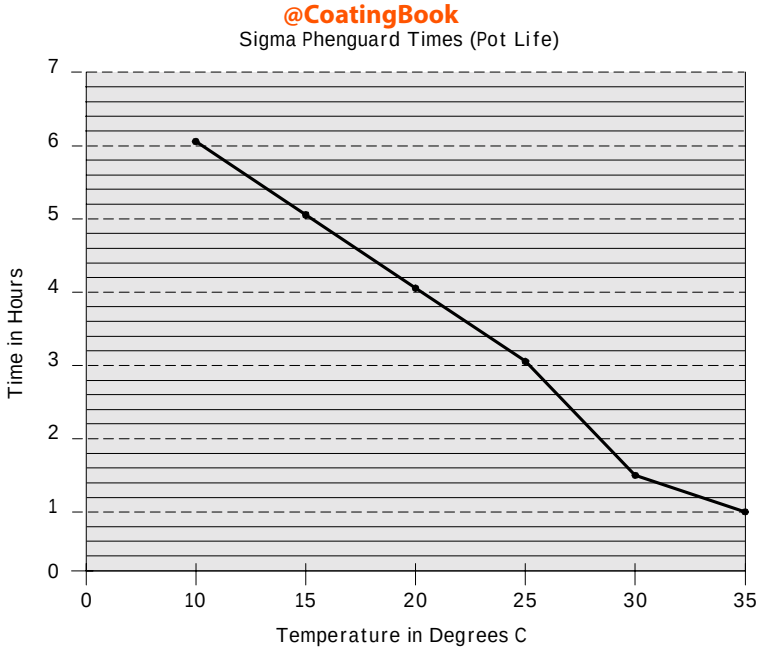
Relative Humidity	-7 °C	-1 °C	4 °C	10 °C	16 °C	21 °C	27 °C	32 °C	38 °C	43 °C	49 °C
90	-8	-2	3	8	14	19	25	31	36	42	47
85	-8	-3	2	7	13	18	24	29	35	40	45
80	-9	-4	1	7	12	17	23	28	34	39	43
75	-9	-4	1	6	11	17	22	27	33	38	42
70	-11	-6	-1	4	10	16	20	26	31	36	41
65	-11	-7	-2	3	8	14	29	24	29	34	39
60	-12	-7	-3	2	7	13	18	23	28	33	38
55	-13	-8	-4	1	6	12	16	21	27	32	37
50	-14	-9	-5	-1	4	10	15	19	25	30	34
45	-16	-11	-6	-2	3	8	13	18	23	28	33
40	-17	-12	-8	-3	2	7	11	16	21	26	31
38	-19	-13	-9	-5	-1	4	9	14	18	23	28
30	-21	-16	-11	-7	-2	2	7	11	16	21	25

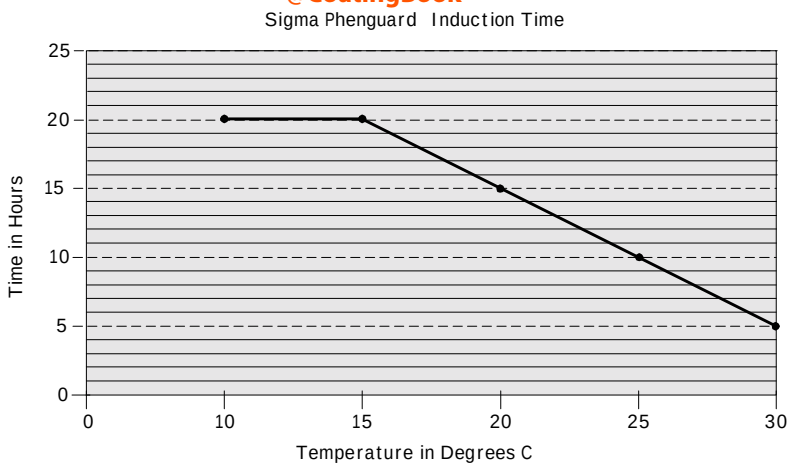
Example: if the air temperature is 21 deg. C the relative humidity is 70%, the dew point is 16 deg. C.











SACCID Inspection Reports

http://saoo.aramco.com.sa/data/saccid/saccid%20forms/GenlInsp/

INSP-9000

Ultrasonic Thickness Measurements
for Hot Tap/Sleeve Calculations

Plant Number: _____ Plant Name: _____ **Date:** _____

Equip./Line Number: _____ System: _____

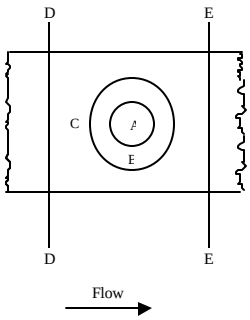
Description: _____

Ref: SAES-L-052, SAEP-311, Standard Drawing L-AB-036719

Equip./Pipe Details:	Diameter	Grade	Schedule	Flange Rating
Header				
Branch per Dwg.				

Continuous Scanning

	Measurement of Header in mm	Min	Max
1	Branch Centre -Point A.		
2	Branch Diameter Circle B.		
3	Reinforcing Pad Diameter Circle C.		
4	Reinforcing Sleeve Ends -Line D-D		
5	Reinforcing Sleeve Ends -Line E-E		
6	180 degree from Point A.		



Measurement on Header **MIN:** _____ mm **MAX:** _____ mm

Measurement on Sticker **MIN:** _____ mm **MAX:** _____ mm

Signed: _____ **Inspector** **Inspection Unit:** _____

Note: **For connection reinforcement requirements, refer to ASME B31.3, B31.4, B31.8, ASME Section VIII & SA Standard Drawing L-AB-036719.**

cc: Inspection File _____

SACPID-INSPECTION

INSP-9002

REQUEST FOR RADIOGRAPH, IN LIEU OF HYDROTEST

WAVER NUMBER (TO BE FILLED IN BY INSPECTION): _____

REFERENCE: _____ DATE: _____

PLANT NO: _____ SYSTEM #: _____

BI: _____ JO: _____ (If applicable)

ORIGINATOR'S NAME: _____ DEPT/DIV: _____

JUSTIFICATION: (PLEASE INCLUDE A DESCRIPTION AND/OR SKETCH OF FACILITIES INVOLVED)

SIGNATURES REQUIRED: (RETURN APPROVED ORIGINAL WAIVER TO RESPONSIBLE INSPECTION UNIT)

Please sign as numbered

1) ORIGINATOR: _____
2) UNIT SUPV., PLANT ENGG. _____
3) OPERATIONS SUPT.: _____
4) SUPV., INSP. UNIT: _____
5) GEN. SUPV., SACPID: _____
6) MANAGER, OPERATIONS: _____

RADIOGRAPHS WILL BE INTERPRETED TO APPLICABLE CODE.

CONDITIONS OF APPROVAL

_____
_____
_____
_____
_____

SACCID

FACILITY EXCEPTION ITEM LIST

ARAMCO 6133-
T INSP-9003

Date prepared:	Revision	1	2	3	4
Prepared by:					
Approved by:	Date				

	PLT.	Section:	Subject:

Item No.	Item Description	Required for Startup	Covered by Contract	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

SACCID

INSP-9006

LEAK REPAIR REPORT

(Fill in and/or encircle your choice)

Date Leak Reported: _____ Plant Number: _____ **System:** _____
Date Repair Started: _____ SACPID/____.: _____
Date Repairs Completed: _____ Date: _____

DATA

Equipment: _____ Plant Name: _____ On Plot: Yes / No
From: _____
To: _____ Service: * (Oil / Gas / Water / Sewer / Firewater/ Disposal / Chem. / Air / Seawater N2 / SO2 / S / SO2 SOL Injection Water / Supply Water)

Installation Date: _____ (Year)
Material: * CS / SS / PVC / FRP / GI / CI/RTR
Nominal Diameter: _____ (Inches)
Nominal Wall Thickness: _____ (Inches) Restrained: Yes / No

INSPECTOR'S REPORT

LEAK INFORMATION

Leak Location: _____
Leak Position: _____ Buried: Yes / No
Length / Dia.: HOLE " : _____ Backfill Type: Sand / Subkah / Marl / Rocky
RUPTURE " : _____
CAUSE : * Corrosion / Erosion / Mechanical / Crack
TYPE: * Internal / External
Corrosion Form: * General / Pit / Lake / Bands/ Groove

EXISTING COATING APPEARANCE

Details:
1. * Smooth / Cracked / Damaged
2. * Adherent / Detatched

Data Base Comments: Coating Type: APCS -

I. _____

II. _____

Repair: (Wood plug /Steel plug / Sleeve / Replaced / Weld Overlay/Patch)

NOTE: You may encircle more than one if necessary.

REPAIR DETAILS:

A. _____

B. _____

C. _____

INSPECTOR: _____ FIELD SUPERVISOR: _____

Inspection File: _____

*** Choose One Only.**

APPR. FOR COMP. INPUT

SIGNED:

SACCID

PRESSURE TEST REPORT

SAUDI ARAMCO 2642 INSP-9008 (Dec 00)

Reference Details:

Plant Name:	Plant No:	Insp. Unit:	SACPID/
Equipment Description:			
Location in Service:		System #:	
Shop Order:	DWG No:	SACPID Ref:	
Verbal Report To: [Contact Name & Position]		At: [Date & Time]	

Test Details:

Test Procedure in Accordance with:		Initial Test ☐ Revalidation ☐	Repair ☐ Modification ☐
Preliminary Tests:		Test Type: [Hydro /Pneu/ Leak	
Repairs During Tests:		Test Fluid:	
MAOP:		Test Temp:	
Relief Valve Tag #:		Test Pressure:	
Relief Valve Test Date:		Test Duration:	
Relief Valve Set Pressure:		Test Date:	
Pressure Gauge Cal Date:		Gauge Range:	

Sketch:

Test Results:

Accept: ☐ Reject: ☐ Conditional: ☐

Comments:

Inspector:	Field Supervisor:
Badge #:	Badge #:
Date:	Date:

SACCID

INSP-9009

RADIOGRAPHY REQUEST SHEET

Radiography ☐ *Corrosion*
☐ *Scale*

PLANT NAME: _____ AREA: _____
PLANT NO.: _____ INSPECTOR: _____ Date: __/__/__
[ ] ON PLOT INTERPRETER: _____ Date: __/__/__
[ ] OFF PLOT SYSTEM #: _____

FILM INDENT.	LINE IDENTIFICATION	SIZE DIA. x THKS	TYPE*	FINDINGS/REMARKS

* Type: 1. Offset Side Shot 3. Contact Side Shot File: _____
2. Offset Bottom Shot 4. Contact Bottom Shot

SACCID

INSP-9011

Ultrasonic Testing Inspection Report

Date: _____

Plant Name: _____ Plant Number: _____

Equipment Name: _____

Size / Line # : _____ System #: _____ Pressure: _____

OSI DWG. # : _____ Nominal Thk. : _____ mm

U.T. Location : _____ Retirement Thk. : _____ mm

U.T Equipment: _____ U.T. Measurement:

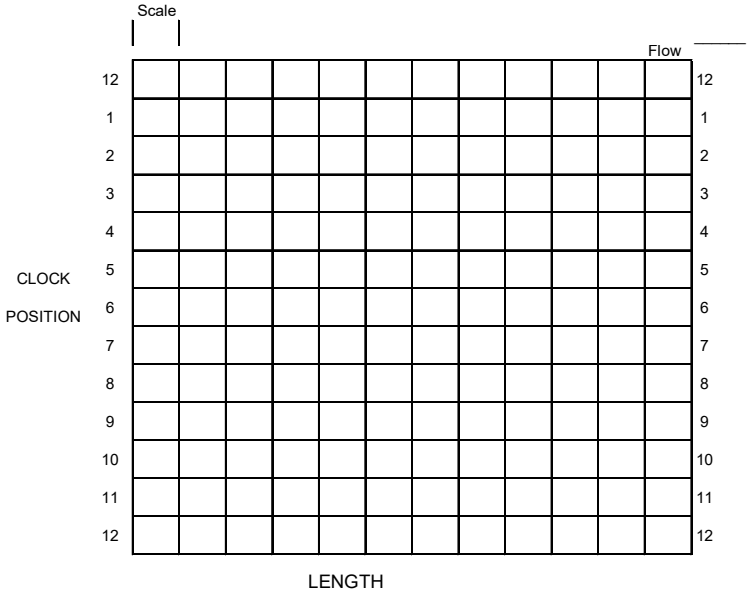
Probe Size: _____ mm Min: _____ mm Max: _____ mm

Frequency: _____ Mhz

Gain: _____ db Technicians: _____ Verified: _____

Range: _____ mm

Description / Sketch:



SACCID

INSP-9013

FREQUENT INSPECTION FORM

Plant Name						
Plant Number						
System Number						
Frequency		Weekly	Monthly	6 Monthly	Yearly	Other: Specify
Start Date						
End Date						
Letter Book#						
Job						
Remarks						
Inspector						
Field Supv.						

Plant Name						
Plant Number						
System Number						
Frequency		Weekly	Monthly	6 Monthly	Yearly	Other: Specify
Start Date						
End Date						
Letter Book#						
Job						
Remarks						
Inspector						
Field Supv.						

Plant Name						
Plant Number						
System Number						
Frequency		Weekly	Monthly	6 Monthly	Yearly	Other: Specify
Start Date						
End Date						
Letter Book#						
Job						
Remarks						
Inspector						
Field Supv.						

cc: Supervisor

File: D:\DATA\INSPFORM\INSP9013 Revised: Dec. 1995

INSP-9014

VESSEL INSPECTION REPORT

Plant Name: _____ **Plant Number:** _____ **Date:** ____/____/____

VESSEL DATA

Vessel Name: _____ Vessel Number: _____ System #: _____

Length/Height: _____ Diameter: _____ Mat'l: _____ Year Built: _____

Total Surface Area: _____ T-Minimum: Shells: _____ SIS Number: _____

Heads: _____

COATING DATA

Existing Type: _____ Date Applied: _____ Existing Dry Film Thk: _____

New Type: _____ Date Applied: _____ New Dry Film Thk: _____

ANODES

Old
Type: _____ Number: _____ % Consumed: _____ Date Installed: ____/____/_____

Replaced: YES/NO New Type: _____ Date Installed: ____/____/_____

REMARKS:

Recommendations:

Signed: _____

See reverse for vessel drawing

Date: ____/____/_____

SACCID

Aramco 4719-0 **INSP-9030**

ARAMCO INSPECTION PROCEDURES

LIQUID PENETRANT EXAMINATION REQUEST & REPORT SHEET

Log No.	B.I. No.	Job. No.	Plant No.	Plant Name	Contractor	
Location/Kilometer Reference		Aramco Rep.	Unit	Requested by:	Phone	Date
Technician	Date	Acceptance Criteria	Material Type	Approved by (Proj. Insp.)		Date
Sch/Wall Thick	Penetrant System A-3 ____ B-3 ____		Penetrant batch Batch No:	Penetrant Mfg.	Penetrant Part No.	Cleaner/Remover Part No.
Ultraviolet Light Used	Measured UV light Intensity		Developer Part No.		Surface Condition	

ITEM NO.	DRAWING NO.	EQUIPMENT NO/DIA/ LINE REFERENCE	SYSTEM NO.	WELD NO.	WELDER SYMBOL	EXAM RESULTS ACC.	EXAM RESULTS REJ.	REPAIR LOCATION AND DEFECT TYPE	COMMENTS

DISTRIBUTION:

1 _____
2 _____
3 _____
4 _____
5 _____

Note 1: Comments include type of work examined. New?, Repair?, Rework?, Tope of part if not weld. etc.

Note 2: All blanks are to be listed in. If information in particular blank is not applicable, write in N/a

Audited by: _____

COATING SURVEY

PLANT # :
PLANT NAME :
SYSTEM # :

DATE:

EQUIP. #	YEAR BUILT	SIZE		% AREA COATED	EXISTING COATING		COATING FAILURE		COATING REPAIR		CORROSION			WELD REPAIRS	ANODES	
		DIA	L.		TYPE	YEAR APPLIED	%	LOCATION	TYPE	YEAR COATED	TYPE	LOCATION	DEPTH	YES/NO	TYPE	#

PIPELINE HYDROTEST DATA FORM

Plant Name: _____ Plant Number: _____

Flowline/Trunkline Name: _____ System Number: _____

Hydrotest Date: ____/____/____

Test Pressure: _____ PSIG

MAOP: _____ PSIG

Hydrotest Interval _____ Year

Comments: _____

Inspector: _____

Field Supervisor: _____

Approved (Data Entry): _____

SACCID

Aramco 4719-8 **INSP-9031**

ARAMCO INSPECTION PROCEDURES

MAGNETIC PARTICLE EXAMINATION REQUEST & REPORT SHEET

Log No.	B.I. No.	Job. No.	Plant No.	Plant Name	Contractor	
Location/Kilometer Reference		Aramco Rep.	Unit	Requested by:	Phone	Date
Technician	Date	Acceptance Criteria	Material Type	Approved by (Proj. Insp.)		Date
Sch/Wall Thick.	Magnetic Particles, Mfg.	Particle Color	Wet Method or Dry?	Particles Part No.	Particles Batch No.	
Particle Size	Power Supply Descrptn. & Mfg.	Pwr. Sup. Model No. & Sl. No.	Magnettizing Current: Amps. _____ AC _____ DC _____			
Prod or Probe Method	Prod of Probe Mfg/Model No./Serial No.		Demagnetization Performed? Yes ___ No___ Equipment and Method Used:			
Surface Condition & Cleaning						

ITEM NO.	DRAWING NO.	EQUIPMENT NO/DIA LINE REFERENCE	SYSTEM #	WELD NO.	WELDER SYMBOL	EXAM RESULTS ACC	EXAM RESULTS REJ.	REPAIR LOCATION AND DEFECT TYPE	COMMENTS

DISTRIBUTION:

1 _____
2 _____
3 _____
4 _____
5 _____

Note 1: Comments include type of work examined. New?, Repair?, Rework?, Type of part if not weld. etc.

Note 2: All blanks are to be listed in. If information in particular blank is not applicable, write in N/a

Audited by: _____

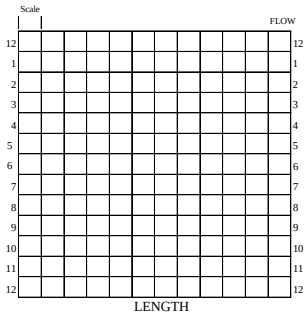
Ultrasonic Testing Inspection Report

Date: _____

Plant Name: _____ Palnt Number: _____

Equipment Name: _____
Size / Line #: _____
System #: _____ Pressure: _____
OSI DWG. #: _____ Nominal Thk.: _____mm
U.T. Location: _____ Retirement Thk: _____mm
U.T. Equipment: _____ U.T. Measurement:
Probe Size: _____mm
Frequency: _____Mhz Min: _____ mm Max: _____mm
Gain: _____db
Range: _____mm Technicians: _____ Verified: _____

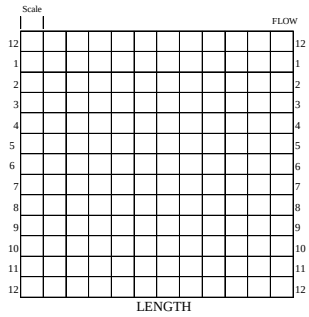
Description / Sketch:



Plant Name: _____ Palnt Number: _____

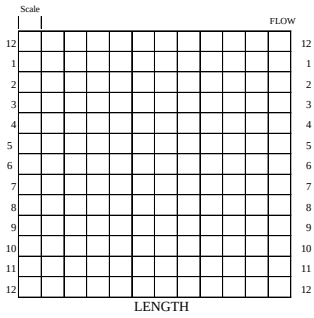
Equipment Name: _____
Size / Line #: _____
System #: _____ Pressure: _____
OSI DWG. #: _____ Nominal Thk.: _____mm
U.T. Location: _____ Retirement Thk: _____mm
U.T. Equipment: _____ U.T. Measurement:
Probe Size: _____mm
Frequency: _____Mhz Min: _____ mm Max: _____mm
Gain: _____db
Range: _____mm Technicians: _____ Verified: _____

Description / Sketch:



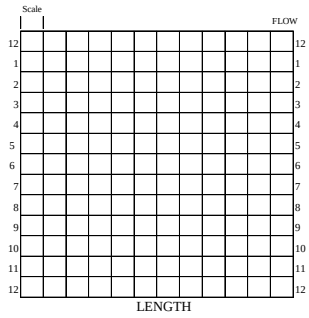
Equipment Name: _____
Size / Line #: _____
System #: _____ Pressure: _____
OSI DWG. #: _____ Nominal Thk.: _____mm
U.T. Location: _____ Retirement Thk: _____mm
U.T. Equipment: _____ U.T. Measurement:
Probe Size: _____mm
Frequency: _____Mhz Min: _____ mm Max: _____mm
Gain: _____db
Range: _____mm Technicians: _____ Verified: _____

Description / Sketch:



Equipment Name: _____
Size / Line #: _____
System #: _____ Pressure: _____
OSI DWG. #: _____ Nominal Thk.: _____mm
U.T. Location: _____ Retirement Thk: _____mm
U.T. Equipment: _____ U.T. Measurement:
Probe Size: _____mm
Frequency: _____Mhz Min: _____ mm Max: _____mm
Gain: _____db
Range: _____mm Technicians: _____ Verified: _____

Description / Sketch:



SACCID

INSP-9036

CHANGE OF REVALIDATION HYDROTEST INTERVAL

Plant Name: _____ **Plant Number:** _____ **Date:** _____

Pipeline #: _____ **System Number:** _____

Last Hydrotest Date: _____ **Initial Hydrotest:** YES ☐ NO ☐

Existing Hydrotest Interval: _____ years **Proposed Hydrotest Interval:** _____ years

Date of Next Hydrotest: _____

Justification Comments:

_____

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Originator

_____ _____

Supervisor, INSPECTION UNIT **Supervisor, PLANT ENGINEERING**

CONCURRENCE: _____

_____

SUPT. PRODUCING OPERATIONS DIV.

COATING ENVIRONMENT RECORD SHEET

Plant Name: _____ **Plant Number:** _____ **INSP-9038**

DATE	TIME	AMBIENT TEMP. ºC	STEEL TEMP. ºC	RELATIVE HUMIDITY	DEW POINT ºC	INSPECTOR

NOTES

1) Record the readings every two hours.
2) Coating shall not be applied if steel temperature is less than 10ºC or more than 50ºC.
3) Coating shall not be applied if steel temperature is less than 3ºC above the dew point (refer to Table I of SAES-H

HYDROSTATIC TESTING

3.0 Hydrostatic Testing

Types of Pressure Tests and Their Purposes

The following describes various types of pressure tests and their purposes. Each test can either be a hydrostatic test or, if approved by the Chief Inspection Engineer, a pneumatic test. **As previously noted, pressure tests will normally by hydrostatic.**

Strength Test

A Strength Test is a pressure test at an internal pressure that is high enough to verify the integrity of the piping and/or equipment for service at the Maximum Allowable Operating Pressure (MAOP). During this test, the equipment shall not be subject to impact. The test pressure shall be maintained for a duration of not less than 30 minutes for piping and 60 minutes for exchangers.

A strength test is applied in the following cases:

- Before piping system is initially placed in service.
- After repairs or alterations have been made that affect the strength of pressure containing parts, except as noted in SAES-A-004/SAES-L-56.
- At intervals as specified by Equipment Inspection Schedules.

Tightness Test

A Tightness Test is a pressure test, which is conducted at a reduced pressure from the strength test pressure, and is done immediately after the strength test. A tightness test only applies to cross-country pipelines, boilers, and pneumatic tests. The pressure must be maintained long enough to permit inspection of the entire system for leaks, and for at least 10 minutes in all cases.

Leak Test

A Leak Test is a pressure test to demonstrate that there are no leaks in the system at the test are normally conducted by Operations during start-up or commissioning of the facilities, using approved plant procedures, and are outside the scope of SAES-A-004.

System Test

A System Test is an in-situ strength test which is applied to a system that is comprised of piping and other equipment that operate at one MAOP, as limited by the weakest element in the system.

Service Test

A Service Test is a strength test for low-pressure utility services that is conducted at the operating pressure with the service fluid.

Revalidation Test

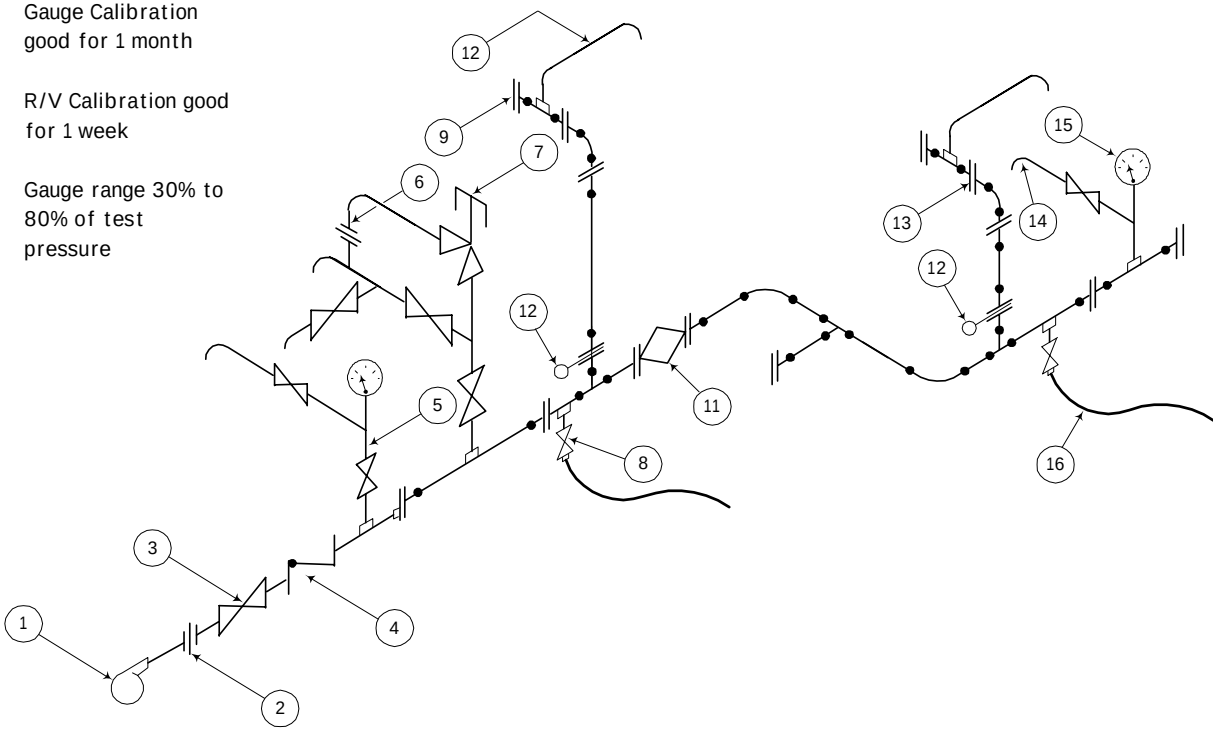
A Revalidation Test is a pressure test, which is meant to prove the integrity of buried cross-country pipelines. This test is conducted at the option of, and at the intervals set by, the responsible operating organization. Saudi Aramco Engineering Standard SAES-A-004 and the applicable industry code provide test pressure requirements. The following sections discuss test pressures for plant piping and cross-country pipelines.

The above was taken from the Saudi Aramco 1998 Engineering Encyclopedia.

Gauge Calibration good for 1 month

R/V Calibration good for 1 week

Gauge range 30% to 80% of test pressure



1.	Hand or reciprocating test pump
2.	Union (TYP.)
3.	Gate Valve (TYP.)
4.	Check Valve.
5.	Pressure Gauge with necessary valves and piping to release the pressure in the transition piping between the valve on the mainline and pressure.
6.	Relief valve by-pass-piping assembly when pressures exceed relief valve setting.
7.	Pressure Relief Valve
8.	Drain installed at 6.00 O'clock position on the mainline and preferably at the lowest point of the line being tested. A hose should be installed to the drain valve and run clear of any excavations to an improved dumping area.
9.	Weld Neck, Raised Face, Ring Joint and Blind Flange (TYP.)
10.	Vent with valve and piping assembly located at the high point of the piping network.
11.	Plug Valve in an open position during a typical hydrotest of more than one component.
12.	Spectacle plate illustrating an opening position during a hydrotest.
13.	Weld Neck, Raised Face or Ring Joint companion flanges.
14.	Calibrated pressure gauge and piping assembly for release of pressure following the mainline liquid dump.
15.	Calibrated pressure gauge liquid filled (Ethylene Glycol, thick liquid alcohol).
16.	Water discharge and suction.

HYRDROSTATIC TEST PRESSURES

FLANGE AND VALVE BODY RATING	FLANGE AND VALVE BODY TEST PRESSURE	VALVE RATING	VALVE SEAT TEST PRESSURE
150	450	150	315
300	1125	300	815
600	2225	600	1630
900	3350	900	2440
1500	5575	1500	4075
2500	9275	2500	6785

WELDING PROCEDURES

4.0 Welding Procedures

SAEP-1101 Refinery Pipe

Material Form	Plate or Pipe
Base Metal Thickness	Unlimited
Process	SMAW
Base Material	Carbon Steel (P1) & low alloy steels (P3, P4, P5, P9, P11)
Positions	All
Current	Direct (DC)
Polarity	Reverse (electrode +)
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm 5^{o}$)
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Root Bead	E6010 (1/8", 5/32")
Fill/Cap	E7018 or E8018-C1 (1/8", 5/32")
Diameter Range	2.5" NPS & greater
Filler Metal Root Fill/Cap	 EXX10/11 (A5.1, A5.5) EXX15/16/18 (A5.1, A5.5)

SAEP-1102 Cross Country (Downhill/Stovepipe Welding)

Material Form	Plate or Pipe
Base Metal Thickness	Unlimited
Process	SMAW
Base Material	Carbon Steel (P1)
Positions	All
Current	Direct (DC)
Polarity	Reverse (electrode +)
Weld Progression	Downhill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm 5^{o}$)

Root Face	1/16" (± 1/32")
Root Opening	1/16" (± 1/32")
Root Bead	E6010 or E7010 (1/8", 5/32")
Fill/Cap	E6010 or E7010 (1/8", 5/32")
Diameter Range	2.5" NPS & greater
Filler Metal Root/Fill/Cap	Exx10/11 (A5.1, A5.5)

SAEP-1103 Stainless Steel SMAW Welding

Material Form	Plate or Pipe
Base Metal Thickness	Unlimited
Process	SMAW
Base Material	Stainless steels (P8)
Positions	All
Current	Direct (DC)
Polarity	Reverse (electrode +)
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} (± 5^{o})
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Root Bead	E308, or 308L, E309, E310, E316 E316L (3/32", 1/8")
Fill/Cap	E308, or 308L, E309, E310, E316 E316L (3/32", 1/8") can be used
Diameter Range	2.5" NPS & greater
Filler Metal: Root/Fill/Cap	EXXX-15/16 (A5.4 austenitic)

SAEP-1104 Stainless Steel SMAW Welding with Backing Ring

Material Form	Plate or Pipe
Base Metal Thickness	Unlimited
Process	SMAW
Base Material	Stainless steels (P8), nickel (P41)

	and Ni-based (P42-47) alloys to themselves. Dissimilar metal welds include: Ni-based alloys to carbon steels, low alloy steels, stainless steels, nickel and Monel alloys; Monel alloys joined to carbon steels; nickel joined to stainless steels; and stainless steels joined to carbon steels.
Positions	All
Current	Direct (DC)
Polarity	Reverse (electrode +)
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	45^{o} ($\pm 5^{o}$)
Root Face	None
Root Opening	1/4" (± 1/16")
Metal Backing	Carbon steel backing strip
Root/Fill/Cap	E308, 308L, E309, E310, E316 or E316L (3/32", 1/8")
Diameter Range	2.5" NPS & greater
Filler Metal (Root/Fill/Cap): Stainless Steels Nickel Alloys Dissimilar Welds	 EXXX-15/16 (A5.4) Ni-based (A5.11) Ni-based (A5.11)

SAEP-1105 Dissimilar Steels

Material Form	Plate or Pipe
Base Metal Thickness	Unlimited
Process	SMAW
Base Material	Nickel alloys (P4X) to themselves and to carbon steels. Dissimilar metal welds include: Ni-based alloys to carbon steels, low alloy steels, stainless steels, nickel and monel

	alloys; monel alloys joined to carbon steels; nickel joined to stainless steels; stainless steels to carbon steels.
Positions	All
Current	Direct (DC)
Polarity	Reverse (electrode +)
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60° (± 5°)
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Metal Backing	None
Root/Fill/Cap	EniCrFe-3 (1/8", 5/32")
Diameter Range	2.5" NPS & greater
Filler Metal	Ni-based (A5.11)

SAEP-1106 Aluminum GTAW (TIG Welding)

Material Form	Plate or Pipe
Base Metal Thickness	0.474" maximum
Process	GTAW
Base Material	Aluminum and aluminum alloys (P21, P22, P23, and P25) to each other
Positions	All
Current	Alternating (AC)
Shielding Gas	Argon (10-20 CFH)
Gas Backing	Not required
Tungsten Electrode	1/8" 1/2-1% Zirconium oxide
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60° (± 5°)
Root Face	None
Root Opening	1/4" (± 1/16")
Metal Backing	Aluminum backing strip
Root/Fill/Cap	ER4043 (1/8")

Diameter Range	2.5" NPS & greater
Filler Metal	ERXXXX, (5.10)

SAEP-1107 Stainless Steel (TIG Welding)

Material Form	Plate or Pipe
Base Metal Thickness	0.436" maximum
Process	GTAW
Base Material	Carbon steels (P1), low alloy steels (P3, P4, P5, P9, & P11), stainless steels (P8) only to themselves. And carbon & low alloy steels to each other.
Positions	All
Current	Direct (DC)
Polarity	Straight (electrode -)
Shielding Gas	Argon (10-20 CFH)
Gas Backing	Argon (2-5 CFH)
Tungsten Electrode	3/32" 2% Thoriated
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm 5^{o}$)
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Metal Backing	None
Root/Fill/Cap Stainless steel Carbon Steel Low Alloy Steel Stainless Steel	 ER308L (3/32") or ER309L ER316L ERXXS-X (A5.18) ERXX (X) S-X (X) (A5.28) ERXXX (A5.9)
Diameter Range	1" NPS and greater with no restrictions. For the occasional job requiring welding of butt joints less than (1") diameter, the welder shall weld a 2G and 5G-test coupon on the smallest job size diameter

	tubing. The OTU Inspector shall witness the welding and the weld radiographed.

SAEP-1108 Small Bore Stainless Steel (TIG Welding)

Material Form	Plate or Pipe
Base Metal Thickness	0.436" maximum
Process	GTAW
Base Material	Nickel (P41) and Ni-based alloys (P42-47) to themselves and to each other. Dissimilar metal welds include Ni-based alloys to carbon steels, low alloy steels, stainless steels, nickel monel alloys; Monel alloys joined to carbon steels; nickel joined to stainless steels; and stainless steels to carbon steels.
Positions	All
Current	Direct (DC)
Shielding Gas	Argon (10-20 CFH)
Gas Backing	Argon (2-5 CFH)
Tungsten Electrode	3/32" 2% Thoriated
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm 5^{o}$)
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Metal Backing	None
Root/Fill/Cap	ERNiCr-3 (3/32")
Filler Metal	A5.14
Diameter Range	1" NPS and greater

SAEP-1109 Aluminum (TIG Welding)

Material Form	Plate or Pipe
Base Metal Thickness	0.474" maximum
Process	GTAW
Base Material	Aluminum and aluminum alloys (P21, P22, P23, P25) to each other
Positions	All
Current	AC (Alternating)
Shielding Gas	Argon (10-20 CFH)
Gas Backing	Argon (2-5 CFH)
Tungsten Electrode	1/8" 1/2-1% Zirconium oxide
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm 5^{o}$)
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Metal Backing	None
Root/Fill/Cap	ER4043 (1/8")
Filler Metal	ERXXXX, (A5.10)
Diameter Range	2.5" NPS and greater

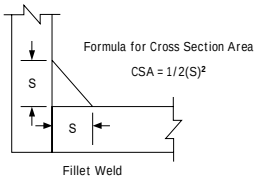
SAEP-1112 Small Bore Piping

Material Form	Pipe
Base Metal Thickness	0.436" maximum
Process	SMAW
Base Material	Carbon Steel (P1)
Positions	All
Current	DC
Polarity	Reverse (electrode +)
Weld Progression	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm 5^{o}$)
Root Face	1/16" (± 1/32")
Root Opening	1/8" (± 1/32")
Metal Backing	None
Root	E6010 (3/32" or 1/8")

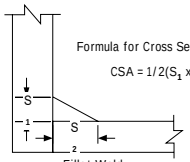
Fill/Cap	E7018 or E8018-C1 (3/32" or 1/8")
Filler Metal	
Root	EXX10/11 (A5.1, A5.5))
Fill/Cap	EXX15/16/18 (A5.1, A5.5))
Diameter Range	1" NPS and greater

SAEP-1114 Plate Welding

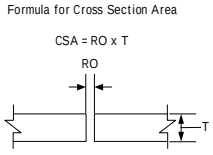
Material Form	Plate
Process	SMAW
Base Material	Carbon Steel (P1) and low alloys steels (P3, P4, P5, P9, P11) to themselves and to each other
Positions	All
Current	DC
Polarity	Reverse (electrode +)
Weld Progression	Uphill except for the root bead which can be run uphill or downhill
Root Bead	Uphill or downhill (downhill progression can only be performed with E6010) (E7018 Uphill progression only)
Fill/Cap	Uphill
Backside Arc gouged	Uphill
Joint Type	Single vee
Bevel Angle	60^{o} ($\pm$ 5^{o})
Root Face	1/8" ($\pm$ 1/16")
Root Opening	1/8" ($\pm$ 1/16")
Metal Backing	None
Root	E6010 (3/16") or E7018 (1/8")
Fill/Cap	E7018 (1/8" or 5/32")
Filler Metal Root	EXX10/11 (A5.1, A5.5)) or EXX15/16/18 (A5.1, A5.5)
Fill/Cap	EXX15/16/18 (A5.1, A5.5)
Base Metal Thickness	Unlimited



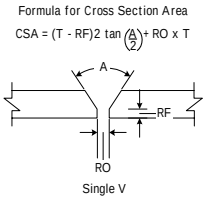
Fillet Weld
(Equal Legs)



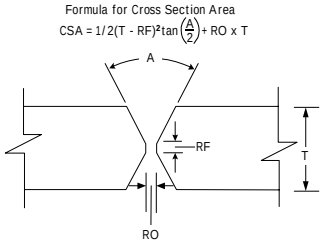
Fillet Weld
(Unequal Legs)



Square



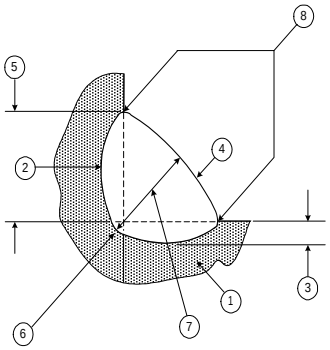
Single V



Double V

The Fillet Weld

(1)	BASE METAL:	Metal to be welded.
(2)	BOND LINE:	The junction of the weld metal and the base metal.
(3)	DEPTH OF FUSION:	The distance that fusion extends into the base metal
(4)	FACE OF WELD:	The exposed surface of a weld on the side from which the weld was done
(5)	LEG OF FILLET WELD:	The distance from the root of the joint to the toe of the fillet weld.
(6)	ROOT OF WELD:	The point or points, as shown in crosssection, at which the bottom of the weld intersects the base metal surface or surfaces.
(7)	THROAT OF FILLET WELD:	The shortest distance from the root of the fillet weld to its face.
(8)	TOE OF A WELD:	The junction between the face of a weld and the base metal.

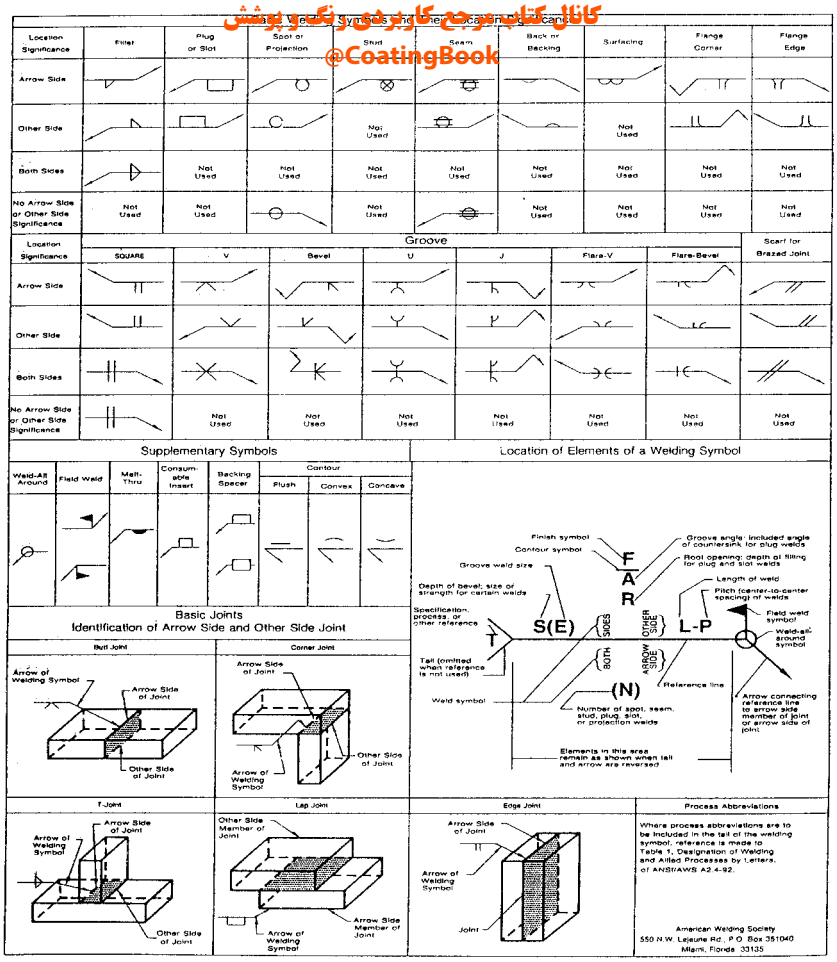


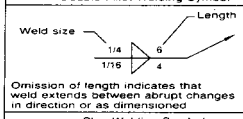
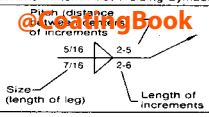
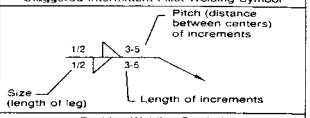
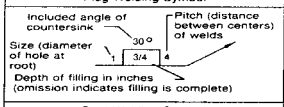
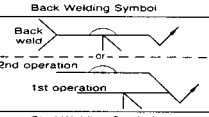
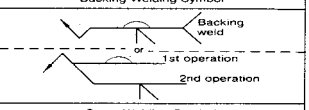
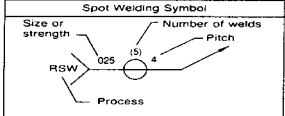
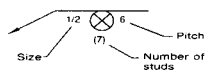
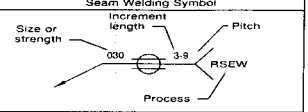
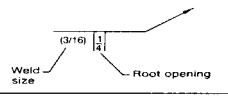
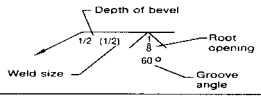
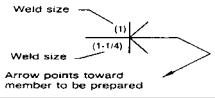
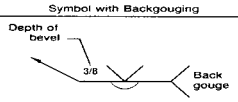
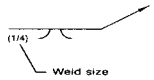
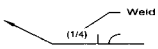
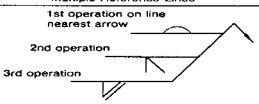
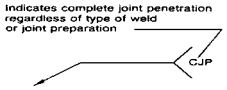
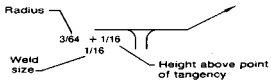
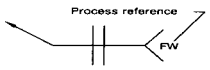
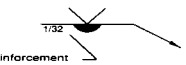
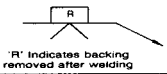
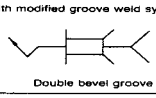
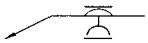
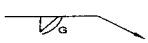
	Carbon Steel	Killed Steel	Carbon Moly Steel	Cast Iron	304 SS (18-8 Cr. Ni.)	310 SS (25-20 Cr.-Ni.)	316 SS	Inconel	Incoloy	Hastelloy B
Carbon Steel	E6010 E7018	E7018	E7018	Certanium 889 Ni-Rod 55 Braze (Oxweld 25M)	1. E309 2. Inco A 3. E310*	1. E309 2. Inco A 3. E310*	1. E309 2. Inco A 3. E310*	Inconel 182	Inco A	1. Hast. B 2. Inconel 182
	Killed Steel	E7010	E7018	Certanium 889 Ni-Rod 55 Braze (Oxweld 25M)	1. E309 2. Inco A 3. E310*	1. E309 2. Inco A 3. E310*	1. E309 2. Inco A 3. E310*	Inconel 182	Inco A	1. Hast. B 2. Inconel 182
		Carbon Moly Steel	E7010 A1 (for plate) E7010 A1 (for pipe only)	Certanium 889 Ni-Rod 55 Braze (Oxweld 25M)	1. E309 2. Inco A 3. E310*	1. E309 2. Inco A 3. E310*	1. E309 2. Inco A 3. E310*	Inconel 182	Inco A	1. Hast. B 2. Inconel 182
			Cast Iron	Certanium 889 Ni-Rod 55 Braze (Oxweld 25M) Gas Weld (Cast iron filler rod)	X	X	X	Braze (Oxweld 25M)	Braze (Oxweld 25M)	X
				304 SS (18-8) Cr. Ni.	E308	1. E309 2. E308	1. E308 2. E316	Inconel 182	Inco A	1. Hast. B 2. Inconel 182 3. E310
					310 SS (25-20 Cr. Ni.)	E310	1. E309 2. E316	Inconel 182	Inco A	1. Hast. B 2. Inconel 182 3. E310
						316 SS	E316	Inconel 182	Inco A	1. Hast. B 2. Inconel 182 3. E310
							Inconel	Inconel 182	Inco A	Inco A
								Incoloy	1. Inco A 2. E310*	Inco A
									Hastelloy B	1. Hast. B

	Hastelloy C	Monel	Brass	3-1/2% Nickel	1-1/4% & 2-1/4% Chrome Moly	5% Chrome Moly	9% Chrome Moly	12% Chrome SS
Carbon Steel	Hast. C	1. Monel 190 2. Inco A	Braze (Oxweld 25M)	1. E7018 A 2. Inco A A 3. E8018 C2 A	1. E7018 B 2. E9018 B3 B	1. E7018 B 2. E9018 B3 B 3. E502 B 4. E310* A	1. E9018 B3 B 2. E502 B 3. Murex Croloy 9A B 4. E310* A	1. Inco A A 2. E310 A 3. E410 B
Killed Steel	Hast. C	1. Monel 190 2. Inco A	Braze (Oxweld 25H)	1. E7018 A 2. Inco A A 3. E8018 C2 A	1. E7018 B 2. E9018 B3 B	1. E7018 B 2. E9018 B3 B 3. E502 B 4. E310* A	1. E9018 B3 B 2. E502 B 3. Murex Croloy 9A B 4. E310* A	1. Inco A A 2. E310 A 3. E410 B
Carbon Moly Steel	Hast. C	1. Monel 190 2. Inco A	Braze (Oxweld 25H)	1. E7018 A 2. Inco A A 3. E8018 C2 A	1. E7018 B 2. E9018 B3 B	1. E7018 B 2. E9018 B3 B 3. E502 B 4. E310* A	1. E9018 B3 B 2. E502 B 3. Murex Croloy 9A B 4. E310* A	1. Inco A A 2. E310 A 3. E410 B
Cast Iron	X	Braze (Oxweld 25H)	Braze (Oxweld 25H)	Braze (Oxweld 25H)	Braze (Oxweld 25H)	Braze (Oxweld 25H)	Braze (Oxweld 25H)	Braze (Oxweld 25H)
304 SS (18-8 Cr. Ni.)	1. Hast. C 2. Inconel 182 3. E310	Inconel 182	X	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. Inco A A 2. E310 A
310 SS (25-20 Cr. Ni.)	1. Hast. C 2. Inconel 182 3. E310	Inconel 182	X	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. Inco A A 2. E310 A

	Hastelloy C	Monel	Brass	3-1/2% Nickel	1-1/4% & 2-1/4% Chrome Moly	5% Chrome Moly	9% Chrome Moly	12% Chrome SS
316 SS	1. Hast. C 2. Inconel 182 3. E310	Inconel 182	X	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. E309 A 2. Inco A A	1. Inco A A 2. E310 A
Inconel	Inco A	Inconel 182	Braze (Oxweld 25H)	1. Inco A A 2. E310 A	Inco A A	Inco A A	Inco A A	1. Inco A A 2. E310 A
Incoloy	Inco A	Inconel 182	Braze (Oxweld 25H)	1. Inco A A 2. E310 A	Inco A A	Inco A A	Inco A A	1. Inco A A 2. E310 A
Hastelloy B	Hast. B	1. Monel 190 2. Inco A	X	Hast. B A	1. Hast. B A 2. Inco A A	X	X	X
Hastelloy C	Hast. B	1. Monel 190 2. Inco A	X	Hast. B A	1. Hast. B A 2. Inco A A	X	X	X
	Monel	Monel 190	Braze (Oxweld 25H)	1. Monel A 190 2. Inco A A	Inco A A	X	X	X
		Brass	Braze (Oxweld 25H)	X	X	X	X	X
			3-1/2% Nickel	1. E8018 C2 B 2. Inco A A	X	X	X	X
				1-1/4% & 2-1/4% Chrome Moly	E9018 B3 B	1. E9018 B3 B 2. E502 B 3. E310* B	1. E9018 B3 B 2. E502 B 3. Murex Croloy 9A B 4. E310* B	Inco A A
					5% Chrome Moly	E502 B	1. E502 B 2. Murex Croloy 9A B 3. E310* B	Inco A A
						9%	1. Murex Croloy 9A B 2. E310* B	Inco A A
							12% Chrome SS	1. E410 B 2. Inco A A 3. E310* B

	Monel	Brass	3-1/2% Nickel	1-1/4% & 2-1/4% Chrome Moly	5% Chrome Moly	9% Chrome Moly	12% Chrome SS
Monel	Monel 190	Braze (Oxweld 25H)	1. Monel 190 A 2. Inco A A	Inco A A	X	X	X
	Brass	Braze (Oxweld 25H)	X	X	X	X	X
		3-1/2% Nickel	1. E8018 C2 B 2. Inco A A	X	X	X	X
			1-1/4% & 2-1/4% Chrome Moly	E9018 B3 B	1. E9018 B3 B 2. E502 B 3. E310* B	1. E9018 B3 B 2. E502 B 3. Murex Croloy 9A B 4. E310* B	Inco A A
				5% Chrome Moly	E502 B	1. E502 B 2. Murex Croloy 9A B 3. E310* B	Inco A A
					9%	1. Murex Croloy 9A B 2. E310* B	Inco A A
						12% Chrome SS	1. E410 B 2. Inco A A 3. E310* B



Double-Fillet Welding Symbol	Chain Intermittent Fillet Welding Symbol	Staggered Intermittent Fillet Welding Symbol
		
Plug Welding Symbol	**Back Welding Symbol**	**Backing Welding Symbol**
		
Spot Welding Symbol	**Stud Welding Symbol**	**Seam Welding Symbol**
		
Square-Groove Welding Symbol	**Single-V Groove Welding Symbol**	**Double-Bevel-Groove Welding Symbol**
		
Symbol with Backgouging	**Flare-V-Groove Welding Symbol**	**Flare-Bevel-Groove Welding Symbol**
		
Multiple Reference Lines	**Complete Penetration**	**Edge Flange Welding Symbol**
		
Flash or Upset Welding Symbol	**Melt-Thru Symbol**	**Joint with Backing**
		
Joint with Spacer	**Flush Contour Symbol**	**Convex Contour Symbol**
		

* It should be understood that these charts are intended only as shop aids. The only complete and official presentation of the standard welding symbols is in A2.4.

INSPECTION TOOLS

5.0 Inspection Tools

The following is a list of some auxiliary items that can be used to assist in conducting an effective visual inspection.

• Standard forms/inspection checklist

This item includes the Saudi Aramco EIS form, if appropriate; as well as any other approved procedural checklists.

• Notebook and pencil

Use a notebook and pencil to write down observations at the time they are made rather than attempting to recall them later.

• Original designs and data from earlier inspections

Refer to new or previously noted conditions in order to distinguish between deviations and normal or desired conditions. Notes and photographs or drawings from earlier inspections can be useful in making decisions about current conditions.

• Cleaning tools

When needed, use simple cleaning tools such as a scraper or steel brush to clean a surface before making a preliminary visual inspection. Chalk or similar marking device. Use marking materials such as chalk to identify potential or suspected problem areas.

• Straight ruler, square, and level

Use these items to measure problem areas and record the results for use in follow-up inspections or treatments.

• **Vernie**r, **micrometer**, and measuring tape

Use these simple measuring tools to determine and record material thicknesses, a key indicator of corrosion.

Visual inspections can include both external and internal surfaces of equipment. Internal surfaces, especially, are often inaccessible and require the use of special inspection tools. In addition to the auxiliary items listed earlier, the following tools can be used to gather and record data during visual inspections.

- Fiber Optics
- **Pit Gauges**
- Cameras
- Mirrors
- Magnets

The uses, advantages, and limitations of each of these instruments will be discussed in depth later in this module.

Visual Details of Corrosion Types

TABLE 2. Characteristics of Some Corrosion-Related Failures

Appearance	Probable Contributing Factors
Small conical pits with steep sides and smooth edges. Pits filled with black deposit.	Hydrogen sulfide attack (H_2S may be natural or generated by bacteria)
As above plus transverse cracks.	Hydrogen sulfide attack with tensile stress (stress corrosion fatigue)
Transverse fracture with little or no pitting but with black deposit.	Sulfide stress cracking Excessive metal hardness
Round bottom connecting pits with sharp sides. Grey deposit but pit bottoms are bright.	Carbon dioxide attack
General thinning with sharp feathery or weblike residual metal. Little or no deposits.	Mineral acid corrosion
Rust deposits. Shallow, widespread pitting or deep pits under rust nodules.	Oxygen corrosion
Single, isolated pits in a row on one side.	Electrolytic corrosion due to current discharge
Worn or abraded areas with numerous small pits.	Erosion by solids or metal rubbing presence of H_2S, CO_2, or O_2

Pit Gauges

Description/Operation. Pit gauges are instruments used to measure the depth of pitting by placing a calibrated rod in the pit.

Application. Pit gauges are used to access the severity of localized corrosion pitting. They can be used to measure the depth and width of a depression or cavity in a pitted metal surface. The distribution of the attack and an indication of the rate of corrosion can be determined by using these tools.

Advantages and Limitations. Pit gauges are relatively simple to use and the data gathered by using them is easily interpreted. These tools can be used to measure the depth of pitting on any accessible surface.

Mirrors

Description/Operation. To handle a variety of circumstances, mirrors of varying sizes should be available, from a small dentist-style mirror for small openings too much larger mirrors for larger exterior surfaces. Miniature light sources can be attached to mirrors in order to illuminate dark areas.

Application. Mirrors can be used to observe inaccessible areas such as the external surfaces of pipelines that are near the ground or a wall. They can also be used to inspect the underside of a pipe that is difficult to see. In addition, mirrors can be used to look around corners or through small openings.

Advantages and Limitations. The advantages of mirrors include the fact that they are simple to "operate" and easy to use. They are also inexpensive. Their greatest limitation is the fact that, although mirrors are an effective tool for close-up observation, their usefulness is limited to short-range viewing.

Magnets

Application. Magnets can assist in identifying the individual material composition of a piece of equipment by checking the magnetic properties. Since only a few metals are easily identified by visual observation alone, a magnet can be used to distinguish, for example, between magnetic types of steel and nonmagnetic stainless steel and other alloys.

Advantages and Limitations. Magnets provide a simple, easy, and inexpensive means of identifying certain types of metal. This simplicity is also a limitation since the use of magnets as an inspection tool is limited to this single application.

6.0 Safety Guidelines

Basic Safety Precautions

Burn Protection

Molten metal sparks, molten slag, and welding, cutting and other related processes produce hot metal surfaces. Serious burns can occur if correct precautionary measures are not taken. Appropriate footwear, clothing and eye protection should be used.

Fumes & Gases

Many welding, cutting and related processes produce fumes and gases, which may be harmful to health. Avoid breathing arc-welding fumes at all times. When inspecting welding in a confined area, ensure there is an adequate ventilation system.

Radiation Burns

Arc welding produces ultra-violet and infrared radiation rays, which will severely burn exposed eyes and skin. Always wear protective clothing and eye protection to protect the skin and eyes from radiation burns.

Electrical Hazards

Electric shock can kill. However, it can be avoided if the correct safety precautions are practiced. Never touch live electrical parts. The manufacturer's instructions and recommended safe practices should be read and understood. Faulty installation, improper grounding and incorrect operation and maintenance of electrical equipment are all sources of danger.

PIPING

7.0 Piping

ANSI B36.10Welded and Seamless Wrought Pipe

Nominal Pipe Size	Out Side Diam.	Sched 10	Sched 20	Sched 30	Stand ard	Sched 40	Sched 60
1	1.315	-	-	-	0.133	0.133	-
2	2.375	-	-	-	0.154	0.154	-
2½	2.875	-	-	-	0.203	0.203	-
3	3.5	-	-	-	0.216	0.216	-
3½	4.0	-	-	-	0.226	0.226	-
4	4.5	-	-	-	0.237	0.237	-
5	5.563	-	-	-	0.258	0.258	-
6	6.625	-	-	-	0.280	0.280	-
8	8.625	-	0.250	0.277	0.322	0.322	0.406
10	10.75	-	0.250	0.307	0.375	0.365	0.500
12	12.75	-	0.250	0.330	0.375	0.406	0.562
14	14.0	0.250	0.312	0.375	0.375	0.438	0.594
16	16.0	0.250	0.312	0.375	0.375	0.500	0.656
18	18.0	0.250	0.312	0.438	0.375	0.562	0.750
20	20.0	0.250	0.375	0.500	0.375	0.594	0.812
22	22.0	0.250	0.375	0.562	0.375	-	0.875
24	24.0	0.250	0.375	-	0.375	0.688	0.969
26	26.0	0.312	0.500	0.625	0.375	-	-
28	28.0	0.312	0.500	0.625	0.375	-	-
30	30.0	0.312	0.500	0.625	0.375	-	-
32	32.0	0.312	0.500	0.625	0.375	0.688	-
34	34.0	0.312	0.500	0.625	0.375	0.688	-
36	36.0	0.312	0.500	0.625	0.375	0.750	-
38	38.0	-	-	-	0.375	-	-
40	40.0	-	-	-	0.375	-	-

ANSI B36.10Welded and seamless Wrought Pipe

Nominal Pipe Size	Out Side Diam.	Extra Strong	Sched 80	Sched 100	Sched 120	Sched 160	XX Strong
1	1.315	0.179	0.179	-	-	0.250	0.358
2	2.375	0.218	0.218	-	-	-	0.436
2½	2.875	0.276	0.276	-	-	0.375	0.552
3	3.5	0.300	0.300	-	-	0.438	0.600
3½	4.0	0.318	0.318	-	-	-	-
4	4.5	0.337	0.337	-	0.438	0.531	0.674
5	5.563	0.375	0.375	-	0.500	0.625	0.750
6	6.625	0.432	0.432	-	0.562	0.719	0.864
8	8.625	0.500	0.500	0.594	0.719	0.906	0.875
10	10.75	0.500	0.594	0.719	0.844	1.125	1.000
12	12.75	0.500	0.688	0.844	1.000	1.312	1.000
14	14.0	0.500	0.750	0.938	1.094	1.406	-
16	16.0	0.500	0.844	1.031	1.219	1.594	-
18	18.0	0.500	0.938	1.156	1.375	1.781	-
20	20.0	0.500	1.031	1.281	1.500	1.969	-
22	22.0	0.500	1.125	1.375	1.625	2.125	-
24	24.0	0.500	1.219	1.531	1.812	2.344	-
26	26.0	0.500	-	-	-	-	-
28	28.0	0.500	-	-	-	-	-
30	30.0	0.500	-	-	-	-	-
32	32.0	0.500	-	-	-	-	-
34	34.0	0.500	-	-	-	-	-
36	36.0	0.500	-	-	-	-	-
38	38.0	0.500	-	-	-	-	-
40	40.0	0.500	-	-	-	-	-

Plant Piping

• Unless limited by flanges or by valves in the line, the hydrostatic strength-test pressure shall be calculated to produce a hoop stress of 90% of the specified minimum yield strength (SMYS), but shall not be less than the minimum test pressure that is determined per ASME/ANSI B31.3. For new installations, the test pressure shall be calculated based on nominal pipe wall thickness less mill tolerance (manufacturer's minus tolerance). Strength test pressures for existing piping shall be per ASME/ANSI B31.3, based on the design pressure.

• Based on ASME/ANSI B31.3, Paragraph 345.4, for hydrostatic leak tests, the hydrostatic test pressure at any point in a metallic piping system shall be as follows:

(a) Not less than 1-1/2 times the design pressure.

(b) For design temperatures that are above the test temperature, the minimum test pressure shall be calculated as follows, except that the value of ST /S shall not exceed 6.5:

$$P_T = \frac{1.5PS_T}{S}$$

where: PT = Minimum hydrostatic test gauge pressure.

P = Internal design gage pressure.

ST = Allowable stress at test temperature.

S = Allowable stress at design temperature.

(c) If the test pressure as defined above would produce a stress in excess of the yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

• Pneumatic strength tests, when approved, shall be conducted per Paragraph 345.5 of ASME/ANSI B31.3. The tightness test shall be per Paragraph 345.5.4 of ASME/ANSI B31.3. Only during the tightness test shall the piping be approached and inspected for leakage

Based on ASME/ANSI B31.3, Paragraph 345.5, for pneumatic leak tests, the test pressure is 110% of the design pressure.

• Underground pressure piping that is in process water service and employs non-welded girth joints (bell and spigot) shall be strength tested to 1.5 times the system design pressure prior to backfilling. The test pressure shall be maintained for two hours while the joints are inspected for leakage.

If for operational safety reasons the line must be back-filled, then the joints shall remain exposed during testing, or be subjected to a 24-hour recorded test.

• Lube and seal oil piping shall be strength tested with the service fluid. The test pressure shall be 1.5 times the design pressure or 690 kPa (ga) (100 psig), whichever is greater.

• Low-pressure lines that are designed for less than 690 kPa (ga) (100 psig) may be pneumatically strength tested. The pneumatic strength test shall be the lesser of 110% of the design pressure or 125% of the normal operating pressure, but never less than 170 kPa (ga) (25 psig). A tightness test at 21-35 kPa (ga) (3-5 psig) shall be conducted and the piping checked for leakage with a soap solution.

• Instrument take-off piping and sampling system piping, up to the first block valve, shall be strength tested with the piping or equipment to which it is connected.

• Instrument lead lines, between the first block valve and the instruments to which they are connected, shall be subjected to the same strength test as the piping or equipment the instruments are connected to. Elements that may be damaged shall be disconnected.

• Piping systems in vacuum service shall be strength tested to 100 kPa (ga) (15 psig)

Paragraph 345.4.3 of ASME/ANSI B31.3 states that for a hydrostatic test of piping with vessels as a system:

(a) Where the test pressure of piping attached to a vessel is the same as or less than the test pressure for the vessel, the piping may be tested with the vessel at the piping test pressure.

(b) Where the test pressure of the piping exceeds the vessel test pressure, and it is not considered practical to isolate the piping from the vessel, the piping and the vessel may be tested together at the vessel test pressure, provided the owner approves and the vessel test pressure is not less than 77% of the calculated piping test pressure.

• Unless limited by flanges or valves in the line, hydrostatic strength test pressure of newly constructed pipelines shall be calculated to produce a hoop stress of 90% of the SMYS of the pipe material based on the nominal wall thickness. The test pressure at the lowest point of the pipeline, including the static head, shall not result in a hoop stress greater than the SMYS. The strength test pressure shall be maintained for two hours.
• The strength test temperature shall not result in a combined longitudinal stress exceeding the SMYS. The combined longitudinal stress is calculated based on 0.7 hoop stress at the test pressure plus temperature stress plus bending stress.
• Tightness test of newly constructed pipelines shall be conducted at 95% of the strength test pressure immediately at the completion of the strength test. The tightness test pressure shall be maintained long enough for the inspector to examine all exposed joints. A 24-hour recorded tightness test shall be applied when the pipeline is buried or covered by insulation, or is partially buried with a total buried length of more than 300 m (1000 ft).
• Where pressure variations caused by test-water temperature changes can occur, such as in cross-country pipelines, a sufficient number of thermocouples shall be installed to obtain accurate pipe metal temperature measurements that are required in order to determine the acceptance of the pressure test. The Consulting Services Department shall be consulted with regard to any deviations that are noted in the 24-hour pressure chart.

Strength test pressure of existing pipelines shall be per the applicable ASME/ANSI B31.4 or B31.8 piping code based on the Maximum Allowable Operating Pressure (MAOP) of the pipeline. This is specified as follows:
(a) Portions of piping systems to be operated at a hoop stress of more than 20% of the specified minimum yield strength of the pipe shall be subjected at any point to a hydrostatic proof test equivalent to not less than 1.25 times the internal design pressure at that point for not less than four hours. When lines are tested at pressures which develop a hoop stress, based on nominal wall thickness, in excess of 90% of the specified minimum yield strength of the pipe, special care shall be used to prevent overstrain of the pipe.

$P_T = 1.25PD$

where: PD = MAOP of limiting component.

(1) Those portions of piping systems where all of the pressured components are visually inspected during the proof test to determine that there is no leakage require no further test. This can include lengths of pipe, which are pre-tested for use as replacement sections.

(2) On those portions of piping systems not visually inspected while under test, the proof test shall be followed by a reduced pressure leak test equivalent to not less than 1.1 times the internal design pressure for not less than four hours.

(b) API RP 1110, *Pressure Testing of Liquid Petroleum Pipelines*, may be used for guidance for the hydrostatic test.

(c) The hydrostatic tests shall be conducted with water, except liquid petroleum that does not vaporize rapidly may be used provided:

(1) The pipeline section under test is not offshore and is outside of cities and other populated areas, and each building within 90 m (300 ft.) of the test section is unoccupied while the test pressure is equal to or greater than a pressure which produces a hoop stress of 50% of the specific minimum yield strength of the pipe;

(2) The test section is kept under surveillance by regular patrols during test; and

(3) Communication is maintained along the test section.

(d) If the testing medium in the system will be subject to thermal expansion during the test, provisions shall be made for relief of excess pressure. Effects of temperature changes shall be taken into account when interpretations are made of recorded test pressures.

(e) After completion of the hydrostatic test, it is important in cold weather that the lines, valves, and fittings be drained completely of any water to avoid damage due to freezing.

The above was taken from the Saudi Aramco Engineering Encyclopedia

PLIDCO WELDING ENDS COUPLING

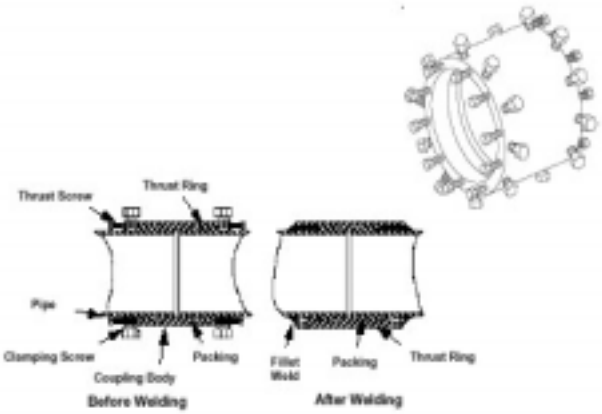


FIGURE 5

PLIDCO SPLIT SLEEVE

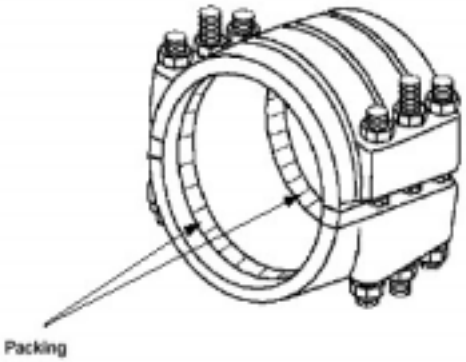


FIGURE 6

Plidco Split Sleeves

Plidco split sleeves are used to:

• Permanently repair small splits, holes, or ruptures which cannot be plugged or patched readily and where downtime for draining oil from a line is excessive.

• Provide quick, temporary repairs without welding on urgently required pipelines, which can be removed from service later for permanent repairs.

• Provide temporary repairs to process lines within plant limits where economically justified. However, in these cases, sleeve pressure and temperature limitations must be considered, and the sleeve must be removed for permanent repair in approximately three months. As referenced in Figure 6, the split sleeve halves are positioned around the pipe such that the leak is located between the two rings of packing. When the sleeves are bolted, the packing is compressed against the pipe surface, which contains the leak. Plidco split sleeves are high in cost compared to other methods of repair. Therefore, their use should be restricted to those cases where speed of repair will provide sufficient economic justification SAEP-311 contains installation instructions, and pressure and temperature limitations for split sleeves. Split sleeves cannot be used to connect two sections of pipe.

HOT TAPS

Inspection Requirements

The engineer responsible for inspection must do the following:

• Inspect weld areas, and 50 mm (2 in.) on each side of them, using continuous ultrasonic examination to determine minimum pipe wall thickness. The measured thickness must be at least that calculated for the hot tap conditions, and no less than 5 mm (0.2 in.).

• Identify laminations, cracks or any discontinuities in the area.

• Approve welding procedure.

• Inspect connection before and during installation for compliance with specification.

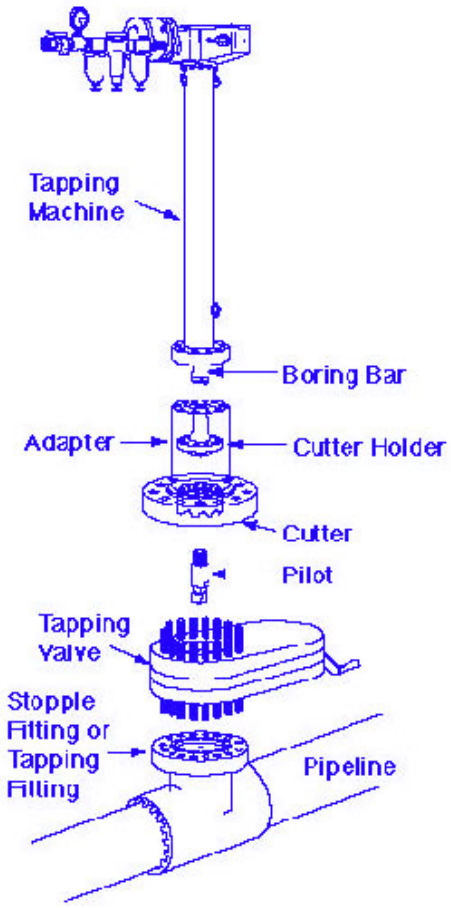
• Confirm that hydrostatic test pressure conforms to that specified.
• Witness and approve the hydrostatic test of equipment and connection.
• Confirm that the connection is opened, drained, and vented after completing hydrostatic test.
• Inspect the removed coupon. Evaluate the extent of header internal corrosion and verify wall thickness.

Testing Requirements

The engineer responsible for testing must apply the following test requirements:

• The hot-tap machine must be periodically pressure tested based on GI 441.010 requirements.
• The hot-tap valve shall be pressure tested prior to installation.
• Pressure test the branch-to-pipe weld, and then pressure test the final branch assembly.
• The reinforcing pad of a welded branch shall be tested with air at 173 kPa (25 psig) through a tapped vent hole.
• The pressure for the test of the hot-tap connection shall be 1.5 times the system design pressure (1.25 times for cross-country pipelines), however, not to exceed the following: - The design hydrostatic test pressure of the pipe or vessel being hot tapped, or - The minimum pressure in the pipe or vessel being hot tapped, while the test is in progress, plus a calculated differential pressure. The differential pressure shall be 1.25 times the allowable external pressure calculated per the ASME Code Section VIII Division 1. The length, L, that is used in this calculation shall be the total length of a split tee, or the inside diameter of the welded nozzle, based on the actual design detail used.
• The test pressure of the hot-tap connection may be lower than the original hydrostatic test pressure. This is acceptable since the purpose of the test is to provide some assurance of the integrity of the connection weld, not a proof test of the weld. The system being tapped need not be down rated if a lower test pressure is used at a hot-tapped connection.

BASIC ARRANGEMENT OF A HOT TAP



CONVERSION FACTORS

8.0 Conversion Factors

FRACTION OF INCH	DECIMAL INCHES	MILLIMETERS
1/64	0.016	0.397
1/32	0.031	0.794
3/64	0.047	1.191
1/16	0.063	1.587
5/64	0.078	1.984
3/32	0.094	2.381
7/64	0.109	2.778
1/8	0.125	3.175
9/64	0.141	3.572
5/32	0.156	3.969
11/64	0.172	4.366
3/16	0.188	4.762
13/64	0.203	5.159
7/32	0.219	5.556
15/64	0.234	5.953
1/4	0.250	6.350
17/64	0.266	6.747
9/32	0.281	7.144
19/64	0.297	7.540
5/16	0.313	7.937
21/64	0.328	8.334
11/32	0.344	8.731
23/64	0.359	9.128
3/8	0.375	9.525
25/64	0.391	9.922
13/32	0.406	10.319
27/64	0.422	10.715
7/16	0.438	11.112
29/64	0.453	11.509
15/32	0.469	11.906
31/64	0.484	12.303
1/2	0.500	12.700

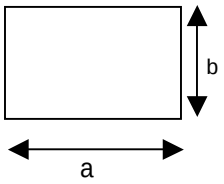
33/63	0.516	13.097
17/32	0.531	13.494
35/64	0.547	13.890
9/16	0.563	14.287
37/64	0.578	14.684
19/32	0.594	15.081
39/64	0.609	15.478
5/8	0.625	15.875
41/64	0.641	16.272
21/32	0.656	16.668
43/64	0.672	17.065
11/16	0.688	17.462
45/64	0.703	17.859
23/32	0.719	18.256
47/64	0.734	18.653
3/4	0.750	19.050
49/64	0.766	19.447
25/32	0.781	19.843
51/64	0.797	20.240
13/16	0.813	20.637
53/64	0.828	21.034
27/32	0.844	21.431
55/64	0.859	21.828
7/8	0.875	22.225
57/64	0.891	22.621
29/32	0.906	23.018
59/64	0.922	23.415
15/16	0.938	23.812
61/64	0.953	24.209
31/32	0.969	24.606
63/64	0.984	25.003
1	1.000	25.400

ENGLISH TO METRIC		
TO CHANGE	TO	MULTIPLY BY
Inches	Millimeters	25.4
Inches	Centimeters	2.54
Inches	Meters	0.0254
Feet	Meters	0.3048
Miles	Kilometers	1.609347
Square Inches	Square Centimeters	6.452
Square Feet	Square Meters	0.0929
Cubic Inches	Cubic Centimeters	16.3872
U.S. Gallons	Liters	3.7854
Pounds	Kilograms	.45359
Ounce Avoir	Grams	28.3495
BTU	Calories	252

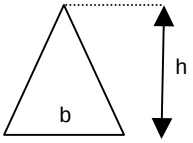
METRIC TO ENGLISH		
TO CHANGE	TO	MULTIPLY BY
Millimeters	Inches	.03937
Centimeters	Inches	.39371
Meters	Inches	39.371
Meters	Feet	3.281
Kilometers	Miles	.62137
Square Centimeters	Square Inches	.1550
Square Meters	Square Feet	10.7649
Cubic Centimeters	Cubic Inches	.061
Cubic Meters	Cubic Feet	35.314
Liters	U.S. Gallon	.26417
Kilograms	Pounds	2.20462
Grams	Ounces Avoir	.03527
Calories	BTU	.003968

MEASURE		
TO CHANGE	TO	MULTIPLY BY
Cubic Feet	Cubic Inches	1728
Cubic Inches	Cubic Feet	.00058
Cubic Feet	Gallons	7.480
Gallons	Cubic Feet	.1337
Cubic Inches	Gallons	.00433
Gallons	Cubic Inches	231
Barrels	Gallons	42
Gallons	Barrels	.0238
Imperial Gallons	U.S. Gallons	1.2009
U.S Gallons	Imperial Gallons	.8326
Square Feet	Square Inches	144
Square Inches	Square Feet	.00695
Long Tons	Pounds	2240
Short Tons	Pounds	2000
Long Tons	Short Tons	1.12

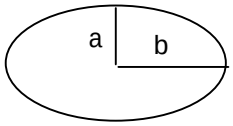
PRESSURE		
TO CHANGE	TO	MULTIPLY BY
Pounds per Square Inch	Pascals	6.895×10^{3}
Pounds per Square Inch	Kilograms per Square CM	7.03×10^{-2}
Pascals	Pounds per Square Inch	1.45×10^{-4}
Kilograms per Square CM	Pounds per Square Inch	1.422×10^{1}
TEMPERATURE		
TO CHANGE	TO	MULTIPLY BY
Centigrade	Kelvin	1.0 + 273
Centigrade	Fahrenheit	1.8 + 17.78
Fahrenheit	Centigrade	-32 x 0.555
Fahrenheit	Kelvin	-32 x 0.555 + 273.15



$$Area = ab$$

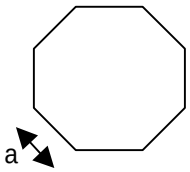


$$Area = \frac{bh}{2}$$

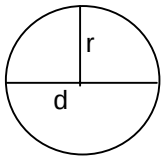


$$Area = \pi ab$$

$$Circ. = \pi\sqrt{2\left(a^2 + b^2\right)}$$



$$a = 2.598a^2$$

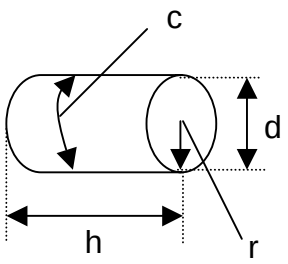


$$Circ. = 2\pi r$$

or

$$Circ. = \pi d$$

$$Area = \pi r^2$$



Total Surface Area (S)

$$S = 2\pi r(r+h)$$

Volume

$$V = \pi r^2 h$$

or

$$V = \frac{c^2 h}{4\pi}$$

SOLUTION OF RIGHT-ANGLED TRIANGLES

As shown in the illustration, the sides of the right angled triangle are designated *a*, *b* and *c*. The angles opposite each of these sides are designated, *A*, *B* and *C*, respectively.

Angle *A*, opposite the hypotenuse *a* is the right angle, and is therefore always one of the known quantities.

Sides and Angles Known	Formulas for Sides and Angles to be Found		
Sides *a* and *b*	$c = \sqrt{a^2 - b^2}$	$\sin B = \frac{b}{a}$	$C = 90° - B$
Sides *a* and *c*	$b = \sqrt{a^2 - c^2}$	$\sin C = \frac{c}{a}$	$B = 90° - C$
Sides *b* and *c*	$a = \sqrt{b^2 + c^2}$	$\tan B = \frac{b}{c}$	$C = 90° - B$
Side *a*, angle *B*	$b = a \times \sin B$	$c = a \times \cos B$	$C = 90° - B$
Side *a*, angle *C*	$b = a \times \cos C$	$c = a \times \sin C$	$B = 90° - C$
Side *b*, angle *B*	$a = \frac{b}{\sin B}$	$c = b \times \cot B$	$C = 90° - B$
Side *b*, angle *C*	$a = \frac{b}{\cos C}$	$c = b \times \tan C$	$B = 90° - C$
Side *c*, angle *B*	$a = \frac{c}{\cos B}$	$b = c \times \tan B$	$C = 90° - B$
Side *c*, angle *C*	$a = \frac{c}{\sin C}$	$b = c \times \cot C$	$B = 90° - C$

INSPECTION TERMINOLOGY

9.0 Inspection Terminology

GLOSSARY (Saudi Aramco Eng Encyclopedia)

angle testing An ultrasonic test method in which transmission is at an angle to the test surface.

back reflection The ultrasonic signal received from the back surface of a test object.

bleed out The action by which liquid penetrants flow out of a discontinuity, due primarily to capillary action and the blotting effect of the developer.

blowhole A hole in a casting or weld caused by gas entrapped during solidification.

blotting The action of a developer in drawing out liquid penetrant from a surface discontinuity causing maximum bleed out for increased contrast and sensitivity.

capillary action The tendency of certain liquid to travel, climb, or draw into tight crack-like interface areas due to such properties as surface tension, wetting, cohesion, adhesion, and viscosity.

Category D Fluid Service As defined in ASME/ANSI B31.3, a fluid service in which all the following apply: the fluid handled is nonflammable, nontoxic, and not damaging to human tissues as defined in Paragraph 300.2; the design gage pressure does not exceed 1,030 kPa (150 psi); and (3) the design temperature is from -29°C through 186°C (-20° F through 366°F).

Category M Fluid Service **As** defined in ASME/ANSI B31.3, a fluid service in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken.

cold crack A flaw that appears as a straight line, usually continuous throughout its length, and generally singly. These cracks start at the surface.

couplant A substance used between an ultrasonic transducer face and the test surface to permit or improve transmission or reception.

crack A material separation that has a relatively large cross-section in one direction and a small or negligible cross-section when viewed in a direction perpendicular to the first.

defect A discontinuity whose size, shape, orientation, location, or properties make it detrimental to the useful service of the part in which it occurs, or which exceeds the accept/reject criteria of the particular design.

developer A finely divided material applied over the surface of a part to help bring out penetrant indications.

discontinuity Any interruption in the normal physical structure or configuration of a part such as cracks, laps, seams, inclusions, or porosity. A discontinuity may or may not affect the usefulness of the part.

dry powder Finely divided ferromagnetic particles selected and prepared for magnetic particle inspection by the dry method.

examination Applies to quality control functions performed by the manufacturer, fabricator, or erector.

false indication An indication that may be interpreted incorrectly as a discontinuity or a defect; a non-relevant indication.

filled crack A crack open to the surface but filled with some foreign material, such as oxide, grease, etc.

flaw An imperfection, which may not be harmful. If harmful, it is a defect or discontinuity.

flux lines Imaginary lines used to explain the behavior of magnetic fields.

fusion The complete joining of two parts in such a manner that loads are effectively transferred across their common boundary.

hot crack A flaw that appears as a ragged dark line of variable width and numerous branches. It has no continuity, may exist in groups, and may originate internally or at the surface.

hot tear A fracture formed in a metal during solidification.

indication An response that requires interpretation to determine its significance.

inspection The process of examining and checking materials and parts for possible defects, or deviation from acceptance standards.

interpretation The process of determining the nature of an indication.

magnet A material having the power to attract iron and other substances to itself and exhibit polarity.

magnetic flux The total number of magnetic lines existing in a magnetic circuit.

Magnetic discontinuity A break in the magnetic continuity of a part, possibly caused by a defect.

Nondestructive examination Testing to detect internal, surface, or concealed defects or flaws in a material using techniques that do not damage the item being tested.

Non-relevant indications These are true indications produced by uncontrolled or incorrect test conditions. They have no relation to discontinuities that might be defects.

normal fluid service As defined in ASME/ANSI B31.3, a fluid service pertaining to most piping covered by this Code, i.e., not subject to the rules for Category D, Category M, or High-Pressure Fluid Service, and not subject to severe cyclic conditions.

pores Small voids in the body of a metal.

porosity charts Standard charts for comparing porosity size, spacing, and number in a given area.

pressure-containing weld A weld that joins two pressure-containing components such as at a branch connection.

prods Two hand-held electrodes, which are pressed against the surface of a part to make contact for passing magnetizing current through the metal.

radiography The use of radiant energy in the form of neutrons, x-rays or gamma rays for NDE of opaque objects. It produces graphical records on sensitized films, which indicate the comparative soundness of the object being tested.

Reference radiographs A group of radiographs containing images of discontinuities. They are used as comparison standards for material acceptability.

severe cyclic conditions As defined in ASME/ANSI B31.3, those in which SE, computed in accordance with Paragraph 319.4.4, exceeds 0.8SA (as defined in Paragraph 302.3.5), and the equivalent number of cycles (N in

paragraph 302.3.5) exceeds 7000, or other conditions which the designer determines will produce an equivalent effect.

suspension The liquid bath in which ferromagnetic particles used in the wet method are suspended.

void Discontinuity in which there is a physical separation between opposite walls.

wet method The magnetic particle inspection method employing ferromagnetic particles suspended in a light oil or water, which acts as a vehicle.

PRESSURE VESSELS

Retirement Thickness:

It is advisable to use the safety instruction sheet (SIS) of the vessel to determine the retirement thickness, as in most cases the calculation may be complex.

Therefore, prior to a pressure vessel inspection, the inspector should obtain a copy of the SIS for the equipment.

Thickness of Shell Under Internal Pressure:

Cylindrical Shell:

Choose the Greater of (1) and (2) Below:

(1) $t = \frac{PR}{SE - 0.6P}$ or $P = \frac{SEt}{R + 0.6t}$

(2) $t = \frac{PR}{2SE + 0.4P}$ or $\frac{2SEt}{R - 0.4t}$

Spherical Shell:

(3) $t = \frac{PR}{2SE - 0.2P}$ or $P = \frac{2SEt}{R - 0.2t}$

$t =$	Minimum thickness	$P =$	Design pressure, (PSI)
$R =$	Inside radius	$S =$	Maximum allowable stress value of the material (PSI)
$E =$	Joint efficiency		

Conditions for (1) above:

T Does not exceed ½ *R* or *P* does not exceed 0.385 *SE*

Conditions for (2) above:

t Does not exceed ½ *R* or *P* does not exceed 1.25 *SE*

Conditions for (3) above:

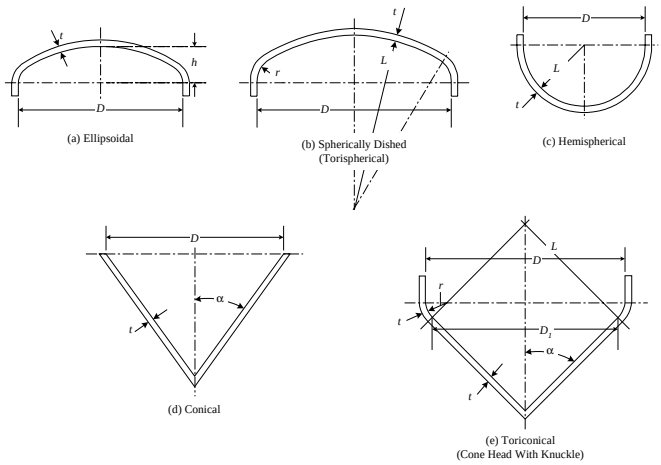
t Does not exceed 0.356 *R* or *P* does not exceed 0.665 *SE*

Thicknesses of shells under external pressure see ASME Sec. VIII Para. UG-28)

(For conditions exceeding the above limits, see ASME sec. VIII Div.1Appendix –1)

Thickness of Formed Heads Under Internal Pressure (Pressure on Concave Side)

Refer to the following figure for the typical types of heads and their dimensions



(1) Ellipsodial Heads

$$t = \frac{PD}{2SE - 0.2P} \quad \text{or} \quad \frac{2SEt}{R + 0.2t}$$

(2) Torispherical

$$t = \frac{0.885PL}{SE - 0.1P} \quad \text{or} \quad \frac{SEt}{0.885L + 0.1t}$$

(3) Hemispherical

$$t = \frac{PL}{2SE - 0.2P} \quad \text{or} \quad \frac{2SEt}{L + 0.2t}$$

(4) Conical

$$t = \frac{PD}{2 \cos \alpha \, (SE - 0.6P)} \quad \text{or} \quad \frac{2Set \, \alpha}{D + 1.2t \cos \alpha}$$

(5) **Toriconical**

t for the conical section – use formula (4) above using *Di* in place of *D*

$$Di = D - 2r(1 - \cos \alpha)$$

t for the knuckle section – use formula (3) above in which,

$$L = \frac{Di}{2 \cos \alpha}$$

Conditions For the Above Formulae:

For (1) above: Half the minor axis = $^1/_4$ of the ID of the head skirt

Note: Approximate values of knuckle radius and spherical radius of a 2.1 ellipsoidal head are 0.17*D* and 0.90*D*, respectively.

For (2) above: Knuckle radius = 6% of inside crown radius

Inside crown radius = outside Dia. of skirt

Note: For materials having tensile strength greater than 80,000 PSI, use S = 20,000 PSI at room temperature.

For (3) above: *t* does not exceed 0.356 *L*

or

P does not exceed 0.665 *SE*

For (4) above: Half apex angle α is not greater than 30 degrees

For Toriconical Heads: Knuckle radius is neither less 6% of the OD of the head skirt nor less than three times the knuckle thickness

Note: Toriconical heads may be used when $\alpha \leq 30$ degrees, but are mandatory for conical head design when α exceeds 30 degrees

Thickness of Heads Under External Pressure (Pressure on Convex Side)

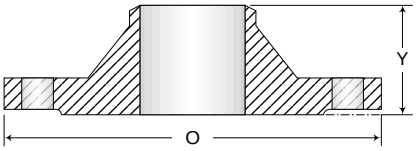
Shall be calculated per ASME Sec. VIII Div. 1, Para. UG-33

Minimum Thickness of Nozzle Neck

In most cases, the retirement thickness of a nozzle neck shall be the minimum thickness of a standard wall pipe (Listed in table 2 of ANSI B 36-10 less 12-½ %).
See ASME Sec. VIII Div. 1, Para. UG-45 for details.

FITTINGS

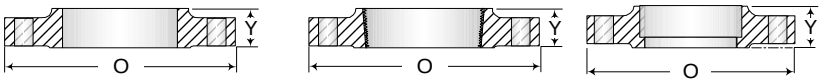
11.0 Fittings



Welding Neck Flanges

Nom Pipe Size	150 LB.		300 LB.		400 LB.		600 LB.	
	Outside Diam Of Flange O	Length Thru Hub Y (1)	Outside Diam Of Flange O	Length Thru Hub Y (1)	Outside Diam Of Flange O	Length Thru Hub Y (2)	Outside Diam Of Flange O	Length Thru Hub Y (2)
1/2	3 1/2	1 7/8	3 3/4	2 1/16	For Sizes 3 1/2 and smaller use 600 Lb. standard		3 3/4	2 1/16
3/4	3 7/8	2 1/16	4 5/8	2 1/4			4 5/8	2 1/4
1	4 1/4	2 3/16	4 7/8	2 7/16			4 7/8	2 7/16
1 1/4	4 5/8	2 1/4	5 1/4	2 9/16			5 1/4	2 5/8
1 1/2	5	2 7/16	6 1/8	2 11/16			6 1/8	2 3/4
2	6	2 1/2	6 1/2	2 3/4			6 1/2	2 7/8
2 1/2	7	2 3/4	7 1/2	3			7 1/2	3 1/8
3	7 1/2	2 3/4	8 1/4	3 1/8			8 1/4	3 1/4
3 1/2	8 1/2	2 13/16	9	3 3/16			9	3 3/8
4	9	3	10	3 3/8	10	3 1/2	10 3/4	4
5	10	3 1/2	11	3 7/8	11	4	13	4 1/2
6	11	3 1/2	12 1/2	3 7/8	12 1/2	4 1/16	14	4 5/8
8	13 1/2	4	15	4 3/8	15	4 5/8	16 1/2	5 1/4
10	16	4	17 1/2	4 5/8	17 1/2	4 7/8	20	6
12	19	4 1/2	20 1/2	5 1/8	20 1/2	5 3/8	22	6 1/8
14	21	5	23	5 5/8	23	5 7/8	23 3/4	6 1/2
16	23 1/2	5	25 1/2	5 3/4	25 1/2	6	27	7
18	25	5 1/2	28	6 1/4	28	6 1/2	29 1/4	7 1/4
20	27 1/2	5 11/16	30 1/2	6 3/8	30 1/2	6 5/8	32	7 1/2
22	29 1/2	5 7/8	33	6 1/2	33	6 3/4	34 1/4	7 3/4
24	32	6	36	6 5/8	36	6 7/8	37	8
26	34 1/4	5	38 1/4	7 1/4	38 1/4	7 5/8	40	8 3/4
30	38 3/4	5 1/8	43	8 1/4	43	8 5/8	44 1/2	9 3/4
34	43 3/4	5 5/16	47 1/2	9 1/8	47 1/2	9 1/2	49	10 5/8
36	46	5 3/8	50	9 1/2	50	9 7/8	51 3/4	11 1/8
42	53	5 5/8	57	10 7/8	57	11 3/8	58 3/4	12 3/4

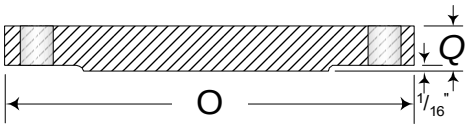
(1) The 1/16" raised face *is* included in "Length thru Hub 'Y'."
(2) The 1/4" raised face *is not* included in "Length thru Hub 'Y'."



Slip-On, Threaded, And Socket Type Flanges

Nom Pipe Size	150 LB. Outside Diam O	150 LB. Length Thru Hub Y (1)	300 LB. Outside Diam O	300 LB. Length Thru Hub Y (1)	400 LB. Outside Diam O	400 LB. Length Thru Hub Y (2)	600 LB. Outside Diam O	600 LB. Length Thru Hub Y (2)
1/4	3 1/2	5/8*†	3 3/4	7/8*†	For Sizes 3 1/2 and smaller use 600 Lb. standard		3 3/4	7/8*†
3/8	3 1/2	5/8*†	3 3/4	7/8*†			3 3/4	7/8*†
1/2	3 1/2	5/8	3 3/4	7/8			3 3/4	7/8
3/4	3 7/8	5/8	4 5/8	1			4 5/8	1
1	4 1/4	11/16	4 7/8	1 1/16			4 7/8	1 1/16
1 1/4	4 5/8	13/16	5 1/4	1 1/16			5 1/4	1 1/8
1 1/2	5	7/8	6 1/8	1 3/16			6 1/8	1 1/4
2	6	1	6 1/2	1 5/16			6 1/2	1 7/16
2 1/2	7	1 1/8	7 1/2	1 1/2			7 1/2	1 5/8
3	7 1/2	1 3/16	8 1/4	1 11/16			8 1/4	1 13/16
3 1/2	8 1/2	1 1/4	9	1 3/4			9	1 15/16
4	9	1 5/16	10	1 7/8	10	2✤	10 3/4	2 1/8✤
5	10	1 7/16	11	2✤	11	2 1/8✤	13	2 3/8✤
6	11	1 9/16	12 1/2	3 7/8✤	12 1/2	2 1/4✤	14	2 5/8✤
8	13 1/2	1 3/4	15	4 3/8✤	15	2 11/16✤	16 1/2	3✤
10	16	1 15/16	17 1/2	2 5/8✤	17 1/2	2 7/8✤	20	3 3/8✤
12	19	2 3/16	20 1/2	2 7/8✤	20 1/2	3 1/8✤	22	3 5/8✤
14	21	2 1/4	23	3✤	23	3 5/16✤	23 3/4	3 11/16✤
16	23 1/2	2 1/2	25 1/2	3 1/4✤	25 1/2	3 11/16✤	27	4 3/16✤
18	25	2 11/16	28	3 1/2✤	28	3 7/8✤	29 1/4	4 5/8✤
20	27 1/2	2 7/8	30 1/2	3 3/4✤	30 1/2	4✤	32	5✤
22	29 1/2	3 1/8†✤	33	4†✤	33	4 1/4†✤	34 1/4	5 1/4†✤
24	32	3 1/4	36	4 3/16✤	36	4 1/2✤	37	5 1/2✤
26	34 1/4	3 3/8†✤	38 1/4	7 1/4†✤	38 1/4	7 5/8†✤	40	8 3/4†✤
30	38 3/4	3 1/2†✤	43	8 1/4†✤	43	8 5/8†✤	44 1/2	9 3/4†✤
34	43 3/4	3 11/16†✤	47 1/2	9 1/8†✤	47 1/2	9 1/2†✤	49	10 5/8†✤
36	46	3 3/4†✤	50	9 1/2†✤	50	9 7/8†✤	51 3/4	11 1/8†✤
42	53	4 †✤	57	10 7/8†✤	57	11 3/8†✤	58 3/4	12 3/4†✤

* Not available in Slip-on type.
† Not available in Threaded type.
✤Not available in Socket type.



Blind Flanges

Nom Pipe Size	150 LB.		300 LB.		400 LB.		600 LB.	
	Outside Diam Of Flange O	Thick ness Q (1)	Outside Diam Of Flange O	Thick ness Q (1)	Outside Diam Of Flange O	Thick ness Q (2)	Outside Diam Of Flange O	Thick ness Q (2)
1/2 3/4 1 1 1/4 1 1/2	3 1/2 3 7/8 4 1/4 4 5/8 5	7/16 1/2 9/16 5/8 11/16	3 3/4 4 5/8 4 7/8 5 1/4 6 1/8	9/16 5/8 11/16 3/4 13/16	For Sizes 3 1/2 and smaller use 600 Lb. standard		3 3/4 4 5/8 4 7/8 5 1/4 6 1/8	9/16 5/8 11/16 13/16 7/8
2 2 1/2 3 3 1/2 4	6 7 7 1/2 8 1/2 9	3/4 7/8 15/16 15/16 15/16	6 1/2 7 1/2 8 1/4 9 10	7/8 1 1 1/8 1 3/16 1 1/4			6 1/2 7 1/2 8 1/4 9 10 3/4	1 1 1/8 1 1/4 1 3/8 1 1/2
					10	1 3/8		
5 6 8 10 12	10 11 13 1/2 16 19 1/2	15/16 1 1 1/8 1 3/16 1 1/4	11 12 1/2 15 17 1/2 20 1/2	1 3/8 1 7/16 1 5/8 1 7/8 2	11 12 1/2 15 17 1/2 20 1/2	1 1/2 1 5/8 1 7/8 2 1/8 2 7/8	13 14 16 1/2 20 22	1 3/4 1 7/8 2 3/16 2 1/2 2 5/8
14 16 18 20 22	21 23 1/2 25 27 1/2 29 1/2	1 3/8 1 7/16 1 9/16 1 11/16 1 13/16	23 25 1/2 28 30 1/2 33	2 1/8 2 1/4 2 3/8 2 1/2 2 5/8	23 25 1/2 28 30 1/2 33	2 3/8 2 1/2 2 5/8 2 3/4 2 7/8	23 3/4 27 29 1/4 32 34 1/4	2 3/4 3 3 1/4 3 1/2 3 3/4
24 26 30 34 36	32 34 1/4 38 3/4 43 3/4 46	1 7/8 2 2 1/8 2 5/16 2 3/8	36 38 1/4 43 47 1/2 50	2 3/4 3 1/8 3 5/8 4 4 1/8	36 38 1/4 43 47 1/2 50	3 3 1/2 4 4 3/8 4 1/2	36 40 44 1/2 49 51 3/4	4 4 1/4 4 1/2 4 3/4 4 7/8
42	53	2 5/8	57	4 5/8	57	5 1/8	58 3/4	5 1/2

SAES-L-009 also lists standard Saudi Aramco drawings that provide mandatory dimensional standards for specific size ranges, ratings, flange types, and facings.

These standard flanges must be used as applicable within their defined scopes, even if API-605, MSS-SP-44, or ASME/ANSI B16.47 has the same designations.

These standard drawings are as follows:

NPS	Range Class	Type Facing	Standard Drawing
26-60	150	WN RF	AD-036634
26-60	300	WN RF	AD-036991
26-48	300	WN RJ	AC-036484
54-60	300	WN RJ	AC-036437
30-48	400	WN RF	AD-036698
26-48	600	WN RF	AD-036673
26-48	600	WN RJ	AC-036442
26-48	300	Lap RJ	AC-036486
54-60	300	Lap RJ	AE-036438
26-48	600	Lap RJ	AC-036443
54-60	75	Blind RF	AD-036696

where:
WN = Weld neck.
RF = Raised face.
RJ = Ring joint.
Lap = Lapped flange.
Blind = Blind flange.

CODES
&
STANDARDS

12.0 Codes & Standards

Typical construction codes in use internationally are:

- American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME-BPVC).
- American Petroleum Institute (API 650- Storage Tanks)
- British Standards (BS5500 Pressure Vessels)
- AD-Merkblatt (German Pressure Vessel Code)
- TRD (German Boiler Code, normally read in conjunction with VGB Directives).
- CODAP (France)
- Stoomwezen (Netherlands)
- ASME 31.1- Boiler Piping Code
- ASME 31.3 – Chemical Piping
- ASME 31.4- Gas transportation piping
- ASME 31.8- Liquid Hydrocarbon transportation piping.

The European codes are currently under review and the following product standards will eventually supercede the existing National Standards:

- CEN/TC54 Unfired Pressure Vessels
- CEN/TC267 Industrial Piping
- CEN/TC269 Boilers.

Saudi Aramco normally uses the ASME-BPVC Construction codes such as ASME VIII Division 1 and 2 for pressure vessels and ASME 1 for Boilers. The main difference between ASME VIII Division 1 and 2 is that 1 currently has a Factor of Safety (FOS) of four (under consideration to change to 3.5) and 2 has a FOS of three. Most of the European codes are based on a FOS of three. That is why ASME VIII Division 2 and the European Construction codes normally stipulate higher quality materials, and in turn a greater level of non-destructive testing. The ASME Construction Codes are supported by other sections such as ASME V (Non-destructive Testing), ASME IX (Welding), etc. When a vessel is constructed by an ASME registered manufacturer, in accordance with the ASME code under the auspices of a valid commissioned Authorized Inspector (National Board of Boiler and Pressure Vessel Inspectors) the vessel can be stamped as being in accordance with the ASME Code. Vessels not required to be code stamped

(U) but are built using the ASME codes are said to be built “Generally in accordance with the ASME Code”. This normally means they have followed the design, materials, testing requirements but have not followed the Code rules fully (i.e. no Authorized Inspector), these vessels are not ASME pressure vessels and are not stamped, the U1 data form when completed will lack the Authorized Inspectors agreement that it complies with the code and acceptance is based on alternative wording.

Repairs or modifications to ASME pressure vessels that have seen service, when such repairs or modifications are not under the auspices of an Authorized Inspector means that the vessels are no longer ASME pressure vessels but remain “pressure vessels generally built in accordance with the ASME code” unless such repairs are conducted by an owner-user with “R” stamp approval.

Typical codes and standards that address pressure equipment that has seen service are:

- ANSI/NB-23 National Board Inspection Code
- API 510 Pressure Vessels.
- API 570 Process Piping.
- API 653 Storage Tanks.

Review of the SAES/SAEP and SAIP includes a number of documents that reference the above documents and typical documents that the Inspector should utilize during the course of his work include:

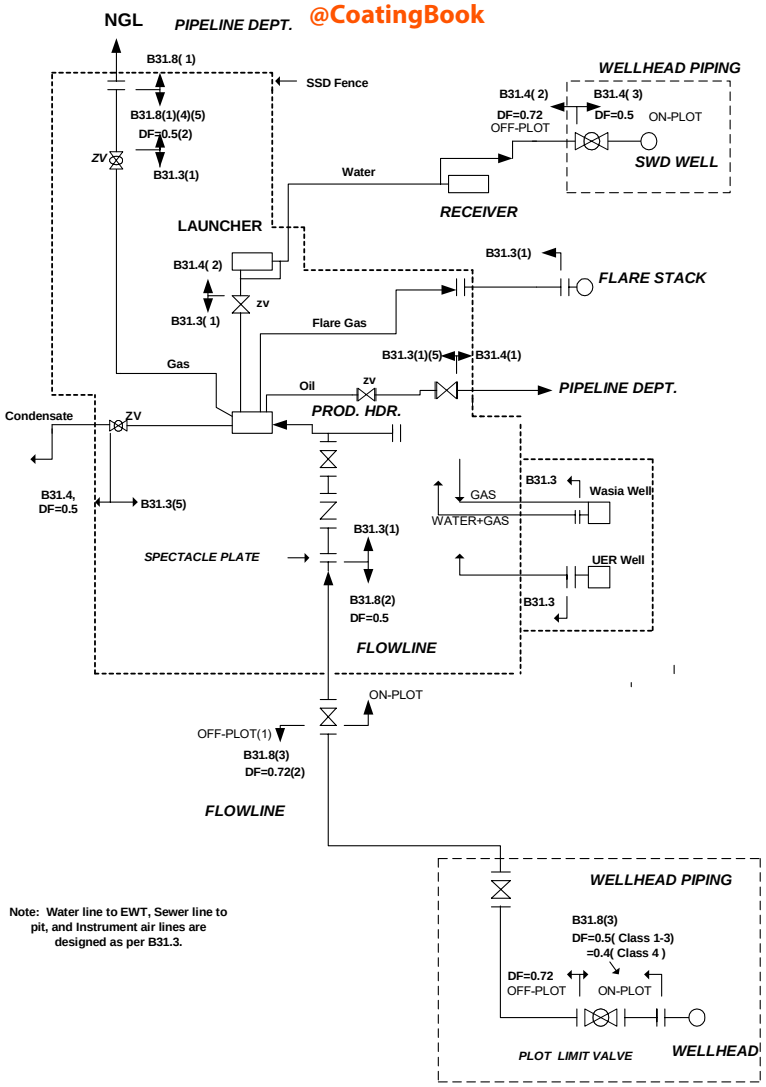
SAES-A-004	General Requirements for Pressure Testing
SAES-A-007	Hydrostatic Testing Fluids and Lay-up Procedures
SAES-A-206	Positive Material Identification
SAES-B-005	Spacing and Diking for Atmospheric and Low Pressure Tanks
SAES-D-001	Design Criteria for Pressure Vessels
SAES-D-100	Design Criteria of Atmospheric and Low Pressure Tanks
SAES-D-108	Storage Tank Integrity
SAES-D-109	Design of Small Tanks
SAES-E-004	Design Criteria of Shell and Tube Heat Exchangers
SAES-E-006	Design Criteria of Double Pipe Heat Exchangers

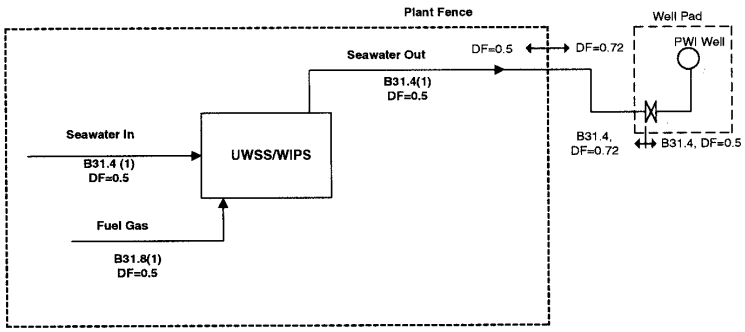
SAES-E-007	Design Criteria of Air Cooled Heat Exchangers
SAES-E-014	Design Criteria of Plate and Frame Heat Exchangers
SAES-E-015	Design Criteria of Electric Heat Exchangers
SAES-F-001	Design Criteria of Fired Heaters
SAES-F-007	Design Criteria of Flares
SAES-H-001	Selection Requirements for Industrial Coatings
SAES-H-002	Internal and External Coatings for Steel Pipelines and Piping
SAES-H-002V	Approved Saudi Aramco Data Sheets
SAES-H-101	Approved Protective Coating Systems
SAES-H-101V	Approved Saudi Aramco Data Sheets- Paints and Coatings
SAES-H-200	Storage, Handling and Installation of Pipe Externally Coated with Fusion Bonded Epoxy or Polyethylene
SAES-H-201	General Specification for Over-The-Ditch External FBE Coating of Field Girth Welds
SAES-H-203	Hand Applied Tape-Wrapping of Buried Pipe
SAES-H-204	General Specification for Applying Heat-Shrink Sleeves to Coated Pipe
SAES-H-204V	Approved Vendor Installation Procedures for Heat-Shrink Sleeves
SAES-L-001	Basic Criteria for Piping Systems
SAES-L-002	Design Conditions for Pressure Piping
SAES-L-003	Design Stress Criteria for Pressure Piping
SAES-L-004	Pressure Design of Piping Components
SAES-L-005	Piping Material Specifications
SAES-L-006	Metallic Pipe Selection
SAES-L-007	Selection of Metallic Pipe Fittings
SAES-L-008	Selection of Valves
SAES-L-009	Metallic Flanges, Gaskets and Bolts for Low and Intermediate Temperature Service
SAES-L-010	Limitations on Piping Joints
SAES-L-011	Flexibility, Support and Anchoring of Piping
SAES-L-012	Design of Piping Systems inside Plant Areas
SAES-L-022	Design of Wellhead Piping, Flowlines, Trunklines and Testlines
SAES-L-032	Material Selection of Piping Systems
SAES-L-033	Corrosion Protection Requirements for Pipelines/ Piping
SAES-L-041	Utility Piping Connections to Process Equipment

SAES-L-042	Plant Utility Stations
SAES-L-043	Thermal Expansion Relief in Piping
SAES-L-044	Anchors for Cross-Country Pipelines
SAES-L-045	Scraper Trap Station Piping and Apparatus
SAES-L-046	Pipeline Crossings Under Roads and Railroads
SAES-L-047	Valve Boxes
SAES-L-050	Construction Requirements for Metallic Plant Piping
SAES-L-051	Construction Requirements for Cross-Country Pipelines
SAES-L-052	Hot Tap Connections
SAES-L-056	Pressure Testing of Plant Piping and Pipelines
SAES-L-060	Nonmetallic Piping
SAES-L-062	Technically Acceptable Class 04 Valve Manufacturers
SAES-L-070	Technically Acceptable Manufacturers of API 6A 10000 PSI Gate Valves and Chokes
SAES-N-100	Refractory Systems
SAES-N-110	Installation Requirements- Castable Refractories
SAES-W-010	Welding Requirements for Pressure Vessels
SAES-W-011	Welding Requirements for On-Plot Piping
SAES-W-012	Welding Requirements for Pipelines
SAES-W-014	Weld Overlays and Welding of Clad Materials
SAES-W-015	Strip Lining Application
SAES-W-016	Welding of Corrosion Resistant Materials
SAES-W-017	Welding Requirements for API Tanks
SAES-X -400	Cathodic Protection of Buried Pipelines
SAES-X -500	Cathodic Protection of Vessel and Tank Internals
SAES-X -600	Cathodic Protection of Plant Facilities
SAES-X -700	Cathodic Protection of Onshore Well Casings

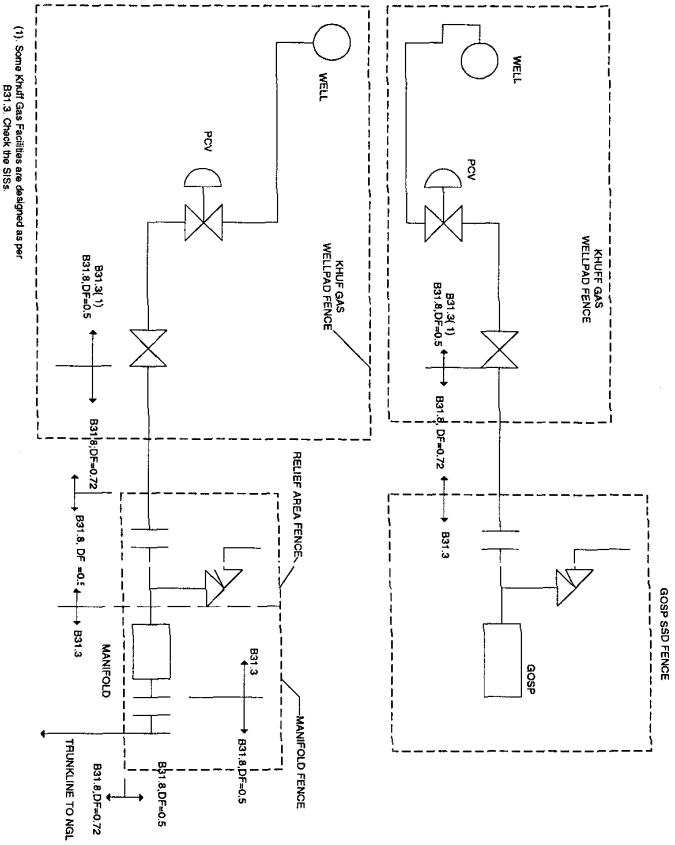
SAEP- 20	Equipment Inspection Schedule
SAEP- 306	Evaluating The Remaining Strength of Corroded Pipelines
SAEP- 308	Operations Inspection Unit Reviews
SAEP- 309	Inspection of Community and Operations Support Facilities
SAEP- 310	Pipeline Repair and Maintenance
SAEP- 311	Installation of Hot-Tapped Connections
SAEP- 312	PLIDCO Weld + Ends Couplings
SAEP- 313	PLIDCO Split Sleeves
SAEP- 314	Use of PLIDCO Smith Pipeline Repair Clamps

SAEP- 315	Installation of Stopple Fittings
SAEP- 316	Performance Qualification of Coating Personnel
SAEP- 317	Testing and Inspection (T & I) of Shell & Tube Heat Exchangers
SAEP- 318	Pressure Relief Valve Program Authorization for Installation, Deletion and Changes
SAEP- 319	Pressure Relief Valves- Routine Test, Inspection, Quality Assurance and Regulation
SAEP- 321	Performance Qualification Testing and Certification of Saudi Aramco Welders
SAEP- 323	Performance Qualification Testing of Contract Welders and Brazing
SAEP- 324	Certification Review and Registration of Project Welders and Brazers
SAEP- 325	Inspection Requirements for Pressurized Equipment
SAEP- 1131	Pressure Relief Valve Program Use of Form 3099A, RV Authorization
SAEP- 1132	Instructions for Using the Relief Valve Stand
SAEP- 1133	Form 3750, Pressuring Relieving Device Valve Test Stand
SAEP- 1135	On-Stream Inspection Administration
SAEP- 1140	Qualification and Certification of Saudi Aramco NDT Personnel
SAEP- 1141	Industrial Radiation Safety
SAEP- 1142	Qualification of Saudi Aramco NDT Personnel
SAEP- 1143	Radiographic Examination
SAEP- 1144	Magnetic Particle Examination
SAEP- 1145	Liquid Penetrant Examination
SAEP- 1150	Inspection Coverage on Projects
00-SAIP-06	Pressure Test Requirements
01-SAIP-02	Retirement Thickness of In-Plant Piping
02-SAIP-01	Inspection of Positive Seal Coupling Systems
32-SAIP-11	Inspection of Air-Cooled Heat Exchangers





1. HAWIP is designed per B31.3. In other Plants, some piping modified by project may be designed per B31.3. Check SIS.



SUPPORTS

13.0 Supports

Saudi Aramco Engineering Encyclopedia outlines the function and design of different types of supports used for:

- Tanks
- Vessels
- Piping

Refer to sections MEX 10107 and 110.03 for background information.

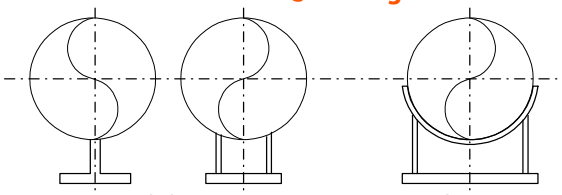
Figure 1 shows different types of supports such as Rigid Supports, Restraints, Stops and Guides. Figure 2 depicts Flexible or Resilient Supports. Figure 3 shows anchors inclusive of concrete anchors.

Table 1 is a guide to commonly referenced drawings within Saudi Aramco relating to supports and reference should always be made to the latest revision. Typical drawings are attached.

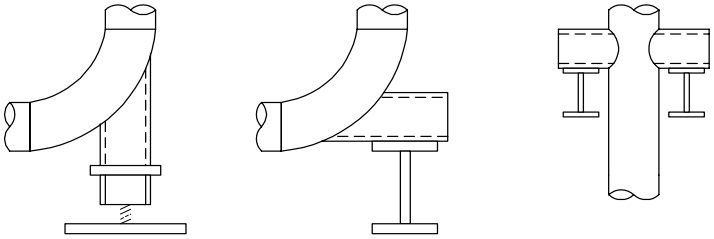
Table 1

Index	Plant No	Drawing No	Sheet No	Revision No	Description
L/M	990	AD-036990	2	0	Metricated saddle details for large diameter unrestrained pipelines.
L	990	AD-036990	1	13	Saddle details for large diameter unrestrained pipelines.
L/M	990	AB-036774	1	7	Pipe ring girder details
S	990	AB-036453	1	2	Wellhead pipe supports and anchor at wellhead
L	990	AB-036555	1	7	Standard wear pads for unrestrained pipelines
L	990	AB-036530	1	8	Offset & portable pipe supports for unrestrained pipelines 16” and smaller. (attached)
L	990	AB-036100	1	8	Ring girders for bolting to supports for 16” O.D through 32” O.D Pipe.
L	990	AB-036207	1	10	Pipe spacings (attached)
L	990	AD-036697	2	0	Metricated standard maximum spans for above ground unrestrained pipelines 14” and larger using wear pads or saddles.
L	990	AC-036697	1	2	Maximum spans for above ground unrestrained pipelines 14” and larger using wear plates or saddles.
L/M	990	AE-036252	1	4	Corrosion bar wear support

RIGID SUPPORTS

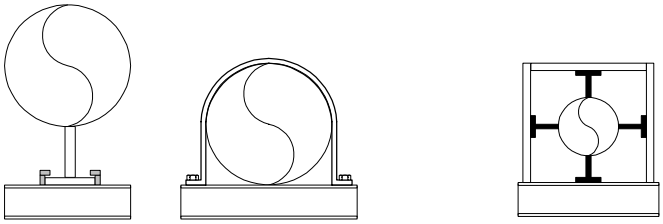


SHOE SADDLE

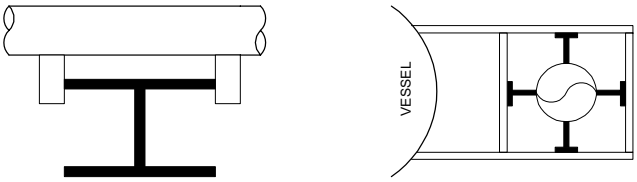


BASE ADJUSTABLE SUPPORT | DUMMY SUPPORT | TRUNNION

RESTRAINTS/GUIDES

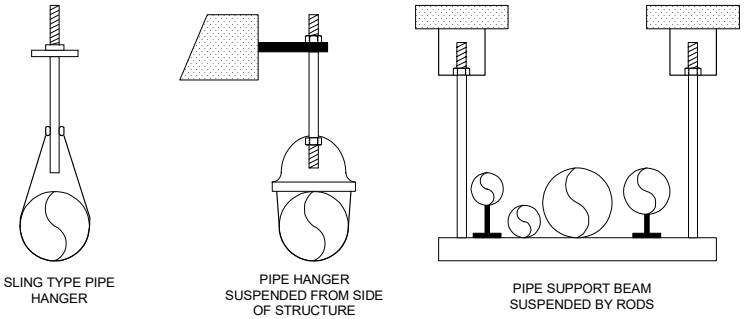


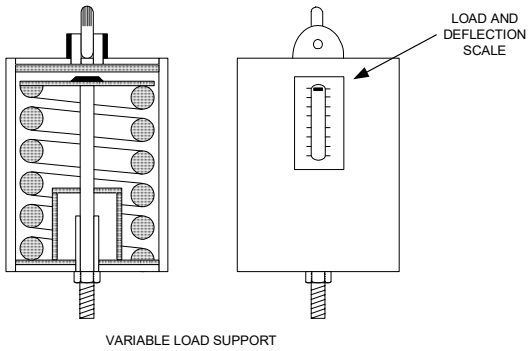
CHANNEL GUIDE | SLEEVE GUIDE | BOX-IN GUIDE

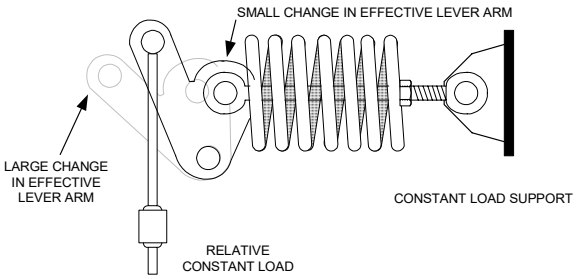


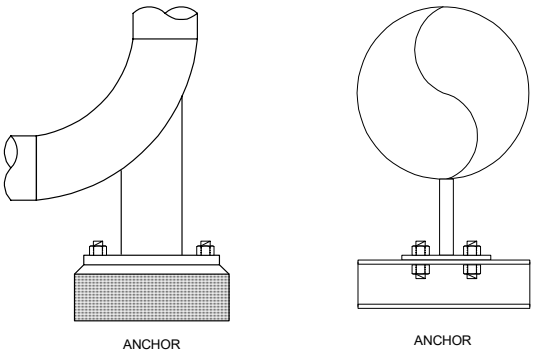
STOP WITH SHOE | VERTICAL BOX-IN GUIDE

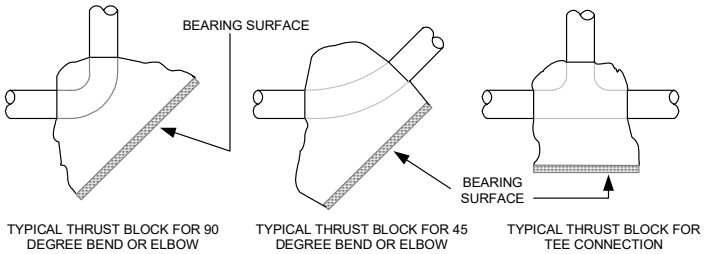
FLEXIBLE OR RESILIENT SUPPORTS

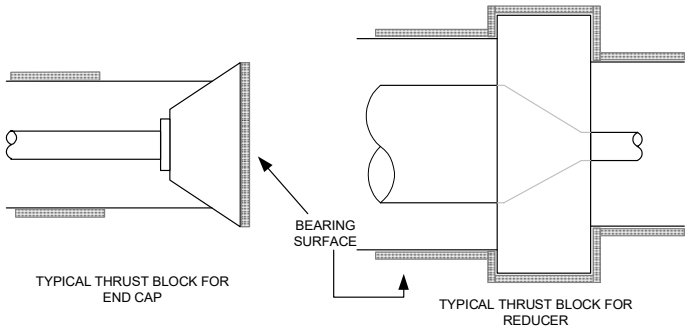












NON-DESTRUCTIVE EXAMINATION

14.0 Non Destructive Examination

Nondestructive Testing

Saudi Aramco Engineering Encyclopedia outlines the basics of the various methods and should be consulted for background information. A number of Saudi Aramco Engineering Procedures (SAEP) exist controlling the performance of nondestructive testing (NDT). Non-destructive Examination (NDE) and Non-destructive Evaluation (NDE) are other frequently used terms dependent on country and context.

Common abbreviations used for NDT methods are P.T (Penetrant Testing), MT (Magnetic Particle Testing), RT (Radiographic Testing), U.T (Ultrasonic Testing), ET (Electromagnetic Testing), V.T (Visual Testing), AET (Acoustic Emission Testing), L.T (Leak Testing), NRT (Neutron Radiographic Testing), IRT (Infra-Red Testing) and can be further sub-divided into sub-methods such as WFMT (Wet Fluorescent Magnetic Particle Testing)

Current SAEP's include:

- SAEP 1143 Radiographic Testing
- SAEP 1144 Magnetic Particle Testing
- SAEP 1145 Penetrant Testing

The listed SAEP's outline how the particular method is to be applied within Saudi Aramco and outlines all necessary steps to perform the test and report the test result. Table 1 outlines the Acceptance Criteria for the applicable SAEP's and the Saudi Aramco form to be used. Figure 5 provides guidance on how to interpret and evaluate radiographs.

Table 1

NDT Method	SAEP	Acceptance Criteria	FORM
VT	Future	Refer Code	Future
PT	1145	Figure 1	Figure 2
MT	1144	Figure 3	Figure 4
RT	1143	Posted in RT Viewing Room (Fig 5)	Figure 6

Currently no SAEP's exist for the performance of neither UT nor other Non-destructive testing that are considered "advanced".
Distinction needs to be made between manufacturing flaws (i.e. lack of fusion, etc) and In-Service deterioration (i.e. Caustic cracking). For the detection of manufacturing defects the type of NDT to be performed, and the extent, is controlled by the applicable construction code. Currently, for detection of in-service deterioration more latitude is available for the extent and type of NDT to be performed. Flaws induced from service normally initiate at manufacturing flaws.

In-Service Deterioration normally manifasts in three basic forms:

- **Cracking (sulfide cracks, amine cracking, etc)**
- **Metal loss due to corrosion/erosion**
- **Change in Material Properties (embrittlement, etc)**

No one NDT method is capable of detecting all types of flaws and selection of an appropriate NDT method for the specific failure mechanism is paramount. Assistance should be sought from the appropriate Saudi Aramco specialist in the Dhahran NDT Unit.

FIGURE 1- PT Acceptance Criteria

Liquid Penetrant Testing Acceptance Criteria

Code	Rejection Criteria
API 1104	1. Linear Indications Indications > 1/16" (1.6mm) shall be considered as relevant. Relevant indications are rejectable if: Evaluated as crater cracks or star cracks and >5/32" (4mm) in length. Evaluated as cracks other than crater cracks or star cracks. Evaluated as IF and >1" (25.4mm) in total length in a continuous 12" (305mm) weld or >8% of the weld length. 2. Rounded Indications. For evaluation, the maximum dimension of rounded indications shall be considered. Indications are rejectable defects if: Individual indication >1/8" (3.2mm) or 25% of the thickness of the thinner member, whichever is less. Distributions of scattered rounded indications exceed the concentration of API 1104, Figures 18 or 19. Clustered rounded indications >1/2" (12.7mm) are present. Combined length of clustered indications > 1/2" in any 12" (305mm) of weld. Any individual indication in a cluster >1/16" (1.6mm).
ANSI/ASME B31.1 & ANSI/ASME B31.3	Indications > 1/16" (1.6 mm) shall be considered as relevant 1. Linear Indication: Any Crack or linear indication 2. Rounded Indications Indications with dimensions > 3/16" (4.8mm) Four or more rounded indication in a line separated by 1/16" (1.6mm) or less edge to edge. Ten or more rounded indication in any 6 sq. in. (3870mm^2) of surface with the major dimension of this area not to exceed 6 in. (150mm).

ASME Section VIII, Div 1	Indications > 1/16" (1.6 mm) shall be considered as relevant The following Indications shall be rejectable: 1. Relevant linear indication > 1/16" (1.6mm) 2. Relevant rounded indications > 3/16" (4.8mm) 3. Four or more rounded indications in a line separated by 1/16" (1.6mm) or less (edge to edge).
AWS D1.1	An Acceptance/Rejection criterion is dependent on service condition. Refer to the relevant project engineer or the Inspection Department.

Figure 2 PT Form

Liquid Penetrant Examination Request & Report Form

Log No.	B.I. No.	J.O. No.	Plant No.	Plant Name	Contractor
Location/Kilometer Reference	Aramco Rep.	Unit	Requested by:	Phone:	Date:
Technician Level	Code / Acceptance Criteria	Material Type	Material Form	Sch. / Thickness	
Liquid Penetrant System: A-1____A-2____A-3____ B-1____B-2____B-3____	Penetrant Mfg	Penetrant Batch No.	Penetrant P/N	Remover P/N.	Developer P/N.
Surface Temperature	White Light Intensity	UV Light Intensity	UV Light Model No.	UV Meter Model No.	Material Form
Surface Condition / Part Description					

Item No.	Drawing No.	Equipment P/N Line Reference.	Weld No.	Welder Symbol	Exam Results		REPAIR LOCATION	DEFECT TYPE & SIZE
					ACC	REJ		

Interpretation by: (print) _____ PT Level II / PT Level III	Badge No.	Signature:	Date:

NOTES:

1. All blanks are to be filled in or marked N/A (not applicable).

2. Examination performed by Level I require a sign-off by Level II or Level III.

Figure 3 – MT Acceptance Criteria

1 ANSI/ASME B31.1 Power Piping

The following relevant indications are unacceptable:

1.1 Any cracks or linear indications.

1.2 Rounded indications with dimensions greater than 3/16 inch (4.8mm).

1.3 Four or more rounded indications in a line separated by 1/16 inch (1.6 mm) or less edge to edge.

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

2 ASME B31.3 - Chemical Plant and Refinery Piping

Any cracks or linear indications are unacceptable.

3 ASME Section VIII, Division 1

3.1 Indications with any major dimension greater than 1/16 inch (1.6 mm) shall be considered relevant. All surfaces to be examined shall be free of:

3.2 Relevant linear indications

3.2.1 Relevant rounded indications greater than 3/16 inch (4.8 mm).

3.2.2 Four or more rounded defects in a line separated by 1/16 inch (1.6 mm) or less (edge to edge) except where the specification for the material establishes different requirements for acceptance so far as defects are concerned.

4 API 1104 - Welding of Pipelines and Related Facilities

Any indication with a dimension greater than 1/16 inch (1.6 mm) shall be considered relevant. Relevant indications shall be unacceptable when any of the following conditions exist:

4.1 Linear indications evaluated as crater cracks or star cracks, which exceed 5/32 inch (3.96 mm) in length.

4.2 Linear indications evaluated as cracks other than crater cracks or star cracks.

4.3 Linear indications evaluated as incomplete fusion (IF) and exceed 1 inch (25.4 mm) in total length in a continuous 12-inch (304.8 mm) length of weld or 8% of the weld length.

4.4 Individual or scattered porosity (P) shall be unacceptable when any of the following conditions exists:

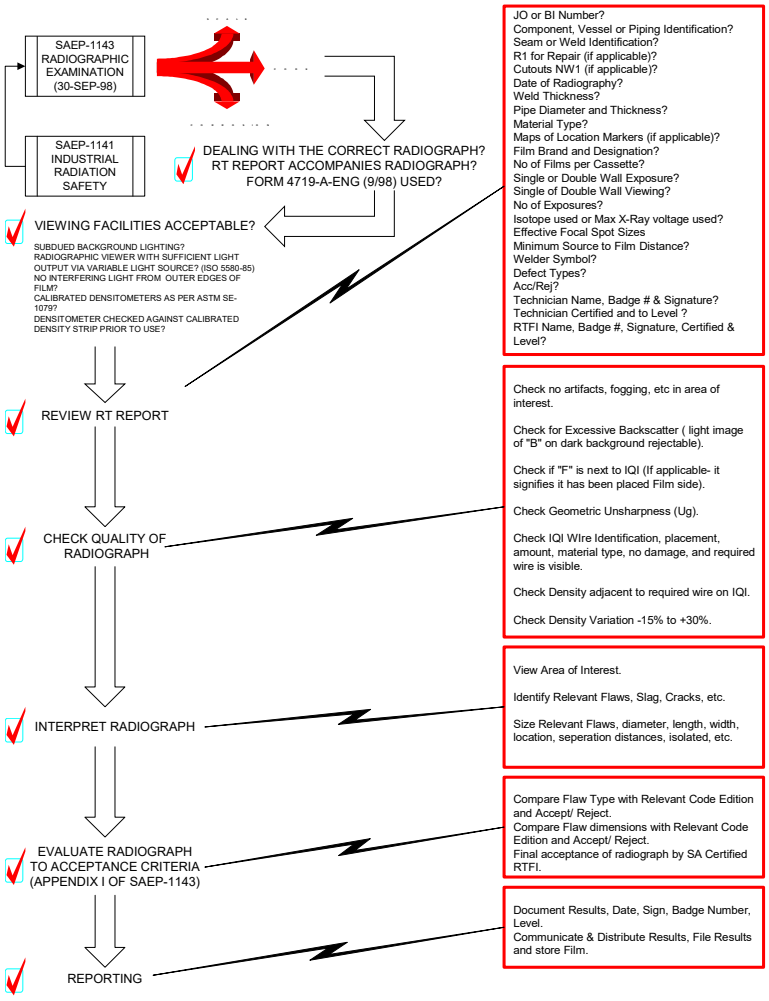
4.5 The size of an individual pore exceeds 1/8 inch (3.17 mm) or 25% of the thinner of the nominal wall thickness joined.

4.6 Cluster porosity (CP) in any pass except the finish pass shall be unacceptable when any of the following conditions exist:

4.7 An individual pore within a cluster exceeds 1/16 inch (1.6 mm).

4.8 The CP diameter exceeds 1/2 inch (12.7 mm).

4.9 The aggregate length of CP in a continuous 12-inch (304.8 mm) length of weld exceeds 1/2 inch (12.7 mm).



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