"PIPELINE WELDING AT SPUR PIPELINE PROJECT"

A thesis submitted in partial fulfilment of the requirements for the Degree of
Master of Technology
(Pipeline Engineering)

By

RAMA RAO.D
R160207017

Under the guidance of

Mr.....
College of Engineering
UPES, Dehradun

Dr. Pinak Biswas
GM(Oil & Gas)
Nandini Impex PLtd.
Delhi

UPES - Library
DH110
RAO-2009MT

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2009

UNIVERSITY OF PETROLEUM & ENERGY STUDIES
LIBRARY
Acc No. DH 110
Date 22/12/11
New Delhi • Dehradun

"PIPELINE WELDING AT SPUR PIPELINE PROJECT"

A thesis submitted in partial fulfilment of the requirements for the Degree of
Master of Technology
(Pipeline Engineering)

By

RAMA RAO.D
R160207017
2007-09

Under the guidance of

Mr.....
College of Engineering
UPES, Dehradun

Dr. Pinak Biswas
GM(Oil & Gas)
Nandini Impex PLtd.
Delhi

Approved

.....

Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2009

NANDINI

NANDINI IMPEX (PVT) LTD.

(TRENCHLESS, TELECOM & ENGG. DIV.)

"White House," 1/18-20, Ground Floor, Rani Jhansi Road, New Delhi-110055
Phone: 011-32495647, 32492819, 23548657/8 Fax: 011-23546218
E-mail: nandini delhi@tirupatigr.com • www.tirupatigr.com

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr Rama Rao.D who Is employed with Nandini Impex Pvt Ltd. has undergone training from Jan 14th 2009 to April 14th 2009. He was particularly interested in pipeline welding and satisfactorily completed his project in **"PIPELINE WELDING AT SPUR PIPELINE PROJECT"** Under my guidance.

Dr Pinak Biswas

GM (Oil & Gas)

Regd. & H. O. : 10, Biplabi Rash Behari Basu Road, Kolkata 700 001 • Tel : 2230 0631/32/33 • Fax : (033) 2248-4751 • E-mail : Kolkata@tirupatigr.com
Branches : 182/184, Nagdevi Street, Mumbai 400 003 • Tel : (022) 2342 0659, 2344 6352/4218 • Fax : (022) 2340 1684 • E-mail : mumbai@tirupatigr.com
119 Raheja Arcade Koramangala Bangalore 560 095 • Tel : (080) 2553 3471, 2553 3680 • Fax : (080) 2553 3471 • E-mail : bangalore@tirupatigr.com

CERTIFICATE

UPES Guide has ascertained quality of the project – II, Anti Plag certification etc for asserting this high quality academic activity.

Signature.....
Name .....
Pipeline Engineering
UPES Dehradun

Corporate Office:
Hydrocarbons Education & Research Society
3rd Floor, PHD House,
4/2 Siri Institutional Area
August Kranti Marg, New Delhi - 110 016 India
Ph.: +91-11-41730151-53 Fax : +91-11-41730154

Main Campus:
Energy Acres,
PO Bidholi Via Prem Nagar,
Dehradun - 248 007 (Uttarakhand), India
Ph.: +91-135-2102690-91, 2694201/ 203/ 208
Fax: +91-135-2694204

Regional Centre (NCR) :
SCO, 9-12, Sector-14,
Gurgaon 122 007
(Haryana), India.
Ph: +91-124-4540 300
Fax: +91-124-4540 330

Regional Centre (Rajahmundry):
GIET, NH 5, Velugubanda,
Rajahmundry - 533 294,
East Godavari Dist., (Andhra Pradesh), India
Tel: +91-883-2484811/ 855
Fax: +91-883-2484822

ACKNOWLEDGEMENT

I would like to take this opportunity to express my most sincere thanks and gratitude to Dr.Pinak Biswas for supervising me throughout the project. His guidance has been phenomenal and without her support the realization of this work would not have been possible. he has been inimitable as a supervisor, with infinite moral endurance, character and resolve and has been pivotal in my pursuit toward this goal.

RAMARAO. D

21st April, 2009

PIPELINE WELDING

PREPARATION FOR WELDING

Pipe Beveled by Manufacturer. Pipe to be welded is usually supplied with a sing bevel of 32½ degrees with a 1/16-in. (1.6-mm) root face for pipe thicknesses up to ³ (19.1 mm). A single U groove is used for heavier pipe. If the pipe has not been pro beveled or has been cut in the field, it must be beveled prior to welding.

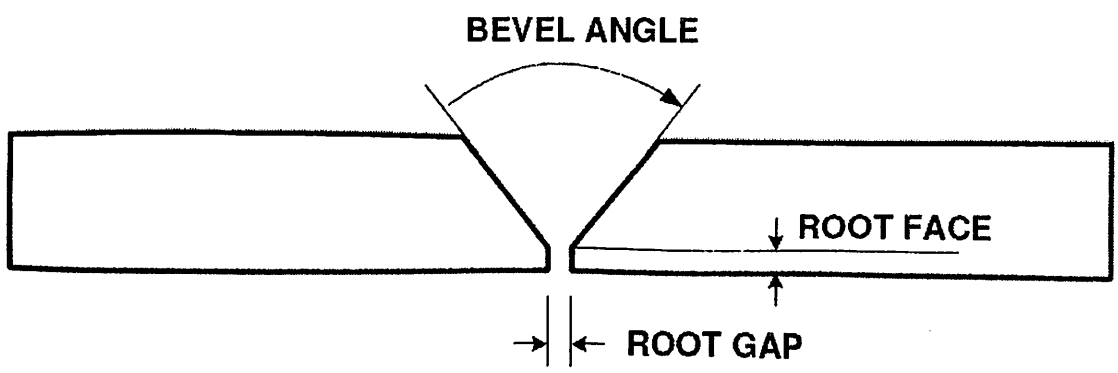
Cutting of Pipe. This operation is necessary when pipe must be cut to suit a spe length requirement. To ensure a leak proof welded joint, the pipe must be cut in a circle in a plane perpendicular to the center line of the pipe. This may be accompli by using a strip of heavy paper, cardboard, leather belting, or sheet gasket material w straight edge longer than the circumference of the pipe to be welded. The materi wrapped around the pipe and overlapped and the pipe marked along the edge o material with a soapstone pencil. Pipe with a wall thickness exceeding 1/8 in. (3.2 should be cut first with a straight cut, then beveled with a hand torch to a 30 to 35 de angle, leaving a shoulder of approximately 1/8 in. (3.2 mm).

Cleaning of Pipe. After beveling, remove all rust, dirt, scale, or other foreign matter the outside of the pipe in the vicinity of the weld with a file, wire brush, grinding dis other type of abrasive. If the bevels are made by oxyacetylene cutting, the oxide fo must be entirely removed. The inside of the pipe in the vicinity of the weld ma cleaned by a boiler tube and flue cleaner, by sandblasting, by tapping with a hammer an airblast followup, or by any other suitable method, depending on the inside dian of the pipe. Care must be taken to clean the scarf faces thoroughly.

Aligning the Joint.

A pipe lineup clamp should be used to align and securely hold the pipe ends before welding. The spacing depends on the size of the electrode used for the root pass.

Standard Edge Preparation



Root Gap

- ✓ Desired Range - 1.6 – 3.0 mm
- ✓ Excessive Gap - No fusion
- ✓ Less Gap - Lack of penetration

Root Face

- ✓ Desired Range - 1.6 – 3.0 mm
- ✓ Excessive Face - Lack of penetration
- ✓ Less Face - Burn Through

Bevel Angle

- ✓ Desired Angle - 60 – 70%
- ✓ Excessive Bevel - High weld deposit
- ✓ Less Bevel - Difficulty in electrode maneuverability

PIPE WELDING PROCESSES

The most commonly used processes for joining pipe is the manual shielded metal-arc process. Automatic and semiautomatic submerged arc, inert gas metal-arc, and atomic hydrogen welding are also used, particularly in shop operations. Manual oxyacetylene welding is generally limited to small size piping or to welding operations where clearances around the joints are small.

Shielded Metal-Arc Process.

(1) The shielded metal-arc process can be used for welding pipe materials such as aluminum, magnesium, and high chromium-nickel alloys that are difficult to weld by other processes. In shielded metal-arc welding, the number of passes required for welding ferrous metal piping varies with the pipe thickness, the welding position, the size of the electrode, and the welding current used.

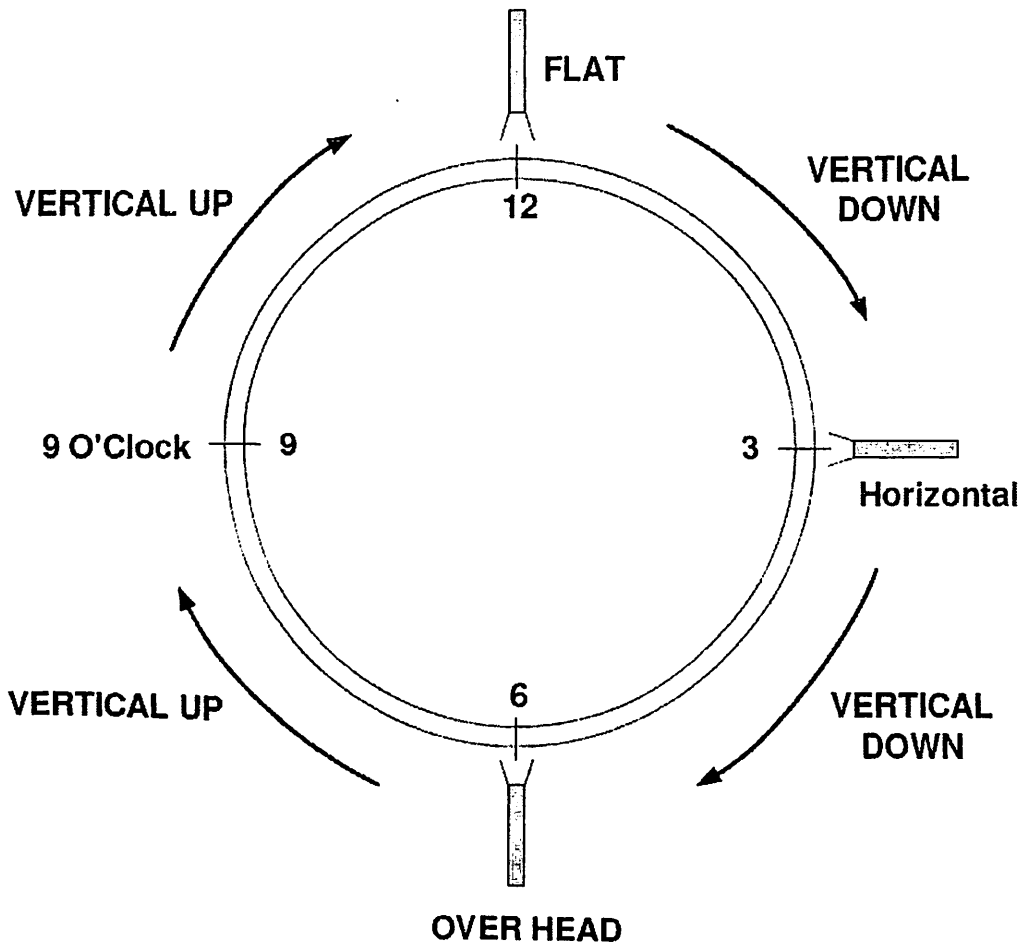
(2) The number of passes required for welding low alloy and low carbon steel pipe depends on the thickness of the pipe, the welding position, the size of the electrode, and the current used but, in general, is approximately one pass for each 1/8 in. (3.2 mm) of pipe thickness. When welding in the horizontal or rolled position, the number of layers is usually increased 25 to 30 percent. Smaller electrodes are used to lessen the heat concentration and to ensure complete grain refinement of the weld metal.

(3) The electrodes used vary from 1/8 to 5/32 in. (3.2 to 4.0 mm) diameter for the first pass, 5/32 in. (4.0 mm) diameter for the intermediate passes, and up to 3/16 in. (4.8 mm) for the top passes and reinforcement.

Direction of Welding.

(1) In manual shielded metal-arc welding, as much welding as possible is done in the flat or downhill position using suitable power driven equipment for rotating the pipe at a speed consistent with the speed of welding. When the pipe is in a fixed horizontal position, the weld is usually made from the bottom uphill. With thin or medium thickness pipe, the welding is done downward. More metal is deposited when welding upward. Complete grain refinement is easier to achieve, and welding downward requires a much higher degree of manual skill.

(2) When the pipe is in a fixed vertical position, it is customary to deposit the filler metal in a series of overlapping string beads, using 1/8 in. (3.2 mm) maximum electrodes, and allowing 25 to 30 beads per square inch of weld area.



Weld Positions

Vertical Down v/s Vertical up

Vertical down uses high welding currents and fast travel speeds to make joints with several beads. This method is fast and economical on pipe under ½" wall thickness. With downhill arc welding, the speed is approximately three times that of the uphill welding method. Most cross country pipelines are welded with vertical down technique.

Vertical up uses low currents, slow travel speeds and often low hydrogen electrodes to produce joints with relatively few, heavy beads. Cleaning time is reduced giving the vertical up method a speed advantage over vertical down on heavy wall pipe. The low hydrogen electrodes and slow travel speed of vertical up effectively eliminate gas holes. Welds made by this method are best able to meet the X-Ray requirement for high pressure, high temperature or low temperature piping.

Multipass Arc Welding sequence

Root Pass (Stringer Bead)

After the pipe is lined up and held in position with a clamp, welder makes the first and most important weld, the root pass. The stringer bead is made using a drag technique. The electrode coating rests on the bevel as the electrode is dragged downhill around the circumference.

Hot Pass

The root pass is thoroughly cleaned with power wire brushing or disc grinding before starting the hot pass. Hot pass is applied with sufficient heat to burn out all wagon tracks and float any remaining slag on the surface. Hot pass is started immediately after completion of Stringer bead.

Filler Pass

A slight side to side weave is used when applying filler passes to completely fill the groove.

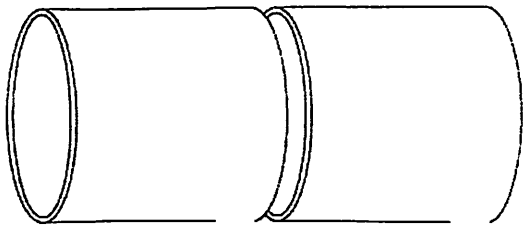
Stripper Pass

Before applying the Cover pass, it is sometimes necessary to flush up concave portions of the weld. These generally occur in the 2-5 o'clock position on the pipe. These short welds are called stripper passes.

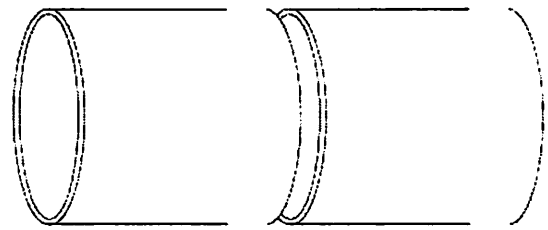
Cover Pass

The cover pass is usually 1/32" to 1/16" higher than the pipe wall and overlaps the groove by 1/16" on each side. Better stress distribution is achieved by keeping the cover pass as narrow as possible.

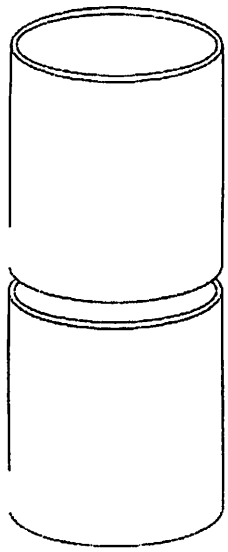
Designations of Butt Weld Positions in Pipes



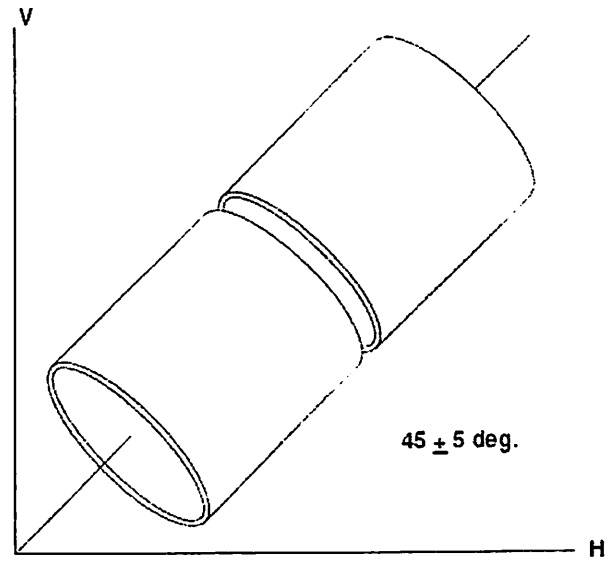
1 G (Rotated)



5 G (Fixed)



2 G (Vertical)

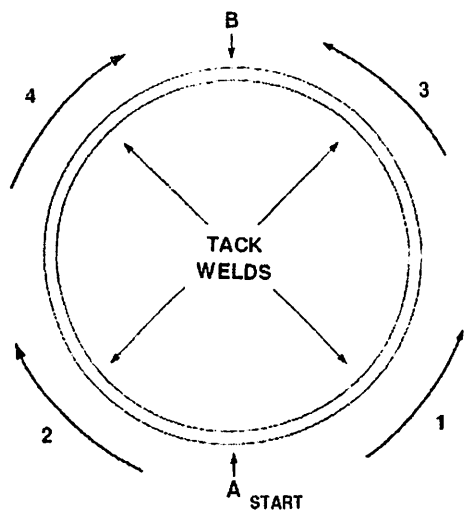


6 G (Inclined)

PIPE WELDING PROCEDURES

Horizontal Pipe Fixed Position Weld (5G)

After tack welding, the pipe is set up so that the tack welds are oriented approximately as shown in figure below. After welding has been started, the pipe must not be moved in any direction.



When welding in the horizontal fixed position, the pipe is welded in four steps.

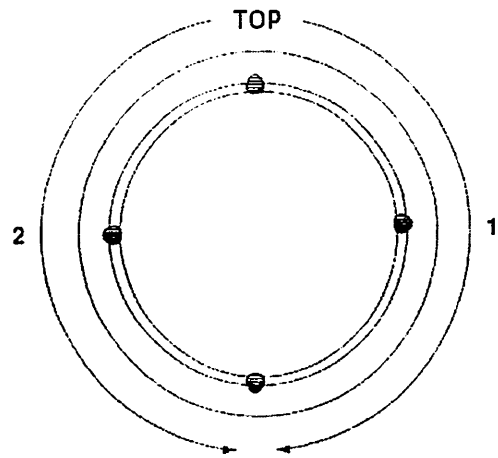
Step 1 Starting at the bottom of 6 o'clock position, weld upward to the 3 o'clock position.

Step 2 Starting back at the bottom, weld upward to the 9 o'clock position.

Step 3 Starting back at the 3 o'clock position, weld to the top.

Step 4 Starting back at the 9 o'clock position, weld upward to the top overlapping the bead.

When welding downward, the weld is made in two stages. Start at the top overlapping the bead. Work down one side 1 to the bottom, then return to the top and work down the other side 2, to join with the previous weld at the bottom.



AWS 5.1 – SPECIFICATION FOR C-STEEL ELECTRODES

Designation	:	E XXXX – X
First two digits	:	Tensile strength in ksi
Third & Fourth digit	:	Indicates welding position, Current type and type of covering
Suffix letter	:	Chemical composition or special characteristics

1 indicates requirements for improved toughness

HZ indicates requirement for diffusible hydrogen test: Z is 4, 8 or 16 ml of H_2/100 g of deposited metal

R requirements of absorbed moisture test

M intended to meet most military requirements

AWS 5.1 – Specification for C – Steel / Low Alloy Steel Electrodes

Electrode	Type of covering	Welding Position	Type of current
E 6010	High cellulose sodium	F, V, OH, H	DCEP
E 6011	High cellulose potassium	F, V, OH, H	AC or DCEP
E 6012	High titania sodium	F, V, OH, H	AC or DCEN
E 6013	Iron oxide titania potassium	F, V, OH, H	AC or DCEP or DCEN
E 6020	High Iron oxide	F, H – Fillets	AC or DCEN
E 7010 – X	High cellulose sodium	F, V, OH, H	DCEP
E 7011 – X	High cellulose potassium	F, V, OH, H	AC or DCEP
E 7014	Iron powder titania	F, V, OH, H	AC, DCEP or DCEN
E 7015	Low Hydrogen sodium	F, V, OH, H	DCEP
E 7016	Low Hydrogen Potassium	F, V, OH, H	AC or DCEP
E 7018	Low H2, Iron powder potassium	F, V, OH, H	AC or DCEP
E 7018 M	Low Hydrogen Iron Powder	F, V, OH, H	AC or DCEP
E 7020 – X	High Iron oxide	H Fillets F	AC or DCEN AC or DCEN or DCEP
E 7024	Iron Powder, Titania	H – Fillets, F	AC or DCEP or DCEN
E 7027	High Iron oxide, Iron Powder	H – Fillets, F	AC or DCEN
E 7028	Low H2, Iron powder potassium	H – Fillets, F	AC or DCEP
E 7048	Low H2, Iron powder Potassium	F, V, OH, H	AC or DCEP





Electrode	Type of covering	Welding Position	Type of current
		V Down	
E 8010 – X	High cellulose sodium	F, V, OH, H	DCEP
E 8011 - G	High cellulose potassium	F, V, OH, H	AC or DCEP
E 8013 – G	High titania potassium	F, V, OH, H	AC or DCEPor DCEN
E 8015 – X	Low H2 Sodium	F, V, OH, H	AC or DCEP
E 8016 – X	Low H2 Potassium	F, V, OH, H	AC or DCEP
E 8018 – X	Low H2 Iron Powder Potassium	F, V, OH, H	AC or DCEP

X : A1, B1, B2, BL, B3, B3L B4L, B5, B6, B6L, B7, B7L, B8L, B9, C1, C1L, C2, C3, C4, C5L, NM1, D1, D2, D3, G, M, M1, P1, W1,W2

Tensile Test requirements

Electrode	Tensile strength (Mpa)	Yield strength (Mpa)	% Elongation
E 6010	414	331	22
E 6011	414	331	22
E 6012	414	331	17
E 6013	414	331	17
E 6020	414	331	22
E 7014	482	399	17
E 7015	482	399	22
E 7016	482	399	22
E 7018	482	399	22
E 7024	482	399	17
E 7027	482	399	22
E 7028	482	399	22
E 7048	482	399	22
E 7018 M	482	365-496*	24

Charpy V Notch Test requirements

Electrode	Average of 3	Single value
E 6010, E 6011 E 6027, E 7015 E 7016, E 7018 E 7027, E 7048	27 J at – 29 Deg.C	20 J – 29 Deg.C
E 6019, E 7028	27 J at – 18 Deg.C	20 J at – 18 Deg.C
E 6012, E 6013, E 6020, E 6022 E 7014, E 7024	Not Specified	Not specified

API 1104 – WELDING OF PIPELINES & RELATED FACILITIES

SCOPE

- ✓ API 1104 covers gas and arc welding for the production of high-quality welds in carbon and low-alloy steel piping used in the compression, pumping, and transmission of crude petroleum, petroleum products, and fuel gases, and where applicable, to distribution systems.

- ✓ This code covers the many different types of welding processes, such as those done by Shielded Metal-arch Welding (SMAW), Submerged Arc Welding (SAW), gas tungsten-arc welding (GTAW), gas metal-arc welding (GMAW) etc.

- ✓ It also covers the acceptance standards to be applied to production welds tested to destruction or inspected by radiography, and includes the procedure for radiographic inspection.

MATERIALS

Pipes & Fittings - API 5L / ASTM Specifications
Consumables - AWS A 5.1, 5.2, 5.5, 5.17, 5.18, 5.20, 5.28, 5.29

QUALIFICATION OF WELDING PROCEDURES

Essential variables

i) Welding process & method of application – Manual, Semi-automatic, Automatic

ii) Base Material
- Group 1 – Yield Strength $\leq$ 42 ksi
- Group 2 - Yield Strength – 42 to 65 ksi
- Group 3 – Yield Strength $\geq$ 65 ksi

iii) Filler Metal

Group	AWS spec	Electrode / Flux
1	A 5.1	E 6010 / 6011
	A 5.5	E 7010 / 7011
2	A 5.5	E 8010 / 8011
3	A 5.1 / 5.5	E 7015 / 7016 / 7018
	A 5.5	E 8015 / 8016 / 8018
4	A 5.17	EL 8/P6XZ (SAW)
5	A 5.18	ER 70S-2 (GMAW)
6	A 5.18	ER 70S-6 (GMAW)

Group	AWS spec	Electrode / Flux
7	A 5.28	ER 80S-D2 (GMAW)
8	A 5.2	RG 60, 65 (FCAW)
9	A 5.20	E 61T – GS – GTA Root
10	A 5.29	E 71T8-K6 (GTAW)
11	A 5.29	E 91T8-G (GTAW)

iv) Joint Design - V or U groove & Major changes in Bevel angle and root face and gap

v) Welding position : Rolled or Fixed

vi) Wall Thickness

vii) Electrical characteristics – Change in Polarity DCEP (Direct Current Electrode Positive) to DCEN (Direct Current Electrode Negative) or AC (Alternating Current) or vice – versa.

In DCEP the electricity flows into the tip of the welding rod and concentrates about two-thirds of the heat, which gives good penetration. DCEP is usually used on thicker steels.

In DCEN the electricity flows out of the rod, concentrating about one-third of the heat on the rod. DCEN is usually used for thinner steels.

viii) Time between passes – Maximum time between completion of Root bead and start of second bead.

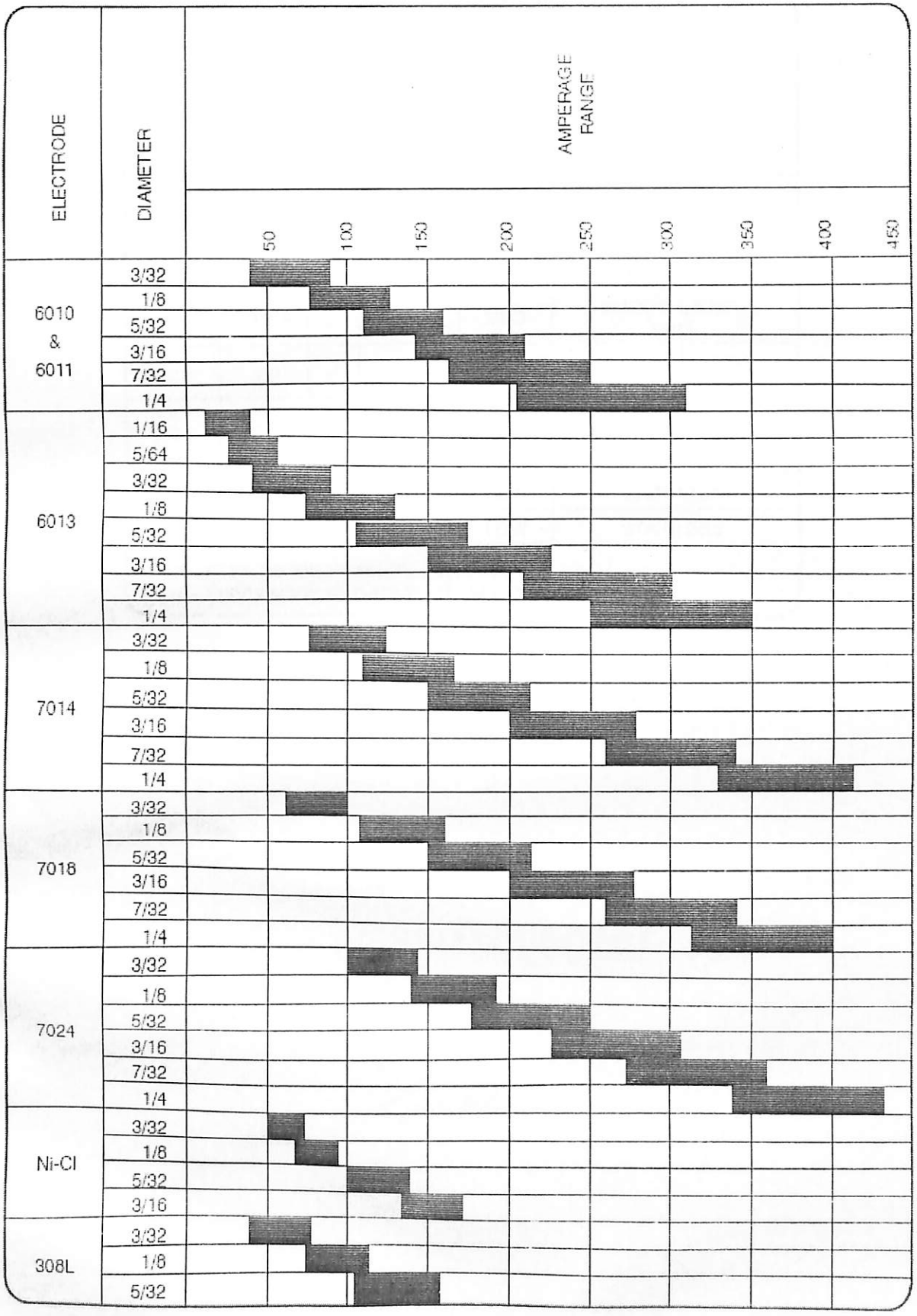
ix) Direction of welding – Vertical Down Hill or Up Hill

x) Shielding gas flow rate

xi) Speed of travel (For automatic welding)

Tests

- ✓ Transverse Tensile Tests
- ✓ Nick Break Test
- ✓ Bend Test (Face, Root & Side bend


ELECTRODE
DIAMETER
AMPERAGE RANGE
50
100
150
200
250
300
350
400
450
6010 & 6011
3/32
1/8
5/32
3/16
7/32
1/4
6013
1/16
5/64
3/32
1/8
5/32
3/16
7/32
1/4
7014
3/32
1/8
5/32
3/16
7/32
1/4
7018
3/32
1/8
5/32
3/16
7/32
1/4
7024
3/32
1/8
5/32
3/16
7/32
1/4
Ni-CI
3/32
1/8
5/32
3/16
308L
3/32
1/8
5/32

ELECTRODE	DC*	AC	POSITION	PENETRATION	USAGE
6010	EP		ALL	DEEP	MIN. PREP. ROUGH HIGH SPATTER
6011	EP	√	ALL	DEEP	
6013	EP,EN	√	ALL	LOW	GENERAL
7014	EP,EN	√	ALL	MED	SMOOTH, EASY, FAST
7018	EP	√	ALL	LOW	LOW HYDROGEN, STRONG
7024	EP,EN	√	FLAT HORIZ FILLET	LOW	SMOOTH, EASY, FASTER
NI-CL	EP	√	ALL	LOW	CAST IRON
308L	EP	√	ALL	LOW	STAINLESS

*EP = ELECTRODE POSITIVE (REVERSE POLARITY)
EN = ELECTRODE NEGATIVE (STRAIGHT POLARITY)

WELDER QUALIFICATION PROCEDURE

Method :

A. Welders will be selected based on certificate of previous experience and or conducting show test pieces at site by NIPL.

B. After selection of welders, SGL / JPKT will be informed to witness the welder's qualification test at site. Using a qualified Welding Procedure and a visual report as per Format prepared. Every welder shall execute for his qualification test a weld at least one half the circumference of the pipe starting from the top of the pipe until the bottom.

C. After acceptance of visual inspection, test piece will be taken for radiography.

D. Radiography accepted welders will be engaged on the job.

E. Welder ID numbering system shall be as follows :-

- During qualification a temporary number like initial (i.e. Mr. R.T.V.Prasad = R.T.V.P.) will be given.

- After success acceptance of NDT, a permanent number will be allotted to the welder as mentioned below :

  For BCPL : W 01 to W100

  Welder's qualification test record as per the approved format will be prepared.

  I.D. Card for qualified welders as per the approved format will be prepared. The original I.D. card will be retained by NIPL welding engineer and a Xerox copy will be carried by the welders working at site. Original card will be produced to SGL / JPKT for any verification on demand.

  A welder will participate only once to the qualification test.

  Qualification validity of any welder is subject to satisfactory performance during production welding.

  Welders performance will also be assessed fortnightly based on NDT result of the joint welded by each welder and reports for the same will be submitted to SGL / JPKT by NIPL.

4.0 **Documentation:**

Witness of Welder Qualification report:

Welder qualification report :

Welder's ID card :

MAINLINE WELDING AND FORMAT

All work shall be carried out as specification No. 11-0234-02-P-01-011-Rev0- Before the fit-up pipe shall be checked for correct thickness, specification etc. Bevel ends shall be visually checked, if any damages are found the same can be repaired as mentioned below:

a. Dents less than 1 mm depth shall be removed by grinding.

b. Dents 1 mm to 3 mm depth shall be re-beveled by grinding.

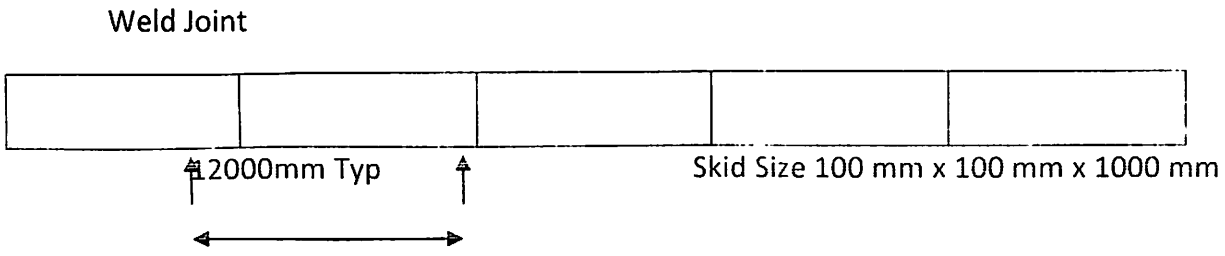
c. Depth more than 3 mm shall be gas cut and re-beveled.

Before welding, all rust and foreign matter shall be removed from the beveled ends by power operated tools at inside and outside edges for minimum distance of 25mmfrom the edge of the weld bevel. Manual cutting and repairing of pipes and bevels by welding is not allowed.

On pipes, which have been cut back, a zone extending 25mm back from the new field bevel, shall be ultrasonically tested to the requirement of the line pipe specification to ensure freedom from lamination. the new bevel shall be 100% visual and 100% dye penetrate/ mpi tested a report shall be written for all testing. The rebevelled pipe heat number identification shall be maintained by transferring information to the new pipe end. Where the pipe is to be field cut and welded, the shop-applied coating shall be neatly peeled and ground for a distance of 100 mm from the weld.

During alignment and fit-up first pipe will be rested and locked on the pre- positioned skids and the second pipe will be held by hydra crane with internal fit- up clamp (Mechanical), the second pipe will be carefully lowered on pre- positioned skids. Skidding arrangement shall be as shown below and skids may be removed only after completion of the entire welding and the pipe shall be rested on the sand bags. Longitudinal weld seams of adjoining pipes shall be staggered such that a minimum distance of 300 mm is maintained along the circumference and both longitudinal weld are at top 90º quadrant of the pipeline (Except for bends). A longitudinal joint shall pass an appurtenance of a structural element at a minimum distance of 50mm.

Welding shall be not done in open areas during blowing sands, dust storms, high wind, rains or relative humidity is higher than 75% as JPKT specification.



Maximum offset of the same nominal wall thickness pipe shall not be more than 1.6 mm. Maximum length of weld string shall be 1000 Mtrs. And the off-set may be checked by using dial guage.

In case of slight misalignment, cold hammering is permissible only by brass hammer. Hot dressing is not permitted. Root gap shall be as per the approved WPS.

After alignment & fit-up, pre-heating shall be carried out and the same shall be checked with thermo chalks / temperature indicating pyrometer before starting the root run.as per wps.

Ear thing clamps used for welding return circuit shall only be placed on bevel area or cir. Welds.

Internal line-up clamps shall not be released before the root run is completed. In case of external clamps at least 60% of the root weld (between all spaces of the bars) shall be completed before releasing the clamp. Weld joints shall be protected from rains / sand storms. Windshield shall be used in the afore said conditions.

Pre-heating and inter-pass temperature shall be done as per the approved WPS / Procedure. Minimum pre-heating shall be 100 degree centigrade.

Before any pipe length is cut, the painted serial number and the heat number shall be transferred to the either side of the joint which is to be made by cutting and records shall be prepared as per approved format.

Pipe pup piece for the Tie-In shall be minimum 1M. Two or more pup pieces shall not be welded together. In no case more than 03 cir. Seam welds shall be permitted in 10M length of pipe. Where different wall thickness pipes are to be welded and the difference in wall thickness is more than 1.6 mm then 1:4 taper internal grinding on the higher thickness shall be done.

Welding:

Welding shall be carried out as per the approved WPS. Minimum number of welders shall be two for mainline and Tie-In welding for each pass.

Weld Sequence:

Welder No.1 shall start from 12 'O' Clock position and proceed towards 6 'O' Clock, Welder No.2 shall start from 9 'O' Clock position and proceed towards 6 'O' Clock and then from 12 'O' Clock to 9 'O' Clock. Proper Overlap shall be ensured.

After completing every pass, the same shall be cleaned / flattened by grinding and power brushing.

Electrode starting & finishing points shall be staggered from pass to pass.

Interruption between first pass to second pass and to third pass shall be as per the approved WPS. After completion of the third pass welding may be suspended if required, so as to allow the weld joint to cool down provided the thickness of the weld metal deposited shall be 50% of the pipe thickness or minimum of 03 passes whichever is more. Upon restarting the welding pre-heating shall be carried out.

Arc Strike outside the beveled area on the pipe surfaces is not permitted.

Acceptance criteria for arc strike / arc burn: < 0.5mm acceptable if ground out, > 0.5mm un-acceptable and cut- out.

Accidental arc strikes / arc burns if any shall be repaired only by an approved procedure.

Repair of arc strike by welding is not allowed.

Pipe should not be pumped or shaken during welding.

Welders shall be qualified as per the approved WPS and all the welders should have identity cards duly signed by SGS.

After completion of welding the number assigned to the welders shall mark all welds on the top off pipe. After completion of welding visual inspection shall be done and all the surface defects shall be removed as per the specification. NDT shall be carried out as per the approved NDT procedures. NDT repairs shall be done as per approved WPS.

Repair procedure to be qualified separately for full through thickness and partial thickness respectively. Only 01 attempt for at repair of any region is permitted.

Repairs are limited to a maximum 30% of the weld length. for internal repairs or external repair which open the weld root, only 20% of the weld length may be repaired .

Destructive testing of weld joints (Production Joints) shall be one test per 0.1% of welding. And Production test to be carry out for each project.

At the end of the day's work or every time when joining and welding operations are interrupted, the open ends are to be closed with nightcaps.

1. **DOCUMENTATION :**

Inspection and Test Plan :

Inspection Report :

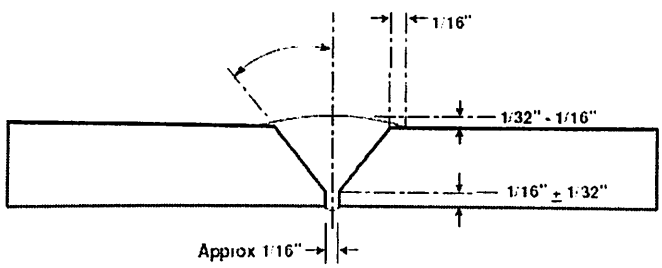
TYPICAL PROCEDURE SPECIFICATION (API 1104, 2.2)

PROCEDURE SPECIFICATION NO. XXX

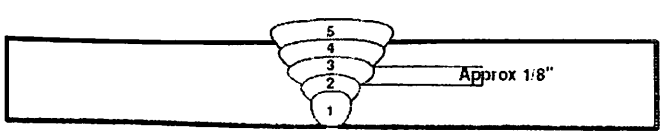
For M/s XYZ company: Welding of Petroleum Gas Pipe & Fittings

Process	:	SAW
Material	:	API 5L X65
Dia & Wall Thickness	:	18" & 6.4 mm
Joint Design	:	Single Vee
Filler material	:	AWS 5.1 E 7010-G
No. of Beads	:	5
Electrical Characteristics	:	24 – 28V, 120-140 A, DCSP
Position	:	1 G
Direction of welding	:	Downhill
No. of welders	:	1
Time lapse between passes	:	2 minutes
Type of clamps	:	External
Removal of clamps	:	Remove after root pass
Cleaning & Grinding	:	Use only hand tools
Preheat	:	Not required
Stress Relief	:	Not required

Tested	:	Welder	:
Approved	:	Supervisor	:
Adopted	:	Chief Engineer:	



Standard V - Bevel Butt Joint



Sequence of Beads

Bead No.	Electrode Size & Type	Voltage	Amperage & Polarity	Speed

NANDINI PROCEDURE SPECIFICATION

WELD JOINT NUMBERING

METHOD

All joints to be welded shall be numbered as indicated below:

Mainline Joints

KM X /Y / A - C - E - G Flow Direction

B – D – F – H ⟶

Here:

- X indicates chainage in Kilometer **eg.** The welds between kilometer KM 0 and KM1 are indicated as KM 0 and the welds between kilometer KM1 and KM2 are indicated as KM1
- Y indicates the joint number **eg.** The weld joint number between KM0 and KM1 are indicated as KM 0 /1, KM 0 /2 , KM0 /3 ,
  KM0/4, KM0/5 etc. If there is Tie – Ins in between KM0/2 & KM0/4 and between KM0/5 & KM0 /7 follow Tie–in weld joint Numbering system as it is as per job procedure. In between KM0 /2 & KM0 / 4, KM0 / 5 & KM0 / 7 mainline are get lapsed as shown below example.

KM0 /3 & KM0 /6 get lapsed and substituted by relevant Tie- in jts.

- A & B are Root welder ID numbers
- C & D is Hot Pass welder ID numbers
- E & F are Filler welder ID numbers
- G & H are Capping welder ID numbers

Tie-In Weld Joints

KM X /Y / A - G Flow Direction

B – H ⟶

Here:

- X indicates chainage in Kilometer **eg.** The welds between kilometer KM 0 and KM1 are indicated as KM 0 and the welds between kilometer KM1 and KM2 are indicated as KM 1.

- Y indicates the joint number **eg.** The weld joint number between KM0 and KM1 are indicated as KM 0/T1, KM 0/T2 etc.
- A & B are Root, Hot pass & Filler-1 welder ID numbers
- G & H are Filler & Capping welder ID numbers

Where pipe ends are cut :

All pipe cutting including cutback, damaged bevel ends shall be reported and revised pipe numbers allocated to each cut pipe (pup). The revision takes the form of a suffix A, B, C etc eg. Pipe No 5003 cut into three piece. Pieces shall be denoted as 5003 A, 5003 B and 5003 C. The revised pup's numbers shall be transferred inside & outside surface of the pups before cutting.

Illustration for welder numbers :

A – C - E – G ⟶ 12 – 3 – 6 o'clock position

B – D – F – H ⟵ 12 – 9 - 6 Anti Clock position

Where A, B, C, D, E, F, G, H are respective welders ID numbers Clock position shall be visualized with a person facing higher chainage and with his back towards lower chainage. (Flow Direction)

All the numbers shall be written with yellow chalk facing towards ROW side and afterwards by yellow / white / red paint. Such paint shall be to the satisfaction of client.

RADIOGRAPHY

(GAMMA RAY)

ULTRASONIC TESTING

1. PURPOSE :

This procedure is used to detect internal discontinuities of Girth welds in Cross Country pipeline. The discontinuities parallel to the scanning surface are the most ones favorably aligned for detection.

2. SCOPE:

This is specific procedure which describes Examination of weld of pipelines, by using Ultrasonic Flaw Detector with pulse echo contact beam method, for thickness 5 mm and above. This procedure is useful for examination of welds of single wall of pipes of diameter 6" and above.

3. REFERENCE DOCUMENTS:

ASME Sec. V

API 1104

TECPL Spec. PTS 21030 Z/02/002A

4. PERSONAL QUALIFICATION:

The qualification of the NDT inspector to carry out this testing shall be minimum ASNT Level II & or Company's level II in accordance with Company's Written Practice WP/SI/001 which is in accordance to ASNT SNT TC 1A & / ANSI CP 189. Documents of NDT personnel as require to SGL/ JPKT for review & approval.

5. EQUIPMENT & ACCESSORIES :

Suitable Miniature and Large Probes

(Normal Probe, TR Probe, Angle Probes of (60^0 & 70^0)

Matching Cables

Couplant – Oil/ Water

Drawing & Gauging Tools

6. STANDARD & REFERENCE BLOCKS:

I.I.W V1 AND / OR I.W .V2 sample block, or the, Step wedge,

Notch Blcok for D.A.C. as shown in figure 1b.

7. CALIBRATION OF ULTRASONIC FLAW DETECTOR :

The calibration of the UFD shall be carried out in accordance with specific written procedure for its vertical & horizontal linearity once in every six months or after repair of UFD whichever is earlier. Or as per API 1104.

In addition, Amplitude control corrections, Beam spread, index point, Beam angle and Resolution will be checked and the type, Method and frequency will be as per approved procedure for weld scanning and lamination check.

8. DISTANCE AMPLITUDE CORRECTION CURVE (D.A.C. CURVE):

Following steps shall be carried out to obtain a DAC curve for angle probe. See figure 1a, & 1b.

I. After finding Beam Index and probe angle (±2 degree).
II. Calibrate the screen range as required beam path using VI or V2 standard block.
III. Apply couplant to notched reference block.
IV. Take echo from ID Notch at 80% (±5%) maximize and mark.
V. Note down the dB.
VI. Repeat the same for OD Notch and ID notch and mark.
VII. Draw the curve connecting three points from Echo leg and connect to draw a curve.

9. SURFACE CONDITION:

The surface with which the probe comes into contact shall be free of metal spatter, dirt, rust and scales of any type, and the scanning surface shall be clean. Surface shall be smooth to carry out effective test for atleast 50mm wide on both sides of the weld. Any how the cleaned strip must be atleast wide enough to allow 1 ½ Skip Examination. If surface is not smooth as reference block, dB correction shall be done.

10 PROBE SELECTION:

The combination of probes in addition to normal probes shall be selected as per specific requirement or as per thickness of the pipe

THICKNESS RANGES	PROBES COMBINATIONS
5 mm to 10mm	TR 60^0 & 70^0
10 mm to 20mm	60^0 & 70^0

11. SCANNING:

Hundred percent area shall be scanned by all selected probes both side of the welds using longitudinal and shear wave probes adding +6 db. Length of scanning shall be minimum of ½ Beam Path to 1 ½ Beam Path on the both side of weld. See figure 2.

In case of only parent metal inspection, normal /TR scanning shall be carried out.

12. PROCEDURE:

Unless otherwise specified inspect the weld on both side by using longitudinal and shear wave probes.

LONGITUDINAL WAVE PROBE:

With reference to first back wall echo 80% ± 5% scanning shall be carried out before and after weld on base metal to confirm any inherent or after weld discontinuity. During scanning with longitudinal wave probe, full contact and echo height shall be maintained. Area of scanning shall be at least ½ Beam Path to 1 ½ Beam Path on the both side of pipe weld. This scanning will reveal discontinuity with major surface parallel to scanning surface.

SHEAR WAVE PROBE:

With respect to DAC, scanning shall be carried out on both sides of weld to determine discontinuity within the weld & base metal, which are not parallel to scanning surface. Both the probes shall be scanned individually on both the side. Scanning shall cover at least ½ Beam Path to 1 ½ Beam Path of beam path. Unless & otherwise specified, circumferential direction scanning shall be carried out on base metal.

13. PERIODIC CHECK OF SCREEN CALIBRATION:

Calibration of screen shall be checked prior to any inspection run, prior equipment shut down and at least in each 4 hours during continuous equipment operation.

14. INTERPRETATION OF RESULTS:

Each time that echoes from the weld bead appear during production testing the instrument amplification shall be altered to coincide with the reference (after reducing 6 db) amplifications and the probe shall be moved until maximum response is obtained, paying attention all the time to the probe tube coupling.

If, under these conditions, the height of the defect echo is equal to or greater than that of the reference echo, the defect shall be evaluated according to the TECPL's specification. If the defect has also been detected by Radiographic and or visual Examination, the dimensions shall be judged according to the type of Examination, which detects the greater defect. Echoes that are less than 50% but lower than 100% of the reference echo, and if the operator has good reasons to suspect that the returns are caused by unfavorably oriented cracks, he shall inform the Contractor/Consultant. Moreover, when there is a defect to be repaired, such defect shall be removed for a length, corresponding to the one where no more return echo is given.

All indications that are equal to or greater than rejection level, established during calibration, as described in acceptance / rejection criteria agreed by client's inspector, shall be considered representing defects and may be cause of rejection or repair of the weld or base metal.

15. ACCEPTANCE OR REJECTION CRITERIA:

Acceptance or rejection criteria shall be in accordance with API 1104 or client's as per specified in client's specification. All defect location shall be marked & / or recorded for repairing.

16. RETEST:

Retest of the repaired area shall be carried out in accordance this procedure.

17. REPORTING:

All details of inspection and results of inspection shall be documented in Report Format No. 4.9 F003 and shall be signed by NDT inspector and client's representative.

WELD REPAIR

METHOD:

a. Equipment

(i) DG Sets

(ii) Gas Burner

(iii) Welding Generator

(iv) Grinding M/c

b. Location

With respect to radiography or other NDT method, the location will be marked on

the weld with reference to marking of ref. Points (markers).

c. Method of evaluation: -

1) Partial repair:
Each layer will be thoroughly checked for this type of discontinuity shown in NDT reports. Smooth grinding will be done to make 'V' Groove and clean all surfaces. Only one attempt at repair of any region is permitted. Repairs are limited to maximum 30% of the weld length. For internal repairs or external repairs which open the weld root, Only 20% of the weld length may be repaired. The minimum length of a repaired shall be cut out and rebevelled to make joint.

The repair weld shall be subjected, as a minimum requirement to the same testing and inspection requirements as the original weld, The entire joint shall be re-radio graphed. A 100% ultrasonic inspection shall be done at the repaired area externally. Any repaired area that is wide, irregular or rough shall be rejected and full cut out shall be done. The repair welding shall have a minimum preheat of 100ºc and shall be preheated for at least 150 mm on either side of repair.

Root sealing or single pass repair deposit shall not he allowed. Internal root defects shall be ground thoroughly and welded with a minimum of two passes. However, while grinding for repair, care shall be taken to ensure that no grinding marks are made on the pipe surface anywhere.

2) Through repair

Grinding will be done up to the root, opening will be done by chisel, hacksaw blade. The entire vol., will be ground smoothly to 'V' groove, root gap will be achieved using blades, thin grinding wheels and filing. Max. repair length is 20% of weld.

d. Welding

After identifying the defects the repair of weld shall be carried out in accordance with approved WPS and PQR. Care shall be taken to ensure that no grinding marks are made on pipe surface anywhere. Repair weld deposition shall be smooth, free from cuts and other surface irregularities. The root gap shall be made carefully and shall confirm to the welding procedure. The welded area shall be thoroughly cleared. Any repaired area that is irregular shall be rejected and a full cut out and re-beveled to make a joint. Repairs opening the root shall be carried out in the presence of experienced Supervisor. All repairs shall be carried out during the day after initial radiography. The reports of all repairs shall be maintained by CIPL and shall be submitted every day to SGS/JPKT for review. CIPL shall identify the welders giving repairs more than acceptable limit and that particular welder shall be warned by CIPL.

In case the percentage of repairs is not reduced within acceptable limits after issuing one warning welder shall be rejected by Contractor and shall maintain records.

e) Cleaning

Each pass will be thoroughly cleaned using power brush / grinding mated

f) No. of Welders

Qualified welder for the appropriate process, consumable and direction alone will be envisaged. Welding carried out in accordance with approved PQR.

g) Parameters

As per WPS & PQR (approved)

h) NDT

i) Radiographic inspection covering the repair welds length.

ii) UT at the repair joint.

i) No. of attempts for repairing: one

TIE IN JOINTS

All work shall be carried out as per specification No. 11-0234-02-P-01-002/-011 -Rev-0, API 1104, ANSI 31.8, ASME Sec IIC and Approved WPS / PQR.

Tie - In shall be made in such ways that without including excessive stresses in the

steel, small displacement necessary for perfect alignment and connection at the ends. Bell Holes with sufficient size shall be made to facilitate for welding and provide adequate clearance to the welders to make sound weld. External line - up clamp shall be released only after 60% of root weld. Pipe pup piece length for Tie- In shall be minimum 1M. Two or more pieces shall not be welded together. In no case more than 3 Cir. Seam welds shall be permitted on a 8M length of pipe.

Tie in welds shall be completed with out delays shall not be left incomplete over night.

In case cutting pipe end ultrasonic inspection shall be done for lamination / checking before welding of tie-in joint.

For Tie- In at already hydro-tested sections, the pre-tested pup pieces shall be used.

Welded joints which are welded using external clamps(e.g. tie-ins welds) shall be 100% tested by ultrasonic & Radiography testing with X or Gamma rays shall be carried out in accordance with the provisions of API 1104.

The mechanical cleaning must be continued to at least 10 Cm beyond the existing intact coating, in such a way that all dirt is removed and the coating is roughened to ensure good adhesion. The intact coating shall be chamfered at the extremities to an angle of 15^0 to 30^0 in order to form a perfect joint.

RADIOGRAPH INTERPRETATION - WELDS

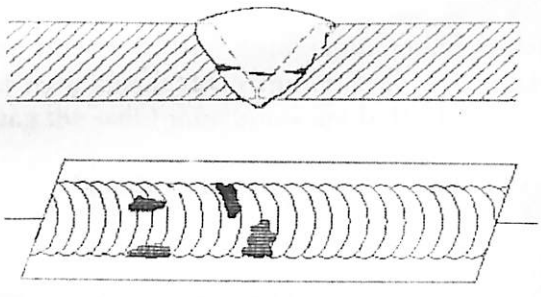
Discontinuities

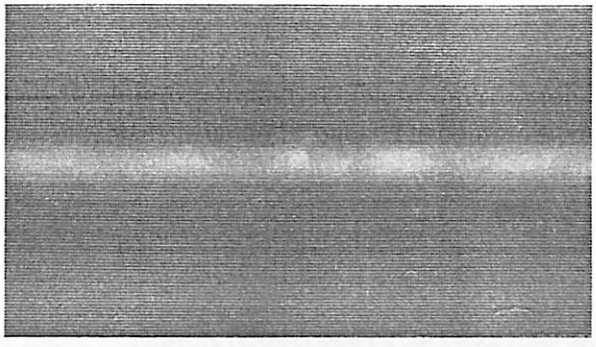
Discontinuities are interruptions in the typical structure of a material. These interruptions may occur in the base metal, weld material or "heat affected" zones. Discontinuities, which do not meet the requirements of the codes or specification used to invoke and control an inspection, are referred to as defects.

General Welding Discontinuities

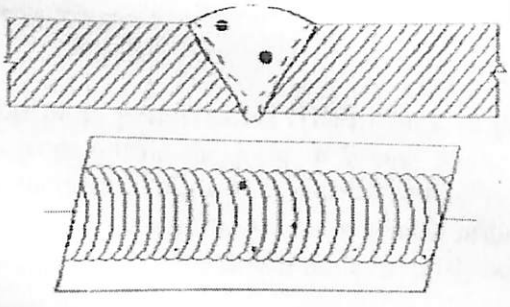
The following discontinuities are typical of all types of welding.

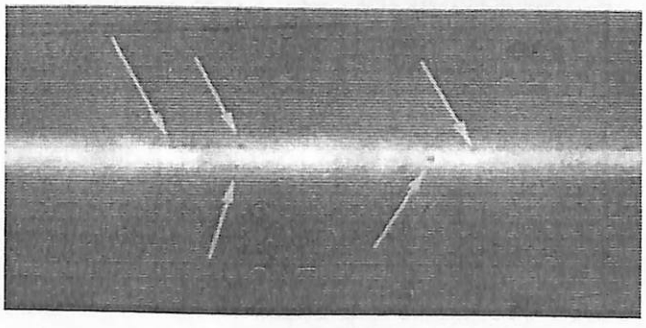
Cold lap is a condition where the weld filler metal does not properly fuse with the base metal or the previous weld pass material (interpass cold lap). The arc does not melt the base metal sufficiently and causes the slightly molten puddle to flow into base material without bonding.



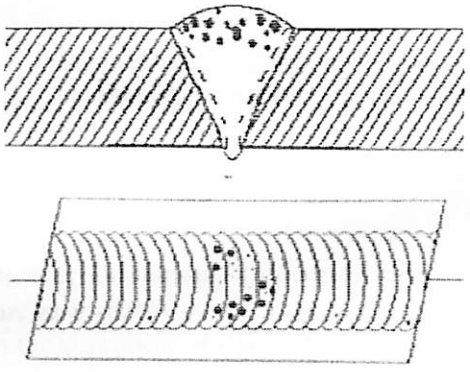


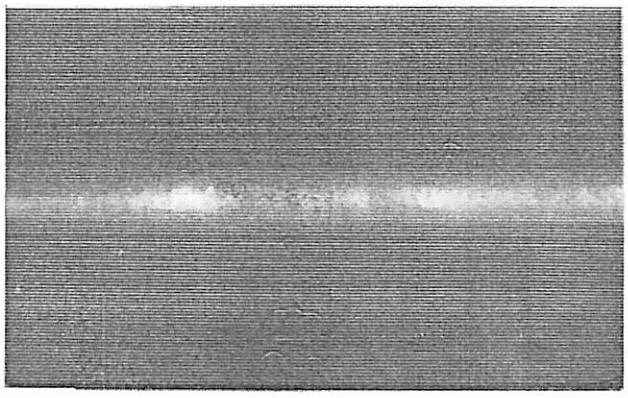
Porosity is the result of gas entrapment in the solidifying metal. Porosity can take many shapes on a radiograph but often appears as dark round or irregular spots or specks appearing singularly, in clusters or rows. Sometimes porosity is elongated and may have the appearance of having a tail. This is the result of gas attempting to escape while the metal is still in a liquid state and is called wormhole porosity. All porosity is a void in the material it will have a radiographic density more than the surrounding area.



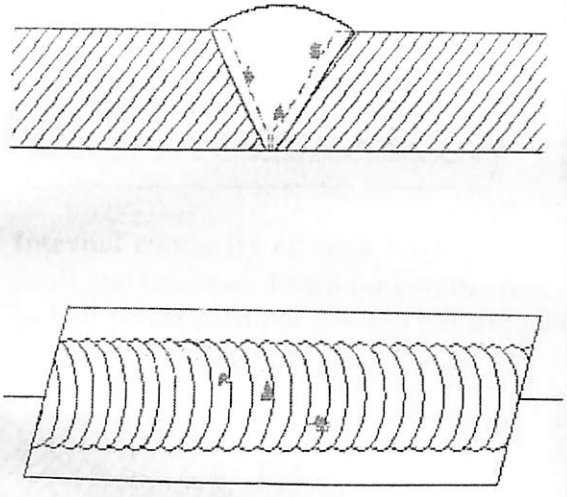


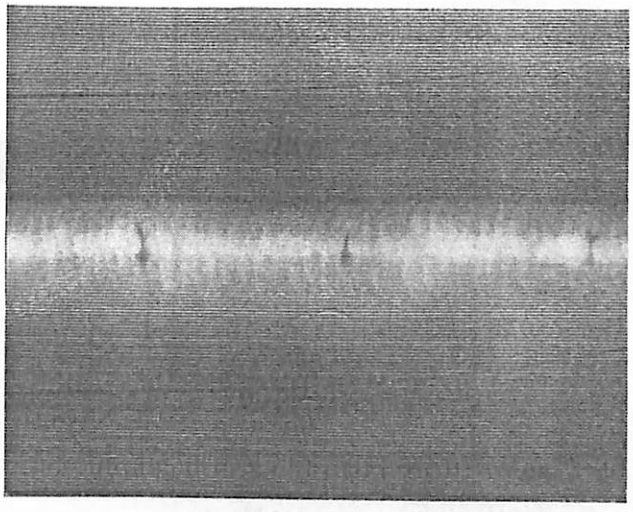
Cluster porosity is caused when flux coated electrodes are contaminated with moisture. The moisture turns into gases when heated and becomes trapped in the weld during the welding process. Cluster porosity appear just like regular porosity in the radiograph but the indications will be grouped close together.



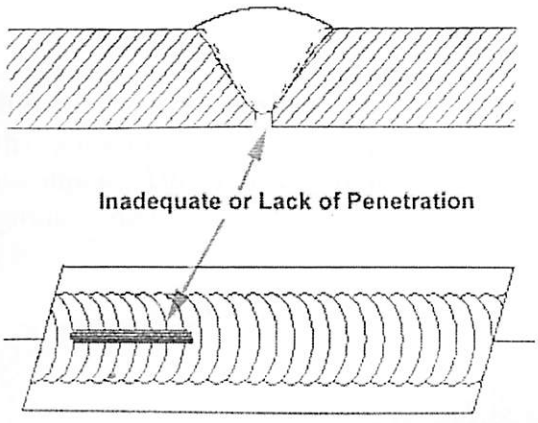


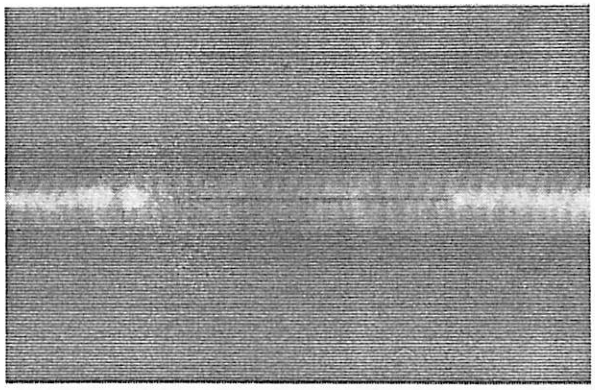
Slag inclusions are nonmetallic solid material entrapped in weld metal or between weld and base metal. In a radiograph, dark, jagged asymmetrical shapes within the weld or along the weld joint areas are indicative of slag inclusions.



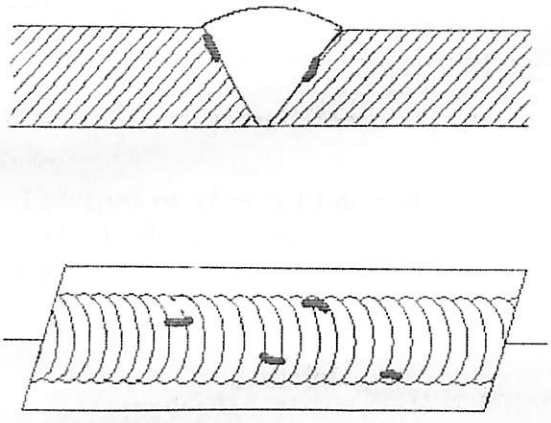


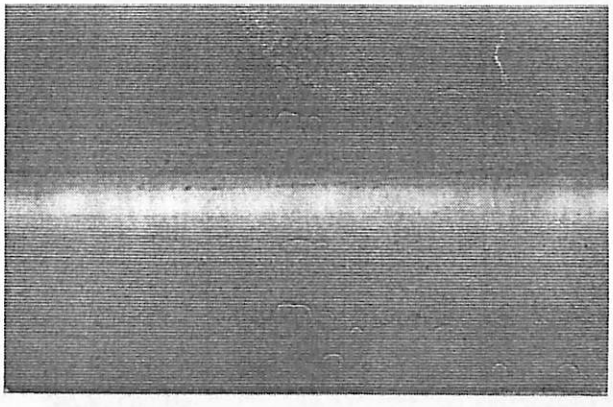
Incomplete penetration (IP) or lack of penetration (LOP) occurs when the weld metal fails to penetrate the joint. It is one of the most objectionable weld discontinuities. Lack of penetration allows a natural stress riser from which a crack may propagate. The appearance on a radiograph is a dark area with well-defined, straight edges that follows the land or root face down the center of the weldment.



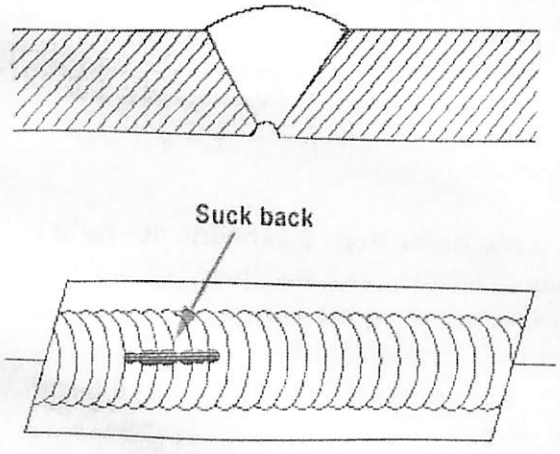


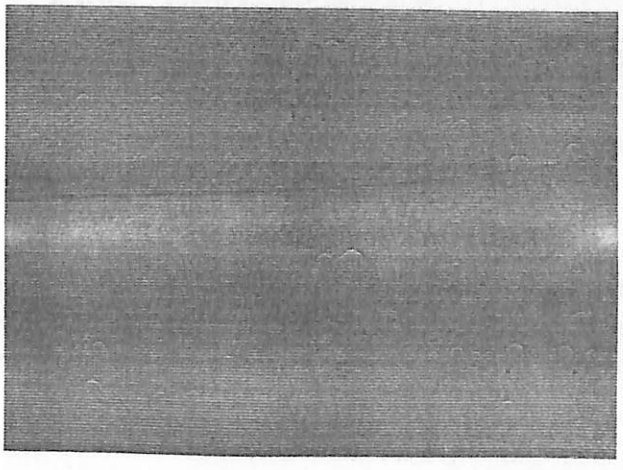
Incomplete fusion is a condition where the weld filler metal does not properly fuse with the base metal. Appearance on radiograph usually appears as a dark line or lines oriented in the direction of the weld seam along the weld preparation or joining area.



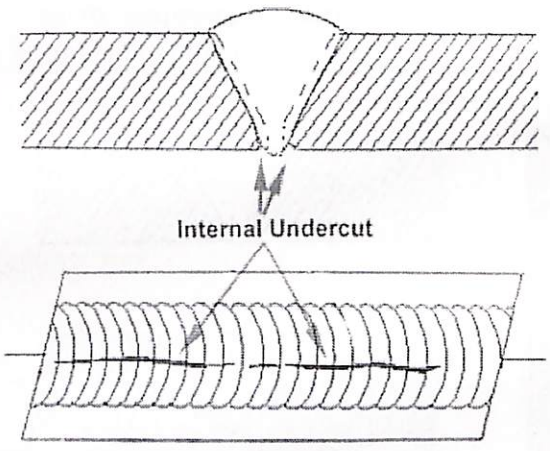


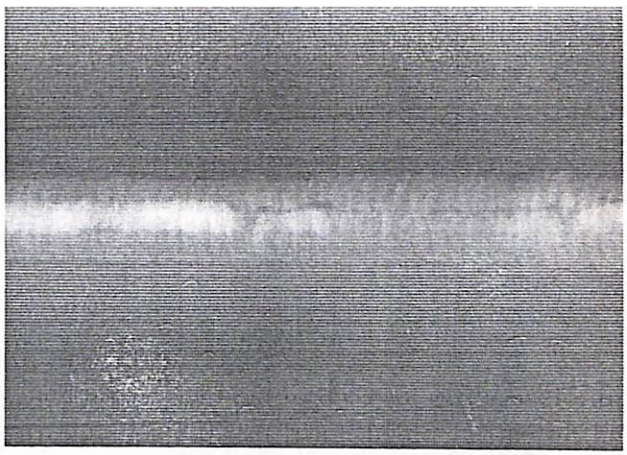
Internal concavity or suck back is condition where the weld metal has contracted as it cools and has been drawn up into the root of the weld. On a radiograph it looks similar to lack of penetration but the line has irregular edges and it is often quite wide in the center of the weld image.



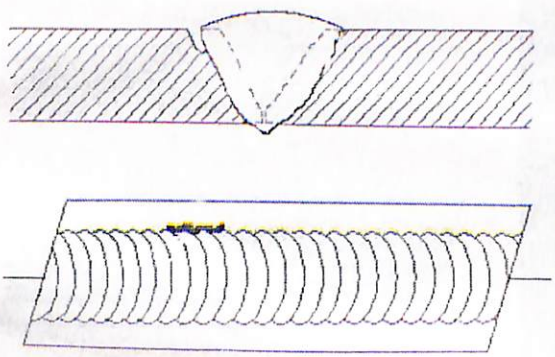


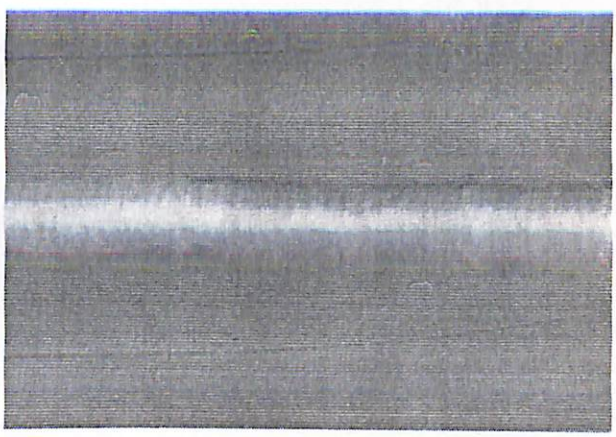
Internal or root undercut is an erosion of the base metal next to the root of the weld. In the radiographic image it appears as a dark irregular line offset from the centerline of the weldment. Undercutting is not as straight edged as LOP because it does not follow a ground edge.





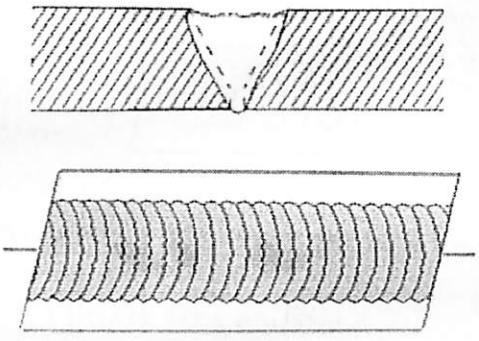
External or crown undercut is an erosion of the base metal next to the crown of the weld. In the radiograph, it appears as a dark irregular line along the outside edge of the weld area.

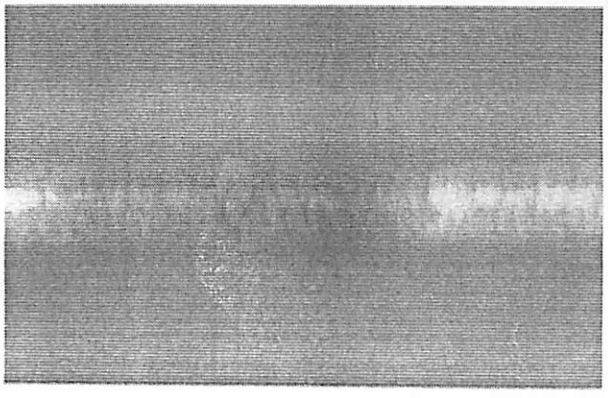




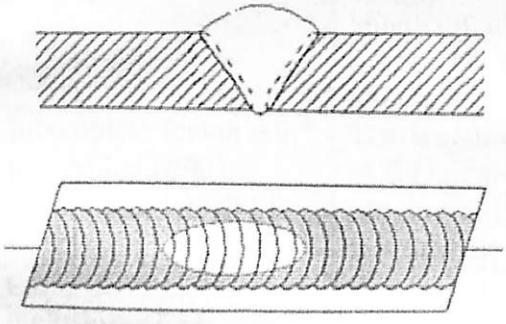
Offset or mismatch are terms associated with a condition where two pieces being welded together are not properly aligned. The radiographic image is a noticeable difference in density between the two pieces. The difference in density is caused by the difference in material thickness. The dark, straight line is caused by failure of the weld metal to fuse with the land area.

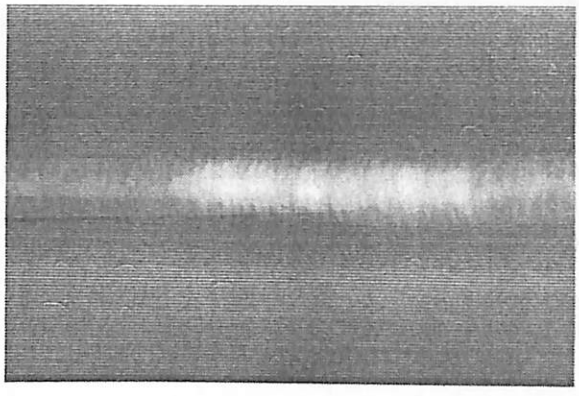
Inadequate weld reinforcement is an area of a weld where the thickness of weld metal deposited is less than the thickness of the base material. It is very easy to determine by radiograph if the weld has inadequate reinforcement, because the image density in the area of suspected inadequacy will be more (darker) than the image density of the surrounding base material.



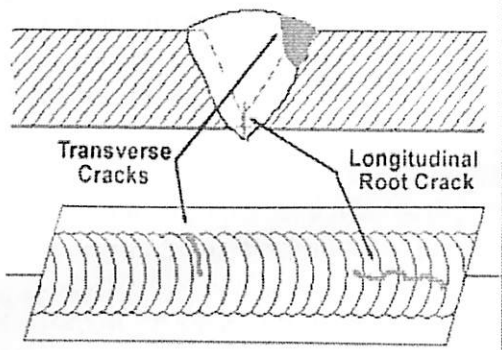


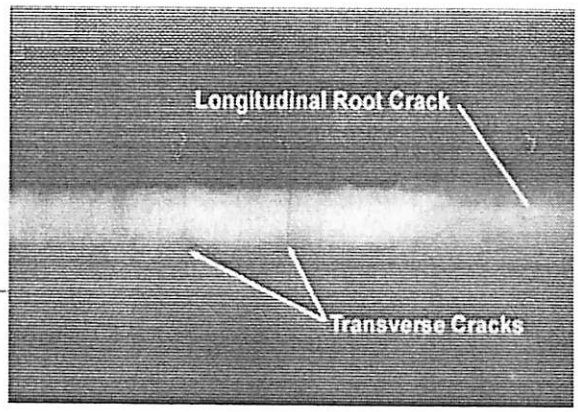
Excess weld reinforcement is an area of a weld that has weld metal added in excess of that specified by engineering drawings and codes. The appearance on a radiograph is a localized, lighter area in the weld. A visual inspection will easily determine if the weld





Cracks can be detected in a radiograph only when they are propagating in a direction that produces a change in thickness that is parallel to the x-ray beam. Cracks will appear as jagged and often very faint irregular lines. Cracks can sometimes appear as "tails" on inclusions or porosity.





Acceptance Standards for Non Destructive Testing

TYPE OF DEFECTS	ACCEPTANCE RANGE
Inadequate penetration (IP)	Length of individual IP not to exceed 1". The aggregate length of indication in any continuous 12" length shall not exceed 1". The aggregate lengths of IP shall not exceed 3% of total weld length.
Inadequate penetration due to High-Low (IPD)	The length of IPD shall not exceed 2". The aggregate length of IPD in any continuous 12" length shall not exceed 3".
Incomplete fusion (IF)	Length of individual IF not to exceed 1". The aggregate length of indication in any continuous 12" length shall not exceed 1". The aggregate lengths of IF shall not exceed 3% of total weld length.
Incomplete fusion due to cold lap (IFD)	The length of IFD shall not exceed 2". The aggregate length of IFD in any continuous 12" length shall not exceed 3".
Burn – through (BT)	Maximum BT shall not exceed ¼". Aggregate BT in any 12" length shall not exceed ¼".
Elongated Slag inclusions (ESI)	The length of ESI shall not exceed 2". The aggregate length of ESI in any 12" length shall not exceed 2". Width of ESI shall not exceed 1/16".
Porosity (P)	Size of individual pore shall not exceed 1/8". Size of pore shall not exceed 25% of nominal wall thickness. Diameter of cluster porosity shall not exceed ½".
Undercut (U)	Aggregate length of U shall not exceed 2" in any continuous 12" length of weld.
Crack (C)	Crack of any length or any size not acceptable. Crater-crack shall not exceed 5/32".

REPAIR & REMOVAL OF DEFECTS

- ✓ During inspection, if cracks whose size is more than 8% of weld length are detected, the cracks are not repairable. The situation may call for replacement of the entire joint.

- ✓ During inspection, if cracks whose size is less than 8% of the weld length are detected, repairs are permitted under the supervision of Technician experienced in Repair Welding.

- ✓ During inspection, if other weld defects (Incomplete penetration, Slag, Burn through etc.) exceed the acceptable limits, repairs are permitted under the supervision of Technican experienced in Repair Welding.

- ✓ Repair procedure must include the following:

    - Method of crack removal
    - Welding procedure with all welding conditions clearly stipulated
    - Repair weld is made by a qualified welder
    - Repaired regions to be re-inspected by Radiography, PT & MT

REFERENCES:

1. API1104
2. J P KENNY SPECIFICATION
3. EIL SPECIFICATION
4. NDT PROCEDURE SPECIFICATION