INVESTIGATION AND DEVELOPMENT OF WATER PIPE LINE SYSTEM FOR LEAKAGE INSPECTION IN DHAKA CITY

SUBMITTED BY

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CERTIFICATION OF APPROVAL

The thesis title " **INVESTIGATION AND DEVELOPMENT OF WATER PIPE LINE SYSTEM FOR LEAKAGE INSPECTION IN DHAKA CITY**" Submitted by BME1803016011-Kanon Kumar Singha, ID:BME1803016086-Annika Khatun, ID:BME1803016147-Md. Emam Mahedi Sujon, ID:BME1803016061-Md. Mehedi Hasan, ID:BME1803016057-Angkan Paul Session 2018-19 has been accepted as satisfactory partial fulfillment of the requirement for the degree of Bachelor of Science in Mechanical Engineering on 14 September 2022.

Countersigned

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DECLARATION

It is stated that the project work on —"Investigation and development of water pipe line system for leakage inspection in Dhaka city". has been performed under the supervision of Md. Ahatashamul Haque Khan Shuvo Lecturer& Course Coordinator, Department of Mechanical Engineering, Sonargaon University, Dhaka. To the best of our knowledge and belief, the project paper contains no material previously published or written by another except where due reference is made in it itself. We, further under take to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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Finalize would like to thank to the NDT Corrosion Control services(NDT CCS) and Abu-Dhabi Marine Operating Company(ADMA-OPCO)

Abstract

Water pollution one of the major topics in the environmental issue and we are facing drinking water pollution problem at Dhaka city and maximum people use of drinking water from city corporation water pipe line.Water pollution is a global issue that needs the evaluation and careful scrutiny of all the water resources and it is suggested that the water pollution is the major reason of deaths and diseases in the Bangladesh. Now we are development country and a lot of development project going on. But we need to sustainable development. This paper discusses the state of pipe materials(piping chemical composition), welding design, welding process, inspection method, international code and standard. Finally, methods to allow planning to occur to priorities asset management solutions.

Key words: Pipe materials, welding design and process, inspection method, International code and asset management.

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Chapter one

Introduction

1.1 General Background Of The Project

In Dhaka city, one of the biggest problem is the lack of pure water. This water may get contaminated in many ways but one of the biggest reason of contamination is the pipe line leakage. It may occur due to use of low quality material or the joint of two pipes has welded badly or welded with a welder who is not 6g qualified welder and proper lack of inspection.

For this leakage most of the water is also get wasted. Pipe used in this pipe line should contain Molybdenum, Nickel, Chromium. lack of these elements it may various defect. These defect anomalies in pipelines are among the most serious threats to their integrity. Not only do these anomalies pose a serious threat to the operation of the pipeline, they also introduce potential hazards to the environment. But they're also among the most difficult anomalies to predict because they can occur during the manufacturing process, pipeline installation, or over time, during operation. Detecting these features is an exacting task because they often can't be seen by the naked eye and can be situated axially or circumferentially. Dye penetrant and radiography test is the non destructive test to find out various defect. Therefore, it need to be inspected properly and welded with 6g qualified welder.

Many characteristics of a weld can be evaluated during welding inspection, some relating to the welds size, and others relating to the presence of weld discontinuities. The size of a weld can be extremely important, as it can often relate directly to the weld's strength and associated performance, undersized weld's may not withstand stresses applied during service. Weld discontinuities can also be important. These are imperfections within or adjacent to the weld, which may or may not, dependent on their size and/or location, prevent the weld from meeting its intended performance. Typically these discontinuities, when of unacceptable size or location, are referred to as welding defects, and can sometimes cause premature weld failure through reduction of the weld strength or through producing stress concentrations within the welded component. The inspection of welds can be conducted for a number of reasons. Perhaps the most fundamental reason is to determine whether the weld is of suitable quality for its intended application. In order to evaluate a weld's quality, we must first have some form of measuring block with which to compare its characteristics. It is impractical to attempt to evaluate a weld's quality without some form of specified acceptance criteria. Weld quality acceptance criteria can originate from a number of sources. The welding fabrication drawing/blue print will typically provide weld sizes and possibly other welding dimensional information, such as length and location of welds. These dimensional requirements will usually have been established through design calculations or taken from proven designs that are known to meet the performance requirements of the welded connection. Acceptable and unacceptable levels or amounts of weld discontinuities for welding inspection are usually obtained from welding codes and standards. Welding codes and standards have been developed for many types of welding fabrication applications. It is important to choose a welding standard that is intended for use within the particular industry or application in which you are involved.

One of the main ingredients of a successful welding quality system is the establishment, introduction and control of a sound welding inspection program. Only after the full evaluation of the weld quality requirements/acceptance criteria, the full appreciation of the inspection and testing methods to be used, and the availability of suitably qualified and/or experienced welding inspectors can such a program be established.

1.2 Objective Of This Project

- To develop the inspection system of Dhaka city water pipeline.
- To get the pure water through the pipeline.
- To reduce the maintenance cost.
- To get the long life of pipe line.

Chapter Two

Literature Review

Welding inspection demonstrates minimum acceptable levels of a welded product according to particular criteria and acceptance standards. Welding Inspectors examine the connections and bonds between metals.

Observe all relevant actions related to weld quality throughout production.
Record or log all production inspection points relevant to quality, including a final report showing all identified imperfections. Compare all recorded information with the acceptance, criteria and any other relevant clauses in the applied application standard.
The welding inspector role can cover all areas from pre-welding, welding, and post-welding procedures.

Application standard/code - for visual acceptance requirements
Drawings - item details and positions/tolerances, etc. suitability of the weather conditions
Compliance with the Welding process used selection of the correct welding techniques
Selection of the suitable welding consumables selection of the appropriate welding parameters
Carrying out inter-run dressing

2.1 Literature Review

Positive Material Identification or PMI is the non-destructive analysis of a metallic alloy to identify the constituent elements and their quantities. To ensure product or alloy quality as per requirement, PMI or Positive Material Identification testing provides a quick solution. PMI is an on the spot (on-site) examination method and highly beneficial for projects where there is a possibility of a material mix-up. To verify the compliance of material certificates of composition, positive material identification is increasingly used in various industries.

Inspection and Testing for Welding Procedure Qualification – Types of inspection used for these requirements and how they can be an essential part of the overall welding quality system.

Many characteristics of a weld can be evaluated during welding inspection, some relating to the welds size, and others relating to the presence of weld discontinuities. The size of a weld can be extremely important, as it can often relate directly to the weld's strength and associated performance, undersized weld's may not withstand stresses applied during service. Weld discontinuities can also be important. These are imperfections within or adjacent to the weld, which may or may not, dependent on their size and/or location, prevent the weld from meeting its intended performance. Typically these discontinuities, when of unacceptable size or location, are referred to as welding defects, and can sometimes cause premature weld failure through reduction of the weld strength or through producing stress concentrations within the welded component.

Weld quality acceptance criteria can originate from a number of sources. The welding fabrication drawing/blue print will typically provide weld sizes and possibly other welding dimensional information, such as length and location of welds. These dimensional requirements will usually have been established through design calculations or taken from proven designs that are known to meet the performance requirements of the welded connection.

Acceptable and unacceptable levels or amounts of weld discontinuities for welding inspection are usually obtained from welding codes and standards. Welding codes and standards have been developed for many types of welding fabrication applications. It is important to choose a welding standard that is intended for use within the particular industry or application in which you are involved.

Surface Crack Detection – Methods such as Liquid Penetrant Inspection and Magnetic Particle Inspection – How they are used and what they will find.

Radiographic Weld Inspection – Methods known as Non Destructive Testing (NDT) and used typically to examine the internal structure of the weld in order to establish the weld's integrity without destroying the welded component.

Chapter Three

Methodology

3.1Positive Material Identification[5][9]

Positive Materials Identification procedure Shall Be Performed In Accordance With Project Specification/International Codes & Standards.

Equipment

The Following Equipments Shall Be Used for PMI,

a. Olympus instruments, Innov-X Analysers

Calibration

Calibration of Base unit. The Equipment Shall Be Calibrated Yearly or After Any Major Repair or Service Done to the Equipment Whichever Is Early.

Daily performance check

The Operators Shall Carry Out Daily Performance Check of the Unit from Any Known Samples (Which Can Be traced) And records to Be Produced Up on request.

Test specimens surface preparation

For Olympus instrument, Innov-X Analysers PMI Equipment Surface Preparation Not Required However Oil, Grease, Surface Contamination and Any Other Foreign Materials Shall Be removed Using Wire Brush or Cotton Cloth Prior or Testing.

The Following Steps Shall Be Followed for The Surface Preparation.

- The surface shall be clean and slightly rough.
- Do not touch the sample after cleaning, finger prints on the surface will affect the analysis results.
- Grinding paper shall be changed when grinding different material to avoid contamination from the previous materials.

Test measurement

- Suitable analyzer mode shall be selected prior to test depends on materials to be tested.
- Adapters shall be used for curved surface to avoid oxidation.
- Observed results shall be saved or recorded before making next test.

Extent of examination

The extent of testing shall be accordance with approved specification, applicable codes and standards.

Test report/result

Figure 3.1: PMI instrument

SonargaonUniversity

147/I,GreenRoad, Panthapath,Tejgaon,Dhaka.

POSITIVEMATERIALIDENTIFICATIONREPORT

Client:SONARGAONUNIVERSITY	**ReportNo:SU-PMI-TH-01**
Project: Investigation anddevelopmentofwaterpipeline system forleakage inspection indhaka city.	**Material Grade :**SS316L **Location:**Field
JobNo:N/A	**PMI Procedure No.** : **MaterialStandard:**ASTMA312/A312MSU-PMI-thesis-01 (rev 0)
PMIEquipment:OLYMPUSINNOV.X	**EquipmentSr.No:**561154 **Calibration Validity :**05-06-2023

PMIWeld &Material Analysis Report									
Material Composition					%Ni	%Cr	%M	PmiNo.	**Result**
				AllowedRange:	10.0-14.0	16.0-18.0	2.0-3.0	SS-316	
DESCRIPTION	**Jt**	**Rev**	**Mat.Class**	**Component/R**	**PercentageofElements**				
TESTPIECE	1	0	#NV	Pipe-01	11.87	16.02	2.56	316	ACC
				Weld-01	13.49	16.82	2.98	316	ACC
				Pipe-01	12.52	16.01	2.35	316	ACC

Remarks:			
		REVIEWED	**SONARGAONUNIVERSIT**
Name:	kanonkumarSingha		
Student	BME1803016011		
Date:	01.06.2022		

3.2 Gas Tungsten Arc Welding [1][3][4][10]

Figure3.2 : Gas Tungsten Arc Welding

Gas tungsten arc welding (GTAW) or tungsten inert gas (TIG) welding is an arc welding process that uses a tungsten (non consumable) electrode to produce the weld. Shielding gas (usually an inert gas such as Argon) is used to protected the weld area from atmospheric contamination, and a filler metal is normally used whereas some autogenous welds do not require it. Energy produced is supplied by a constant-current welding power source which is conducted across the arc through a column of highly ionized gas and metal vapors known as plasma.

"It is a metal arc welding process wherein coalescence is produced by heating the job with an electric arc struck between a job and tungsten electrode. A shielding gas Argon is used to avoid atmospheric contamination of the molten weld pool. A suitable filler metal may be added if required."

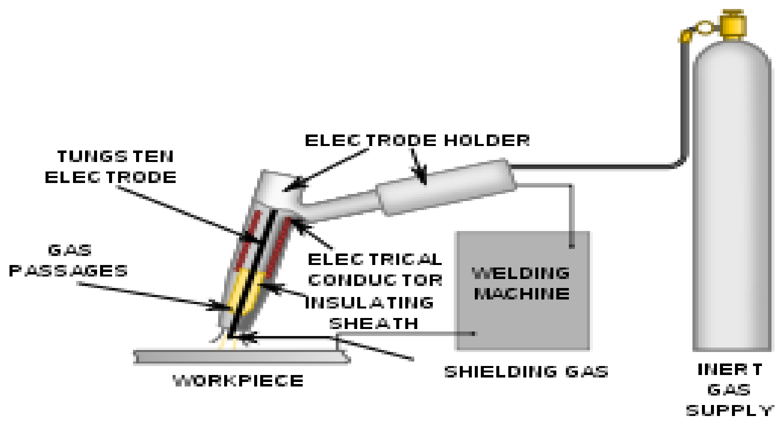


Figure3.3 : GTAW inert gas supply

Thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium, and copper alloys are commonly welded by GTAW. The process gives the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding allowing for stronger and higher quality welds. However, GTAW being significantly slower than most other welding techniques is comparatively more complex, hazardous and difficult to master.

Equipment For Gtaw

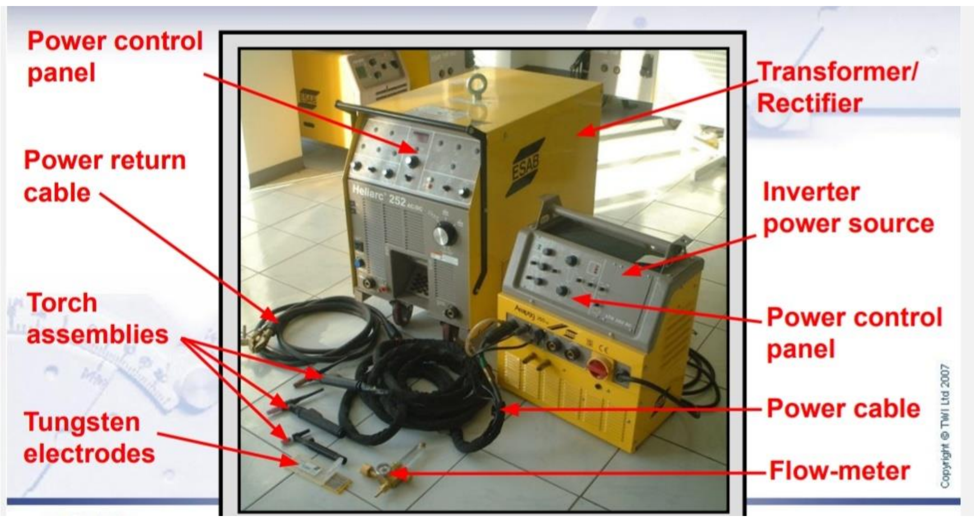


Figure 3.4: Welding unit

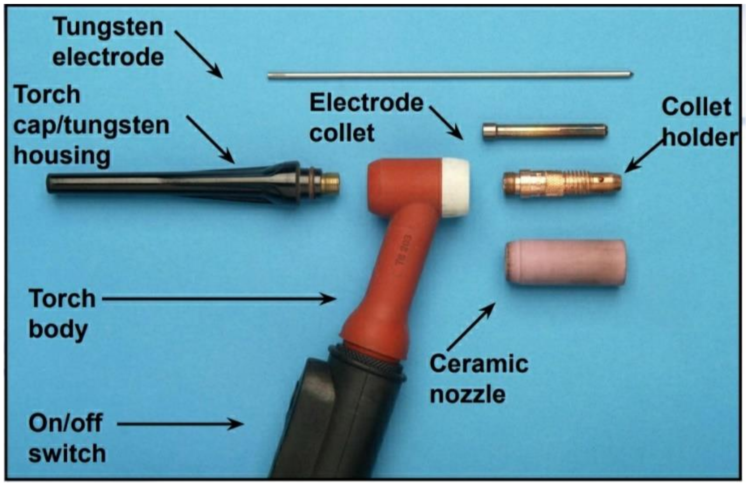


Figure3.5 : GTAW torch with torch body, electrode, ceramic nozzle, collet holder, electrode collet and torch cap

Arc Characteristics

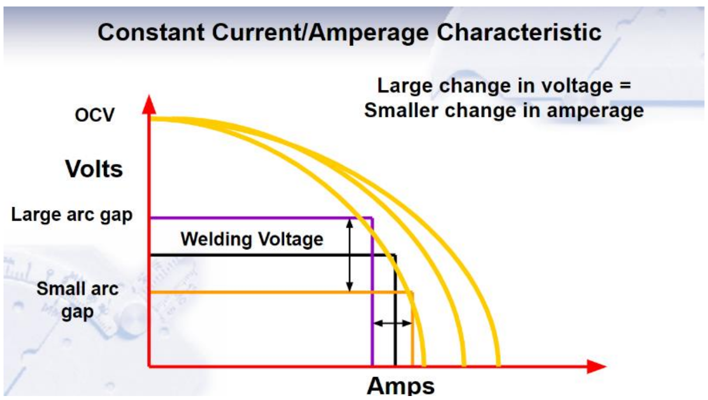


Figure 3.6: Constant Current/Amperage Characteristic

Gas tungsten arc welding uses a constant current power source, meaning that the current (and thus the heat) remains relatively constant, even if the arc distance and voltage change. This is important because most applications of GTAW are manual or semiautomatic, requiring that an operator hold the torch. Maintaining a suitably steady arc distance is difficult if a constant voltage power source is used instead, since it can cause dramatic heat variations and make welding more difficult. Constant Current. This type of power source has a relatively small change in amperage and arc power for a corresponding relatively large change in arc voltage or arc length, thus the name constant current.

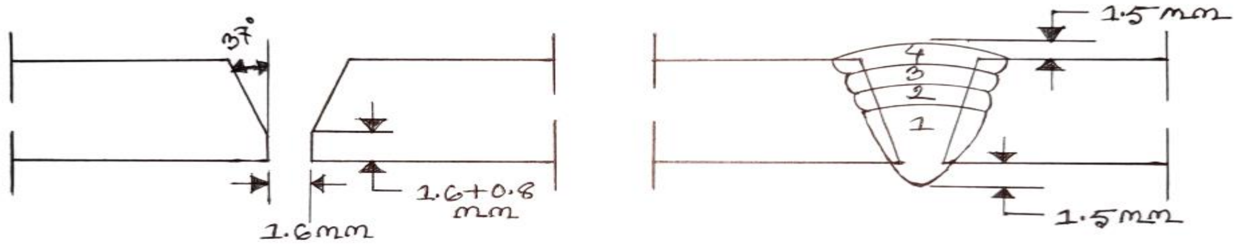
Welding Procedure Specification(WPS)

WPS No.

Welding Process: Gas Tungsten Arc Welding

Types: Manual

Table 3.1a:WELDING PROCEDURE SPECIFICATION(WPS) [1][3][4]



Group Design of
Test Coupon

BASEMETALS	**POSTWELD HEAT TREATMENT**
MaterialSpec.SA-312	Temperature None
TypeofGrade316L	Time N/A
Thickness of Test Coupon 0.218”	Other N/A
Diameter of Test Coupon 2”	
Other N/A	
FILLERMETALS	**GAS**
Weld Metal Analysis A-No._	Type of Gases Argon
Size of Filler metal 1/16”	Composition of gas mixture 100%
Filler Metal F-No.____	Others______
SFA Specification____	**ELECTRICAL CHARACTERISTICS**
AWS Classification ER316L	Current DC
	Polarity Straight
	Amps. 105-115&120-130 , Volt 13-15&15-17 _______
	Tungsten Electrode Size____

POSITION	**TECNIQUE**
Position of Groove__	Travel Speed Manual
Weld Progression _Uphill	String or Weave bead______Weave
Other________	Oscillation______N/A______
PREHEAT	Multipass or Single Pass______Multipass__
Pre heat Temperature:_____50°min_	Single or Multi Electrodes_____Single_____
Interpass Temperature:______350°max_____	Other________

Table 3.1b:Welding Procedure Specification (WPS) [1][3][4]

Project name: investigation and Development of water pipe line system for leakage inspection in Dhaka City. Welding Procedure Specification No. : 316L Rev. : 0 Date: Welding Process: GTWA Type(s) Manual (Automatic, Manual, Machine or Semi-Auto)
To Specification type and grade: Specification not restricted Type 304L Chemical Analysis and Mechanical Properties: 316Lss To Chemical Analysis and Mechanical Properties: 316Lss Base Metal Thickness Range: Groove: 0.218" — 0.22" Pipe Diameter Range: 2" Other:

Filer Metal:		
Process	GTAW	
Specification No. (SFA)	A5.9	
AWS classification	316L	
F-No.	6	
A No.	8	
Size of filler metals	1/16 "	
Weld metal thickness range	8.56" max	
Product form	Bare Solid	
Electrode flux class	N/A	
Consumable inert	None	
Autogenous Welding	Not allowed	

Positions		**Postweld Heat Treatment**	
Position of groove	All	Temperature range	None
Welding progression	Up hill	Time range	N/A
Position of welding	6G	Other	

Preheat				**Gas**			
Preheat Temperature:		SOF					
Interpass Temperature:		350F		Process	Gas (es)	Mixture	Flow Rate
Preheat Maintenance:		Not restricted		Shielding	Argon	100%	20-35 CFH
				Trailing	N/A	N/A	N/A
				Backing	Argon	100%	5-10 CFH
Electrical Characteristics:							
GTAW							
Current	DC	Polarity	Straight				
Amp (Range)	See below	Pulse	N/A				

Tungsten electrode size and type:Size not restricted. type 2% Thoriated

Mode of metal transfer for GTAW:N/A (Spray, short-circuit etc.)

Electrode wire feed speed range:N/A

Heat input:Not restricted

Technique:

Stringer or weave bead Stringer or weave
Initial and Interpass cleaning: Method of cleaning not restricted Slag to be removed after each pass
Oscillation: Manual
Multiple or single: Multiple pass/side:
Multiple or single electrode: Single
Travel speed: Not restricted
Peening: None
Other: Orifice, cup, or nozzle not restricted. Method of back gouge if required grinding, air arc.

		Filler Metal		Current				
Weld Layer (s)	Process	Class	Diameter	Type/ Polarity	Amp Range	Volt Range	Travel Speed	Other
All	GTAW	ER30SL	Not restricted	DC/SP	100-140	12-19	Not restricted	

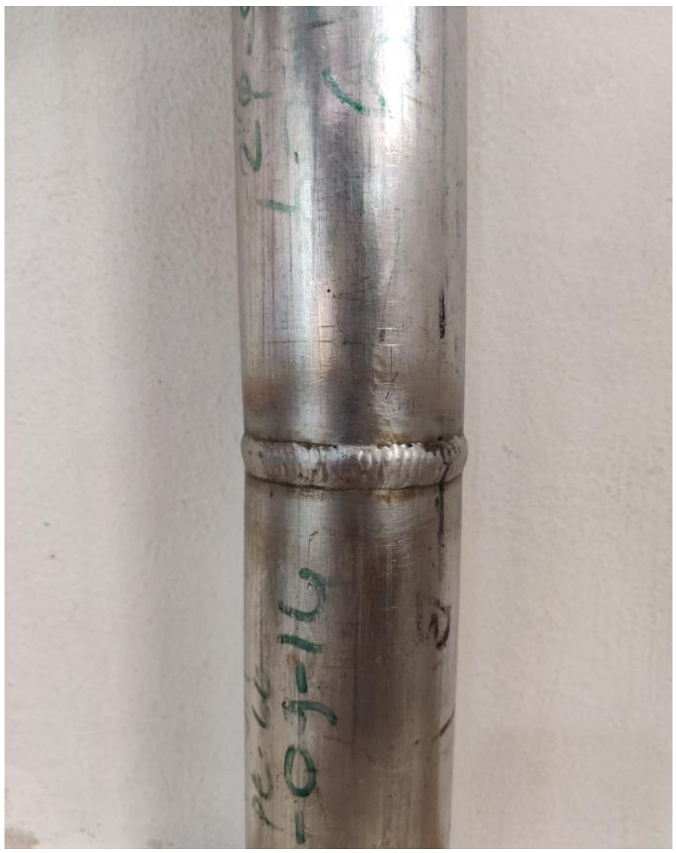


Figure3.7 : Welded Pipe

3.3 Acceptance Standards of Visual Examination

ASME SEC IX [2]

Welder and welding operator performance tests by radiography of welds in test assemblies shall be judged unacceptable when the radiograph exhibits any imperfections in excess of the limits specified below:

(a) Linear Indications

(1) any type of crack or zone of incomplete fusion or penetration

(2) any elongated slag inclusion which has a length greater than

(a) 1 ⁄ 8 in. (3 mm) for t up to 3 ⁄ 8 in. (10 mm), inclusive

(b) 1 ⁄ 3t for t over 3 ⁄ 8 in. (10 mm) to 21 ⁄ 4 in. (57 mm), inclusive

(c) 3 ⁄ 4 in. (19 mm) for t over 21 ⁄ 4 in. (57 mm)

(3) any group of slag inclusions in line that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.

(b) Rounded Indications

(1) The maximum permissible dimension for rounded indications shall be 20% of t or 1 ⁄ 8 in. (3 mm), whichever is smaller.

(2) For welds in material less than 1 ⁄ 8 in. (3 mm) in thickness, the maximum number of acceptable rounded indications shall not exceed 12 in a 6 in. (150 mm) length of weld. A proportionately fewer number of rounded indications shall be permitted in welds less than 6 in. (150 mm) in length.

(3) For welds in material 1 ⁄ 8 in. (3 mm) or greater in thickness, the charts in Appendix I represent the maximum acceptable types of rounded indications illustrated in typically clustered, assorted, and randomly dispersed configurations. Rounded indications less than 1 ⁄ 32 in. (0.8 mm) in maximum diameter shall not be considered in the radiographic acceptance tests of welders and welding operators in these ranges of material thicknesses.

3.4 Dye Penetrant Test Procedure[3][8]

Scope:

- This procedure outlines the method, materials and acceptance standards to be used in the examination and evaluation of welds and materials utilizing non fluorescent, visible color contrast, solvent and water removable type penetrants.

- It conforms the requirements of ASME code section V and related design standard/code such as Section VIII and Section IX for Boiler & Pressure Vessel, API 650 for Tank inspection and ASME B31.1 for power piping & ASME B31.3 for process piping

General :

- Liquid Penetrant examination provides for the detection of discontinuities open to the surface in non-porous, ferrous and non-ferrous materials. Cracks, seams, laps, porosity, cold shut and laminations are defects typically detectable by this method of testing.

- Unless specified in the applicable specifications, drawings or contacts, the acceptance examination shall be performed on the materials or welds in the final surface and final heat treated condition.

- Prior to Dye Penetrant examination, the surface to be tested and any adjacent area within at least one inch of the surface to be tested in each direction , shall be dry and free of any dirt, grease, lint, scale, welding flux, spatter, oil or any extraneous matter that would obscure surface openings or otherwise interfere with the test.

- Should surface irregularities prevent the operator from performing the proper test, it will be required to grind or machine these items prior to Dye Penetrant inspection.

Figure 3.8: Dye penetrant chemical solvent

Type of penetrant material :

- Test materials as defined in below table are used during examination.

Table 3.2:For Color Contrast (Visible) technique

Material	**Brand**	**Manufacturer**
Penetrant	ORION Or PMC FLAWCHECK	The Oriental Chemical Works (P) Ltd. P-Met High-Tech Co. Pvt. Ltd
Solvent Cleaner	ORION Or PMC FLAWCHECK	The Oriental Chemical Works (P) Ltd. P-Met High-Tech Co. Pvt. Ltd
Developer	ORION Or PMC FLAWCHECK	The Oriental Chemical Works (P) Ltd. P-Met High-Tech Co. Pvt. Ltd

- The Test materials used will be in ready-mix aerosol containers.
- Intermixing of test materials from different Brand / Groups in not permitted.

Safety precaution :

- All inspection personnel shall be responsible for compliance with applicable safety rules in the use of Liquid Penetrant materials.
- Penetrant materials are highly volatile, relatively toxic and the liquids may cause skin irritation. Use adequate ventilation at all times and avoids prolonged skin contact.
- Penetrant materials shall never be heated above the recommended temperature limits prescribed by the manufacturer.
- Penetrant materials shall never be exposed to open flames.
- Keep aerosol cans containing penetrant materials out of direct sunlight and storage in excess of the recommended temperature limits specified by manufacturer; an excessive heat may cause aerosol cans to explode.

Testing procedure :

- **Surface Preparation**
  - ➢ In general satisfactory results may be obtained when the surface is in the as weld, as rolled, as cast, or as forged condition. In some cases however, surface preparation by grinding or machining may be necessary when surface irregularities would otherwise mask the indications of unacceptable discontinuities.
  - ➢ Surface preparation (if require) will be completed by client.
  - ➢ The surface to be examined and any adjacent area within at least one inch of the surface to be examined in each direction shall be dry and free of any dirt, grease, lint, scale, welding flux, spatter, oil or any extraneous matter that would obscure surface openings or otherwise interfere with the examination.
  - ➢ Typical cleaning agents, which may be used, are detergents, organic solvents, descaling solutions and paint removers.

- **Pretest Cleaning**
  All surfaces being tested should be thoroughly cleaned of extraneous material. Cleaning solutions used on surface shall be in accordance with the requirement of ASME V, MILSTD-767. As a final cleaning operation, each surface to be tested shall be sprayed with a chlorinated solvent and wiped with a clean, dry cloth of absorbent paper prior to carrying out the inspection.

- **Application of Penetrant**
  The surface to be tested shall be thoroughly and uniformly coated with Penetrant by spraying and shall be kept completely wetted for a minimum of Ten minutes and maximum of twenty minutes. The temperature of the Penetrant and test surface shall be maintained at the temperature recommended by the Penetrant manufacturer but in no case less then 50 C or greater than 520 C. While using

temperatures 100 C and below down to 50 C, the penetrant dwell times shall be doubled than that used for temperatures more than 100 C.

- **Penetrant Dwell Time**
  The minimum penetrant dwell time shall be 5 minutes for casting and welds. For wrought materials e.g. extrusions, forgings and plates, the minimum dwell time shall be 10 minutes. In all cases the maximum dwell time shall not exceed 30 minutes.

- **Removal of excess Penetrant**
  As much excess Penetrant as possible shall be removed by first wiping the surface thoroughly with a clean dry cloth or an absorbent paper. The remaining excess Penetrant shall be removed by wiping the surface with a clean cloth or absorbent paper dampened with the Penetrant remover. Direct flushing the excess Penetrant using remover is prohibited. The test surface shall be dried after the removal of excess Penetrant by normal evaporation. Forced air circulation in excess of normal ventilation in the inspection area shall not be used. Solvent removal drying time is limited to a minimum of 5 minutes normal evaporation. In any event, the drying time shall be limited to a minimum of 5 minutes and maximum of 10 minutes.

- **Application of Developer**
  The developer shall be thoroughly agitated prior to use, to ensure complete dispersion of the powder suspension in the liquid. The developer shall be uniformly applied in a thin coating to the test surface by spraying. Pools of weight developer in cavities on the inspection surface shall not be permitted since these pools will dry to an excessively heavy coating in such areas resulting in the masking of indications. During application of developer, the operator must observe any indications when developer is applied in order to observe any indication.

- **Developing time**
  Developing time for final interpretation begins immediately after the application of a dry developer or as soon as a wet developer coating is dry.

- **Final Interpretation**
  Final interpretation shall be made not less than 10 min nor more than 60 min after the developing time has elapsed. If bleed-out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed or established time, the examination shall be performed in increments.

Evaluation of indications :

- Indications those have their major dimension greater than 1/16th inch (1.5mm) shall be considered as relevant.
- An indication from a discontinuity may show size, which is larger than its actual dimension as seen on the surface; however the size of the indication shall be the basis for evaluation.
- All relevant (including non-relevant, if necessitated by any referencing document or client requirement) indications (type of indication – linear or rounded, location, length or diameter or aligned) shall be recorded as a minimum and interpreted against the relevant acceptance criteria. Where none specified, all the relevant indications shall be recorded.
- This procedure contains sample acceptance standard in Annexure-I as per ASME Section VIII div 1 & ASME Section VIII div-2 ,& ASME B31.1 , ASME B31.3
- Broad areas of pigmentation, which could mask indications, are not acceptable and shall be cleaned and retested in accordance with the method stated in this procedure.

Post cleaning :

The post-examination residues of penetrant or developer will not normally have any deleterious effect on the test component since the test materials are selected to avoid any such effects significantly. However, post-examination cleaning may be required when such residues may have adverse chemical reactions with the test component. Under such conditions, the residues may be cleaned to the desired extent by solvent cleaning or a coarse water spray.

Re inspection of repair areas :

- The procedure of re-inspection of repaired areas shall be the same as for original dye penetrant inspection.
- Whenever defect is removed and welding is not required, the affected area shall be blended into the surrounding surface and re-inspected in accordance with original dye penetrant procedure.

.**Personnel qualification :**

Personnel interpreting liquid penetrating examinations shall be qualified in Level-II in accordance with SNT TC 1A of ASNT or equivalent. Additionally, all personnel performing and evaluating the Liquid penetrant examination results shall have their near vision tested to a minimum of J2 in a standard Jaeger Chart and shall have no deficiency as tested in a standard Ishihara color contrast differentiation chart. These tests shall be conducted annually and shall be valid during the liquid penetrant examination.

ANNEXURE I - Acceptance Criteria[6][7][11]

ASME Section IX (QW-195):

Acceptance Criteria (corrosion resistant overlay welds – performance & procedure qualification) Terminology:

a. Relevant Indications – Indications with major dimensions greater than 1.6 mm (1 /16 in)
b. Linear Indication – An indication having a length greater than three times the width
c. Rounded Indication – An indication or circular or elliptical shape with the length equal to less than three times the width

Acceptance Standard:

Indications in excess of the limits specified below are unacceptable:

a. Relevant linear indications
b. Relevant rounded indications greater than 4.8 mm (3 /16 in.)
c. Four or more relevant rounded indications in a line separated by 1.6 mm (1 /16 in.) or less edge-to-edge.

ASME Section VIII Div. 1 Appendix 8 & ASME Section VIII Div. 2 Para 7.5.7.2 & ASME Sec V & ASME Sec I:

Terminology:

a. a. Relevant Indications – Indications with major dimensions greater than 1.5 mm (1 /16 in)
b. Linear Indication – An indication having a length greater than three times the width
c. Rounded Indication – An indication or circular or elliptical shape with the length equal to less than three times the width
   Any indication, which is believed to be non-relevant, shall be regarded as an imperfection unless it is shown by reexamination by the same method or by the use of other nondestructive methods and / or by surface conditioning that no unacceptable imperfection is present.

Acceptance Standard:

All surfaces to be examined shall be free of:

a. Relevant linear indications
b. Relevant rounded indications greater than 5 mm (3 /16 in.)
c. Four or more relevant rounded indications in a line separated by 1.5 mm (1 /16 in.) or less edge-to-edge.
   Any crack like indication is unacceptable irrespective of surface conditions. (Applicable only for ASME Sec VIII Div. 2)

DYE PENETRATION EXAMINATION REPORT	Report No.:	SU-PT-01
	Page No.:	01
	Inspection Date:	03-04-2022

Name of the Project	Investigation and development of water pipe line system for leakage inspection in dhaka city.	Procedure No.	SU-PT-PROCEDURE-01
Conditions of Test Procedures: ASME V			
Penetrant	Brand: ORION	Type:	
Remover	Brand: ORION	Type:	
Developer	Brand::ORION	Type:	
Surface Condition	■ As Weld ☐ As Grind ☐ Brush ☐ Other	Surface Temp. 35°C	
Penetrate Dwell Time	3 Minuit(s)	Material	316L SS
Evaluation		Acceptance Criteria:_ SEC IX______	

SL#	Weld Identification	Thick. (mm)	Weld No.	Size	Welder Code	Interpretation	Result
TEST COUPON	01	5.54		2”		NSD	ACC
Film Interpretation	**(ASNTLEVEL-II)**						
NAME:	KANON						
SIGNATURE:							
DATE:	05-01-2022						

N.B: P – Porosity, C – Crack, UC – Undercut, NSD – No Significant Defect, A – Acceptable, R – Reject

3.5 Radiography Testing Procedure[6][7][11]

Scope

- This Radiographic Test Procedure establishes the minimum requirements for performing radiographic examination conducted in accordance with the requirements of the referenced codes / standards for piping joints.
- This Procedure applies to department of mechanical engineering of Sonargaon University NDT personnel radiographic examination on behalf of Sonargaon University.
- Alternative specifications to the above may be used when so requested by the project supervisor. If alternative specifications are used, the radiographic procedure will be performed in accordance with that specification.
- This procedure details the radiographic technique for inspection of Produced water tank in accordance with ASME Section VIII, Division 1 of boiler & pressure vessels code, API-1104.

References

Unless stated otherwise all codes & standards reference in this procedure shall be of the latest issue (including revisions, agenda and supplements) and the following documents shall bereferred to along with this procedure.

- **Industry Codes and Standards**
  American Society of Mechanical Engineers
  API-1104 Cross country pipe lines

  Definitions:
  DWE: Double Wall Exposure
  SWE: Single Wall Exposure
  DWV: Double Wall Viewing
  SWV: Single Wall Viewing

Precautions for Personal Safety

- The materials and/or equipment used during radiographic examination shall be utilized in such a manner as to insure compliance with Bangladesh Atomic Energy Regulatory Authority Regulation &International atomic energy agency (IAEA) regulations.
- Protective measures shall be taken by radiographic personnel to insure that no individual is exposed to radiation in excess of the prescribed limits as mandated in Bangladesh Atomic Energy Regulatory Authority Regulation.
- All personnel performing radiography for The welding institute(TWI), The American society for non destructive testing (ASNT) and Bangladesh atomic energy regulatory authority regulation certify the Radiation Safety.

General Requirements

All radiography shall be performed in accordance with this procedure.

Personnel Qualifications

Personnel interpreting and evaluating Radiographs shall be qualified in Level-II in accordance with SNT TC 1A of ASNT or equivalent and The welding institute(TWI).

Additionally, all personnel performing and evaluating the Radiographic examination and evaluating results shall have their near vision tested to a minimum of J2 in a standard Jaeger.

Chart and shall have no deficiency as tested in a standard Ishihara color contrast differentiation chart as well as shades of Gray chart. These tests shall be conducted annually and shall be valid during the radiographic examination.

Surface Preparation

- The weld ripples or weld surface irregularities on both the inside (whereaccessible) and outside shall be removed by any suitable process to such a degree that any such irregularities appearing on the resulting radiographic image do not mask nor are confused with the image of any discontinuity.
- Welds shall be visually examined and found acceptable prior to release forradiography.

- If the weld is ground flush, markers, such as arrows or pointing towards thecenterline of the weld shall be placed on both sides of the weld approximately 0.6mm (.25 inch) away from the toe of the weld. At least two sets of arrows of shall appear on the film, one set near each end of the interpreted area of the film.

Backscatter Radiation

A lead letter “B” with minimum dimensions of 13 mm (0.5 inch) in height and 1.5 mm(0.0625 inch) in thickness shall be attached to the back of each film holder during eachexposure to determine if backscatter radiation is exposing the film.

- When the time of the examination is not specifically stated in the referencedcode orproject specification, final radiography for acceptance of the weld/material shall beperformed .

Figure 3.9: Gamma ray source projector

Figure 3.10: Gamma ray remote control

Equipment and Materials

- Acceptable Radiation Sources: Iridium 192 (Ir-192) (up to 30 Ci)Sources of Ir-192 maybe required to have strengths less than stated above to meet the local regulatory and Client safety standard requirement for safe radiation Level around the work place.

SAFERAD Equipment:
The radiation controlled area barriers can be set at less than 1 meter away from the radioactive source.

- Cordon-off distance requirement during radiography:
  In general a safe cordon-off distance of 3 meters from the radiography source can be obtained during full workload and day time radiography. The following table displays typical shielding characteristics at a 3 meter distance if the guidelines are followed correctly. However, the following table is a guideline only. Actual values of radiation shall be determined by actual measurement of radiation by a calibrated survey meter during radiography and shall be monitored constantly during the full cycle of radiography.

Table 3.3: Cordon Distance

		Primary beam1 with lead pate	(lead Plate)	Primary beam2 with lead pate	(Lead Plate)	Primary Beam 3	Large mat overlapped	
Activity Curies	**Intensity at 3 meter mR/h**	**1Mat mR/h**	**2Mat mR/h**	**3Mat mR/h**	**4Mat mR/h**	**5Mat mR/h**	**6 Mat mR/h**	**7 Mat mR/h**
5	103.33	34.48	11.49	3.83	1.28	0.43	0.14	0.05
7.5	155.00	51.73	17.24	5.75	1.92	0.64	0.21	0.07
10	206.67	68.96	22.99	7.66	2.55	0.85	0.28	0.09
12.5	258.33	86.21	28.74	9.58	3.19	1.06	0.35	0.12
15	310.00	103.45	34.48	11.49	3.83	1.28	0.43	0.14
17.5	361.67	120.69	40.23	13.41	4.47	1.49	0.50	0.17
20	413.33	137.93	45.98	15.33	5.11	1.70	0.57	0.19
30	620.00	206.90	68.97	22.99	7.66	2.55	0.58	0.28
40	826.67	275.87	91.96	30.65	10.22	3.41	1.14	0.38
50	1033.33	344.83	114.94	38.31	12.77	4.26	1.42	0.47
60	1240.00	413.80	137.93	45.98	15.33	5.11	1.70	0.57

- Radiography shall be conducted with industrial radiographic film. Film shall beeither Class I, Class II in accordance with ASTM E 1815. Film shall be selected toproduce radiographs possessing acceptable sensitivity, density and contrast.

- FOMA, Fuji Kodak or Agfa films shall be used for radiography. The followingrecommendation shall be used as a guideline for film selection based on thickness:

  Film class & Material thickness:
  Class I: for t up to 0.5 inches.
  Class II: for t > 0.5 inches up to 1.00 inches.
  Class III: for t > 1.00 inches.

- Radiographic film can be processed by manually. Processing shall be done in accordance with procedures written to the requirements of ASTM SE-94, Part III,the chemical manufacturer's recommendations, and time and temperature charts.Variation to the film manufacturer's processing recommendations to compensatefor exposure is not permitted.

- Unexposed film shall be stored on its side or end and protected from the effects oflight, pressure, excessive humidity, damaging flumes, vapors, or penetratingradiation. Film of which the expiration date has been exceed shall not be used.

Intensifying Screens:

- Only lead intensifying screens shall be used.
- For radiography using gamma ray sources, lead screens shall be used. The minimum thickness of the front lead screen shall be 0.13 mm (0.005 inch) for Ir-192.
  - Special techniques involving the use of intensifying screens of materials other thanlead may be utilized provided the technique is qualified and the density andpenetrometer requirements of this procedure are met. Such special techniquesshall require prior written approval by a designated NDT inspector beforeemployed in production radiography.

Viewing Facilities:

- The Viewing facilities should provide subdued background lighting of an intensity that will not cause troublesome reflections, shadows, or glare on the radiograph.
- Light coming from the outer edges of the radiograph or through low density portions of the radiograph shall not interfere with interpretation.
- Densitometers shall be used to measure the density of the film. The densitometer shall be calibrated annually in accordance with ASTM SE-1079. Performance shall be verified before each use with a density film strip traceable to a national standard.

Examination:

- A single wall exposure technique shall be used for radiography whenever practical. When itis not practical to use a single wall technique, a double wall technique shall be used (SeeTable- 4 for Technique and Exposure Requirements)

Table 3.4: Technique & Exposure Requirements

Nominal Pipe Size	Technique	Type of Exposure and Viewing	Min. Number. Of Exposure Location	Figure
3-1/2 or Less	Elliptical	Double Wall Exp. Double Wall Viewing	2 (0.90)	E
	Elliptical	Double Wall Exp. Single Wall Viewing	4 (0.90, 180, 270)	F
	Superimposed	Double Wall Exp. Double Wall Viewing	3 (0.60.120)	F
Above 3-1/2	Contact	Double Wall Exp. Single Wall Viewing	3 (0.120.240)	C or D
	Panoramic	Single Wall Exp. Single Wall Viewing	1	A
		Single Wall Exp. Single Wall Viewing	4 (0.90,180,270)	B
		Single Wall Exp. Single Wall Viewing	4	A, B

Figure 3.11A&B:Technique& Exposure Requirements

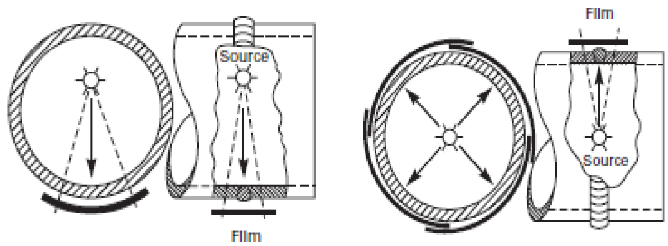
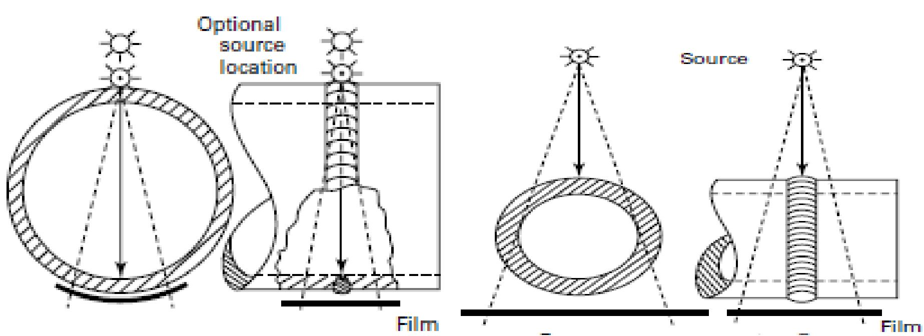


Figure: A Figure: B

Notes:

- Technique other than those described in Table may be used with the approval of the client's inspector.
- If the minimum numbers of exposures, shown above are not adequate to demonstrate the required coverage, additional exposures shall be made as specified by the certified inspector.

- For the Single wall Technique, when the source is located on the inside or outside of the vessel or pipe, and adequate number of exposures shall be made to demonstrate cover again accordance with Figure A, B.



At least three (3) exposures at 120 degree

Figure3.11 : C

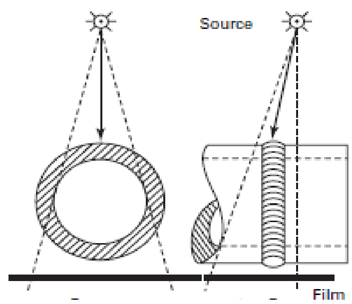
At least three (3) exposures at 120 degree

Figure3.11: D

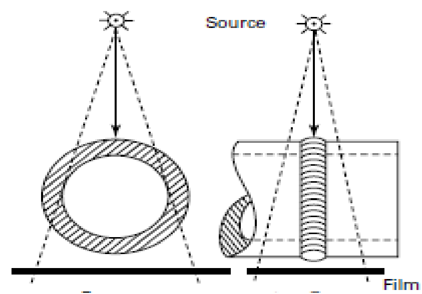
- For the Double Wall Technique for Single Wall Viewing, a minimum of three (3) exposuresseparated by 120O is required. See Figure C, D.

- For the Double Wall Technique for Double Wall Viewing (3-1/2 Inch (89mm) O.D. pipe orless), the following applies:

  - ➢ A minimum of two (2) exposures are required, taken at 90O to each other, when the radiation beam is offset from the plane of the weld centerline at an angle sufficient to separate the images of the weld so there is no overlap of areas to be interpreted. See Figure F.
  - ➢ A minimum of three (3) exposures are required, taken at 60O to 120O to each other, when the radiation beam is positioned so the images of both walls are superimposed. See Figure G.



At least two (2) exposures
At 90 degree



At least three (3) exposures
at 120 degree

Figure3.11 :E

Figure 3.11 : F

Radiographic Exposure Requirements

Selection of Radiation Energy

- Gamma Radiation of Ir-192 may be used for any material thickness provided the radiographic technique used demonstrative that the required radiographic sensitivity has been obtained.

Location Markers

- Each radiograph shall exhibit location markers (i.e.; lead or high atomic number
metals or letter) which appear as radiographic images on the film. The markers shall be place on the part being examined and not on the exposure holder/cassette. Location markers shall be placed on the specimen being radiographed.Figures A to L indicates the recommended placement of

location markers. Location markers shall not intrude into the area of interest.

- The starting point and the direction of numbering shall be identified adjacent to the weld.
- Location shall be marked both inside and outside of tank.
- Number belt spacing around the circumstances of the piping shall not exceed the requirements of Table 6, Number belts shall be in “cm” units of measure unless specifically noted on the report.

Number belts shall be lead number tapes with “cm” units every inch and be of a purpose made manufactured number tape for radiography.

Table 3.5: Number Belt Spacing

Number Spacing	
Nominal Pipe Size	Spacing
Over 31/2 inches through 8 inches	1 inch (2.5 cm) apart
Over 8 inches through 20 inches	4 inch (10 cm) apart

- When using a DWE/DWV technique for pipe or tube welds 3.5 inch NPS or less in
diameter, the first exposure shall be identified with a lead letter “A” and the second exposure shall be identified with a lead letter “B” (and “C” for third exposure, superimposed). Location markers shall not intrude into the area of interest.

- Location markers shall be identified on the surface of the specimen being radiographed. Regardless of the technique used, the area of interest of the radiograph shall be accurately traceable to its location on the part until acceptance.

- Station or location markers (i.e. numbers) shall be spaced in inches or centimeters,
with the unit of measure clearly identified on the RT report.

Film Identification

- Each radiograph shall be permanently identified using lead numbers and/or letters.The radiographic identification shall include the following information:
  - o JO number or BI number
  - o Component, vessel or piping identification
  - o Seam or weld identification
  - o R1 for repair, if necessary, R2, etc. if more than one repair. Cutouts shall be identified as a new weld e.g. NWI, etc.
  - o Date of radiography.

- Radiographs misidentified may be re-identified, with correction tape or equivalent, only when the client's film interpreter or field supervisor has determined that it is impractical to re-radiograph. Re-identification or radiographs shall be noted on the inspection report.

Penetrometer (IQI) Placement

- Source side Penetrometer (s) shall be used at all times unless placement of the penetrometer(s) on the source side of the object is not possible.

- When it is impractical or impossible to place the IQI on the source of the object, film side Penetrometer may be used. The penetrometers shall be in contact with the part being examined. A lead letter “F” of 13mm height and 1.5mm thick shall be used and shall be placed adjacent to or on each penetrometer, and shall not interfere with the penetrometer or be in an area of interest. When film side IQI is used, the essential wire to be viewed on the radiograph shall be at least 1 wire more (of lesser diameter) than that when the IQI is placed on the source side. Refertable-7 above.

- When configuration or size prevents placing the penetrometer(s) on the part or weld, the penetrometer(s) may be placed on a separate block of radiographically similar material. The block shall be placed as close as possible to the item being examined, and the resulting radiographic density of the block image shall be with in the prescribed penetrometer/area of interest density variation tolerances as state din paragraph 8.4. Refer to an Inspector of client recognized for evaluation of radiographically similar material.

- The penetrometers shall be placed perpendicular across the weld. ID numbers and, when used, the lead letter “F” shall not be in the area of interest. Where placement of the penetrometer across the weld or area of interest is not possible refer to the paragraphs above and/or refer to an Inspector for clarification/approval.

- Penetrometer Location for Materials other than Welds- The penetrometer(s) with the penetrometer identification number(s), and when used, the lead letter “F” maybe placed in the area of interest.

- For piping 3.5 inch NPS and less, when using the DWE/SWV technique, only that portion of the weld adjacent to the film, when the penetrometer is placed on the film side of the object, may be viewed for acceptance for the radiographic technique.

Number of Penetrometers

- For DWE/SWV or SWE/SWV techniques requiring multiple exposures for complete inspection of the weld, and where the length of the film to be interpreted is greater than 127 mm (5 inches), two penetrometers placed across the weld and perpendicular to the weld length shall be used. One shall be within 25.4 mm (1inch) of the end of the film length to be interpreted and the other shall be at the center of the film length to be interpreted. When the film length to be interpreted is 127 mm (5 inches) or less, one penetrometer shall be placed across the weld and perpendicular to the weld length at the center of the length to be interpreted.

- If more than two penetrometers are used because of density requirements, one shall be placed in the lightest area of interest and the other in the darkest area of interest. The intervening densities on the radiograph shall be considered as having acceptable density.

- When a complete circumferential weld is radiographed in a single exposure using a source inside the piping, i.e. panoramic radiography, at least four (4) penetrometers shall be used and placed perpendicular to the weld and spaced equally around the circumference.

- When an array of objects in a circle is radiographed, at least one penetrometer shall show on each radiograph.

- Where portions longitudinal welds adjoining the circumferential weld are being examined simultaneously with the circumferential weld, additional penetrometers shall be placed on the longitudinal weld at the ends of the welds being radiographed.

Processing

- Manual processing: Processing shall be performed in accordance with following procedure by manual processing.

- The developer shall be maintained at a temperature of 68º F. Development time shall be adjusted if the temperature is changed more than 2º F. See manufacturer's recommendation.

- Solutions shall be stirred prior to the start of processing.

- Hanger shall be separated by at least 1/2 in. during processing.

- Film shall be agitated at the start of developing to obtain complete even wetting of the film and remove any air bubbles. It shall also be agitated periodically during the development stage increasing to agitation every minute when the developer becomes old.

- Manufacturer's recommendations for development time shall be followed. (This is usually 5 minutes. It is better to expose the film for the shorter development time.)

- After the development is complete, rinse the film in water for a few seconds and plunge into the stop bath to halt the action of the developer. Agitate the film in the stop bath for the period of time recommended by the manufacturer.

- Rinse the film in water for a few seconds and plunge it into the fixer. Agitate it for about 10 seconds. After about one minute agitate again. Normally 10-15minutes is the fixing time.

- The washing efficiency decreases rapidly with decreasing temperatures below 68ºF**.** Washing time at 68□F shall be 30 minutes increasing to 40 minutes at 68ºF. For temperatures above 68□F the washing time shall be decreased to about 20 minutes at 78ºF. When the water temperature is above 68ºFthe film shall be removed from the wash immediately following the wash cycle since the film gelatin softens in warm water. The water flow shall be sufficient to change the volume four times in one hour.

- When the washing cycle is completed the film shall be agitated in a wetting agent.8.1.10 Film shall be left on their hangers for drying.

A more detailed Manual processing procedure required detailing type of processing equipment, dark room light checks, etc.

Radiographic Film Interpretation

- All radiographs shall be free from mechanical, chemical, or other blemishes to the extent that they do not mask and are not confused with the image of any discontinuity in the area of interest. Such blemishes include, but are not limited to, fogging, processing defects such as streaks, watermarks, or chemical stains, scratches, finger marks crimps, dirt, static marks, smudges, or false indications due to defective screens.

- One sheet of film shall be used for each exposure. If an area of interest contains an artifact a second exposure shall be made.

- Radiographic Film Density: For Gamma radiography the minimum density shall be 2.0. For X-radiography, the minimum density shall be no less than 1.8, Radiographic film density through the area of interest or adjacent to the designated wire type penetrometer shall be no greater than 4.0 for radiographs produced by Gamma Rays or X-rays.

Density Variation

- ➢ Radiographic density anywhere through the area of interest shall not vary more than –15% and +30% from the measured density next to the designation wire of the penetrometer. If density variation exceeds the permissible- 15% and +30%range, additional penetrometers shall be used for each exceptional area or areas and the area of interest re-radiographed.

- ➢ The maximum permissible +30% may be exceeded for penetrometers with shims provided penetrometer sensitivity meets the requirements of this Procedure.

- IQI Sensitivity – Acceptance of the radiograph for sensitivity is based on ability of the radiograph to display the required wire on the penetrometer, viewed across the weld, and the penetrometer identifying numbers and letters. Radiographs not meeting this requirement shall be re-radiographed.

- Back Scatter Radiation – Radiographic film displaying a light image of the letter "B" on a darker background shall be cause for rejection of the radiograph. A dark image of the letter"B" on a lighter background shall be considered acceptable.

Film Viewing

- Film shall be viewed in an area with subdued lighting as required by paragraph *5.6.1*.

- Personnel interpreting radiographs shall allow 3 minutes in any darkened area for their eyes to adjust if coming into the darkened area from normal room light and at least 5minutes if coming in from full sunlight.

- Radiographs shall be interpreted only in those areas in which the penetrometer(s) have established that a suitable radiographic technique has been used.

- Composite viewing of double film exposure is not permitted unless approved in writing by an Inspector of client.

- Each exposed film shall be properly stored to prevent damage to the film.

Final Interpretation of Radiographs

- The radiographs shall be examined and interpreted for film quality and for discontinuities by personnel certified to Level-II in RT.

- The film interpreter shall record on a review form (Attachment) accompanying the radiographs, the type of defects present on each radiograph and the area(s) rejected.

3.6 Radiographic Testing Acceptance Criteria[3][6]

Inadequate Penetration without High-low

Inadequate penetration without high-low (IP) is defined as the incomplete filling of the weld root. This condition is shown schematically in Figure 13. IP shall be considered a defect should any of the following conditions exist:

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

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

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

Inadequate Penetration Due to High-low

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

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

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

Inadequate Cross Penetration

Inadequate cross penetration (ICP) is defined as a subsurface imperfection between the first inside pass and the first outside pass that is caused by inadequately penetrating the vertical land faces. This condition is shown schematically in Figure 15. ICP shall be considered a defect should any of the following conditions exist: a. The length of an individual indication of ICP exceeds 2 in. (50 mm). b. The aggregate length of indications of ICP in any continuous 12 in. (300 mm) length of weld exceeds 2 in. (50 mm).

Incomplete Fusion

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

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

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

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

Incomplete Fusion Due to Cold Lap

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

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

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

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

Internal Concavity

Internal concavity (IC) is defined in 3.2.8 and is shown schematically in Figure 18. Any length of internal concavity is acceptable, provided the density of the radiographic image of the internal concavity does not exceed that of the thinnest adjacent parent material. For areas that exceed the density of the thinnest adjacent parent material, the criteria for burn through (see 9.3.7) are applicable.

Burn-through

- A burn-through (BT) is defined as a portion of the root bead where excessive penetration has caused the weld puddle to be blown into the pipe.
- For pipe with an outside diameter greater than or equal to 2.375 in. (60.3 mm), a BT shall be considered a defect should any of the following conditions exist:

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

  b. The maximum dimension exceeds the thinner of the nominal wall thicknesses joined, and the density in any portion of the BTs image exceeds that of the thinnest adjacent parent material.

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

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

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

  b. The maximum dimension exceeds the thinner of the nominal wall thicknesses joined, and the density in any portion of the BT's image exceeds that of the thinnest adjacent parent material.

  c. More than one BT of any size is present and the density in any portion of the BTs image exceeds that of the thinnest adjacent parent material.

Slag Inclusions

- A slag inclusion is defined as a nonmetallic solid entrapped in the weld metal or between the weld metal and the parent material. Elongated slag inclusions (ESIs)—e.g., continuous or broken slag lines or wagon tracks-are usually found at the fusion zone. Isolated slag inclusions (ISIs) are irregularly shaped and may be located anywhere in the weld. For evaluation purposes, when the size of a radiographic indication of slag is measured, the indication's maximum dimension shall be considered its length.
- For pipe with an outside diameter greater than or equal to 2.375 in. (60.3 mm), slag inclusions shall be considered a defect should any of the following conditions exist:

  a. The length of an ESI indication exceeds 2 in. (50 mm). Note: Parallel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single indication unless the width of either of them exceeds 1/32 in. (0.8 mm). In that event, they shall be considered separate indications.

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

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

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

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

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

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

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

a. The length of an ESI indication exceeds three times the thinner of the nominal wall thicknesses joined. Note: Parallel ESI indications separated by approximately the width of the root bead (wagon tracks) shall be considered a single indication unless the width of either of them exceeds 1/32 in. (0.8 mm). In that event, they shall be considered separate indications.

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

c. The aggregate length of ISI indications exceeds two times the thinner of the nominal wall thicknesses joined and the width exceeds one-half the thinner of the nominal wall thicknesses joined.

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

Porosity

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

a. The size of an individual pore exceeds 1/8 in. (3 mm).

b. The size of an individual pore exceeds 25% of the thinner of the nominal wall thicknesses joined.

c. The distribution of scattered porosity exceeds the concentration permitted by Figures 19 or 20.

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

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

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

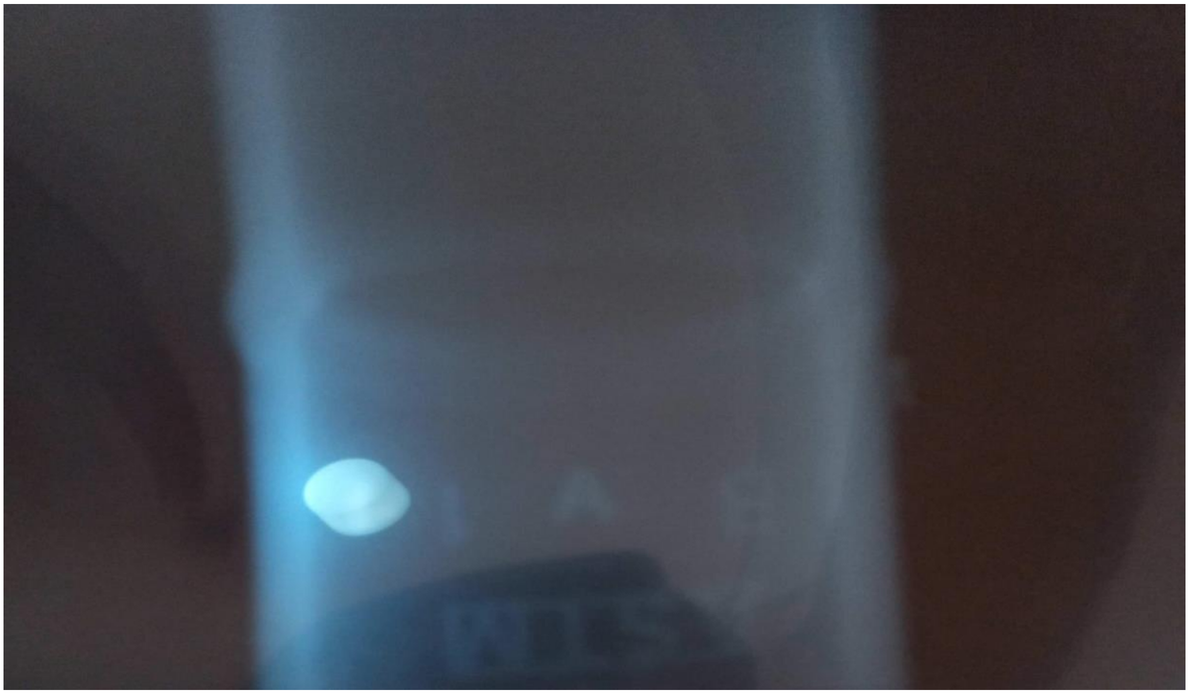
- Hollow-bead porosity (HB) is defined as elongated linear porosity that occurs in the root pass. HB shall be considered a defect should any of the following conditions exist:

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

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

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

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



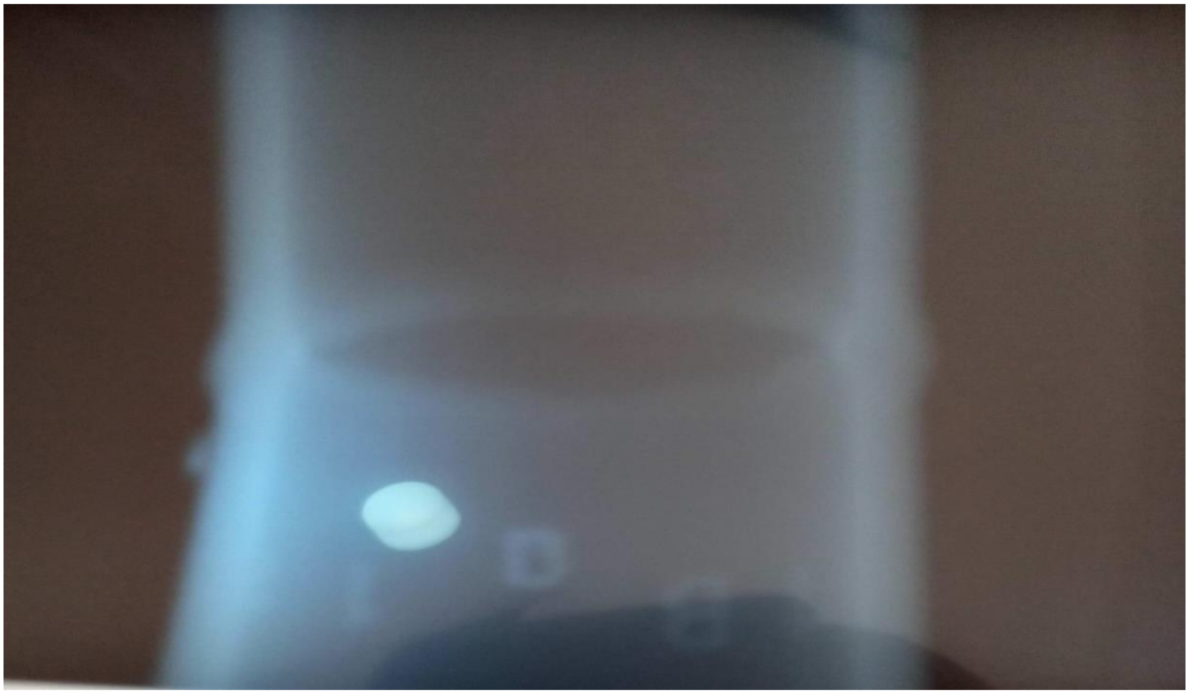


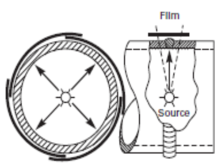
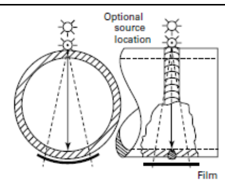
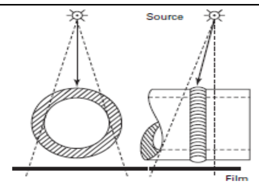
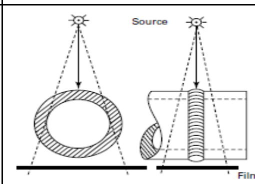
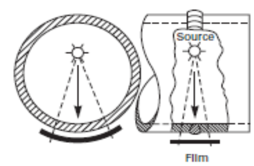
Figure 3.12: Radiography Film

Sonargaon University

147/I,Green Road, Panthapath,Tejgaon,Dhaka.

Radiographic Examination Report

Report No	: SU-RT-REPORT-01	**Location**	: FIELD	**Source/Focal Size**	: 3×2 mm
Date	: 05-01-2022	**Make & Type of film**	:AGFA-D4	**Type of Source**	: Ir- 192
Job No	: N/A	**Film Size**	: 10-24	**Strength or KV**	: 14 Ci
Client	: Sonargaon University	**No. of Exposure**	: 2	**No of Film per Cassettes**	: 01
Project	:	**IQI type**	: ASTM 1B	**Intensifying Screen (F&B)**	:Lead 0.125mm
Procedure No.	:**SU-RT-PROCEDURE -01**	**Exposure Time**	: 15 min	**Acceptance Criteria**	: API-1104
Material	: 316L(SS)	**Density**	: 2.0-3.0	**OFD**	: 40 mm
Job Dia& Thick:	2"x5.54mm	**SOD**	: 457 mm	**Technician Name**	: KANON
Reinforcement:	1.5 mm	**Welding Process**	: GTAW	**Radiographic Technique**	: DWDI

SWSI (Panoramic)	DWSI	DWDI (Elliptical)	DWDI (Superimpose)	SWSI
				

SI. No.	XR.No.	DESCRIPTION	Joint No.	Welder I.D.	Segments 'cm'	Observation	Result	Visible IQI Wire	Remarks
01	N/A	TEST PIECE	01	N/A	A	NSD	ACC	12th	
					B	NSD	ACC		

LEGENDS-			
IP : Inadequate penetration IF : Incomplete Fusion IC : Internal Concavity SL: Slag Line CM: Chemical Mark RS: Reshoot	BT :Burn Through SI :Slag Inclusions PO : Porosity RT : Retake SD : Surface Depression NSD: No Significant Discontinuity	CR : Crack RUC : Root Undercut CUC : Cap Undercut H/L : High Low DRS :Dress& Reshoot ACC : Acceptable FM : Film Mark	HB : Hollow Bead TI : Tungsten Inclusion EP : Excess Penetration DB : Debris CRS : Clean & Reshoot Rep. : Repair SC : Screen Mark

Film Interpretation	**(ASNT LEVEL-II)**				
NAME:	KANON				
SIGNATURE:					
DATE:	05-01-2022				

Chapter Four
Calculation

4.1 Geometric Un-sharpness calculation

- Geometrical un-sharpness. "Ug", equals source size times thickness divided by the object-to source distance.

Ug = Ft/D
=(2×2)/762
=0.005

Ug = Geometrical Un-sharpness
F = Source size, the maximum projected dimension of the radiating source (or effective focal spot) in the plane perpendicular to the distance (D) from the weld or object being radio-graphed.
D = Distance from source of radiation to weld or other object being radiographed.
T = Distance from source side of the object being radiographed to the film.

- The minimum source to object distance, D, shall be great enough to insure that geometric unsharpness,Ug, of the radiograph does not exceed the values listed in Table 4.1.

Table 4.1: Geometric Un-sharpness

Material Thickness, mm (inches)	Ug Maximum mm (inch)
Under 50.8 (2 in.) 50.8 – 76.2 (2 in. through 3 in.) Over 76.2 – 101.6 (> 3 in. through 4 in.) Greater than 101.6 mm (> 4 in.)	0.500 (0.020 in.) 0.760 (0.030 in.) 0.101 (0.040 in.) 1.780 (0.070 in.)

- The following formula should be used to determine the minimum source to object distance, D, necessary to insure that the Ug does not exceed the values listed in Table 5.

4.2 Image Quality Indicators (IQI)

- DIN type penetrometers described in DIN 54 109, ISO type penetrometers descried in ISO 1027, or ASTM type penetrometers described in ASTM SE- 747 shall be used. Tables 1, 2 and 3 shows the standard identification numbers found on the penetrometer packs and the wire sizes found in the DIN type, ISO type and ASTM type typical packs.

Table 4.2: DIN Wire Type Penetrometer

DIN Pack Designation	Wire Diameter mm (inch) Corresponding Wire Number						
1 FE DIN	3.20 (0.125) 1	2.50 (0.098) 2	2.00 (0.078) 3	1.60 (0.062) 4	1.25 (0.050) 5	1.00 (0.040) 6	0.80 (0.032) 7
6 FE DIN	1.00 (0.040) 6	0.80 (0.032) 7	0.63 (0.024) 8	0.50 (0.020) 9	0.40 (0.016) 10	0.32 (0.013) 11	0.25 (0.010) 12
10 FE DIN	0.40 (0.016) 10	0.32 (0.013) 11	0.25 (0.010) 12	0.20 (0.008) 13	0.16 (0.006) 14	0.125 (0.004) 15	0.10 (0.004) 16

Table 4.3: ISO Wire Type Penetrometer

ISO Pack Designation	Wire Diameter mm (inch) Corresponding Wire Number						
1 ISO 7	3.20 (0.125) 1	2.50 (0.098) 2	2.00 (0.078) 3	1.60 (0.062) 4	1.25 (0.050) 5	1.00 (0.040) 6	0.80 (0.032) 7
6 ISO 12	1.00 (0.040) 6	0.80 (0.032) 7	0.63 (0.024) 8	0.50 (0.020) 9	0.40 (0.016) 10	0.32 (0.013) 11	0.25 (0.010) 12

10 ISO 16	0.40 (0.016) 10	0.32 (0.013) 11	0.25 (0.010) 12	0.20 (0.008) 13	0.16 (0.006) 14	0.125 (0.004) 15	0.10 (0.004) 16

Figure 3.13 : penetrometer(IQI)

Table 4.4: ASTM Wire Type Penetrometer

Set	Wire Diameter mm (inch)					
A	0.081 (0.0032)	0.102 (0.004)	0.127 (0.005)	0.160 (0.0063)	0.203 (0.008)	0.254 (0.010)
B	0.254 (0.010)	0.330 (0.013)	0.406 (0.016)	0.508 (0.020)	0.635 (0.025)	0.813 (0.010)
C	0.813 (0.032)	1.016 (.040)	1.27 (0.050)	1.6 (0.063)	2.03 (0.080)	2.54 (0.100)
D	2.54 (0.100)	3.2 (0.126)	4.06 (0.160)	5.08 (0.200)	6.35 (0.250)	8.13 (0.320)

- Damaged IQIs shall not be used (e.g. bent wires)
- IQIs shall be selected from either the same alloy material group or grade as identified in ASTM SE-747 or from an alloy material group or grade with less radiation absorption than the material being radiographed.

4.3Penetrometer (IQI) Selection

- Material: IQIs shall be selected from either the same alloy material group or grade as identified in SE-747 for wire type, or from an alloy material group or grade with less radiation absorption than the material being radiographed. Alternately, IQI in accordance with EN-ISO standard can be used provided the sensitivity requirements as specified in Table 7 is met with equivalent IQI wire.

- Size: The essential wire shall be as specified in Table 7.

- Welds with Reinforcements. The thickness on which the IQI is based is the nominal single-wall material thickness plus the weld reinforcement thickness estimated to be present on both sides of the weld (I.D. and O.D.). The values used for the estimated weld reinforcement thicknesses shall be representative of the weld conditions and shall not exceed the maximums permitted by the referencing Code Section. Physical measurement of the actual weld reinforcements is not required. Backing rings or strips shall not be considered as part of the thickness in IQI selection.

- Welds without Reinforcements. The thickness on which the IQI is based is the nominal single-wall material thickness. Backing rings or strips shall not be considered as part of the thickness in IQI selection.

- Actual Values. With regard to (a) and (b) above, when the actual material/weld thickness is measured, IQI selection may be based on these known values.

Table 4.5: IQI Selection

Unless otherwise stated in the Scope of work, penetrometer shall be Selected as shown in the following columns (ASTM E 747)			
Nominal Material Thickness		Source Side	Film Side
Inch	mm	Wire Number	Wire Number
Up to 0.25 incl.	Up to 6	5	4
Over 0.25 through 0.375	6 through 9.5	6	5
Over 0.375 through 0.50	9.5 through 12.7	7	6
Over 0.50 through 0.75	12.7 through 19	8	7
Over 0.75 through 1.00	19 through 25.4	9	8
Over 1.00 through 1.50	25.4 through 38.1	10	9
Over 1.50 through 2.00	38.1 through 50.8	11	10
Over 2.00 through 2.50	50.8 through 63.5	12	11
Over 2.50 through 4.00	63.5 through 101.6	13	12
Over 4.00 through 6.00	101.6 through 152.4	14	13
Over 6.00 through 8.00	152.4 through 203.2	16	14
Over 8.00 through 10.00	203.2 through 254	17	16

NOTE: Other IQIs may be used; however the IQI wire diameter shall be equivalent or lesser than that indicated for the thickness range described in the table.

4.4 Sensitivity calculation

Sensitivity calculation shall be based on the following formula:

$$\%\ \text{Sensitivity} = (\text{Diameter of thinnest wire visible x } 100)/(\text{Wall thickness} + \text{ reinforcement})$$

$$= \frac{0.25 \times 100}{14}$$

$$= 1.81\%$$

While calculating sensitivity for film side IQI, the thinnest wire visible shall be taken for film side IQI only.

Chapter Five

Result And Discussion

5.1: Result And Discussion

We have developed the better inspection system of pipe line.

We can get pure water as the pipe line is well inspected and developed.

As we used the proper alloy elements of pipe and weld with 6g qualified welder the join and pipe will withstand all the defects, so maintenance cost will be low and long life.

PMI is used to confirm that the chemical composition of the metallic parts has the correct percentage of key elements, this ensures that material properties such as corrosion resistance meets the requirements. Pipe used in this project is SS316L, which is composition of Nickel, Chromium, Molybdenum. For the SS316L the allowed range of this elements is – for molybdenum (2-3%), for Chromium (16-18%), for Nickel (10-14%).

For this pipe line, we weld the pipe specimen with 6g qualified welder so that the weld can be found defect free.

BY applying dye penetration test in 1 mm depth of pipe, there was no round or liner indications found.

Radiographic Testing is a nondestructive examination (NDE) technique that involves the use of gamma rays to view the internal structure of a component. In the welding and casting industry, using this test we can find out the tiniest defects on materials.

By radiographic test we get the quality full welded pipe.

Geometrical un-sharpness = 0.401 (Target value<0.500)

Sensitivity = 1.81% (Target value < 2%) [Accepted]

Chapter Six

Conclusion and Recommendation

6.1 Conclusion

This project aims at introducing pipe line welding and various testing methods to understand its purpose and importance in industries especially in pipeline industry. During the project it had been made in following areas:

1. Welding Methods (GTAW)
2. Welding defects
3. Visual and Dimensional inspection
4. Codes and standards (ASME section-IX, API-1104, ASME section-VIII, Division-1, Article-4.)
5. Non Destructive Testing methods (Dye Penetrant Test, Radiographic Test)

In the government as well as private industry, welding is widely used by metal workers in the fabrication, maintenance, and repair of parts and structures. While there are many methods for joining metals, welding is one of the most convenient and rapid methods available. In order to ensure its quality, the welding shall be flawless. For increasing there liability of the equipment, all the defects/flaw shall be detected as early as possible and correct has to be done before handing it over to client. These acceptable limits have been mentioned in various codes and standards.

6.2 Recommendation

Effect of different grades of filler wire on the mechanical properties and chemical composition of welded joint may be carried out. Shielding gas composition may be carried out its effect on various properties of the steel. Dye Penetrant and Radiography test should be carried out GTAW process on the stainless steel (SS316L). we can find out various defects on the welding joint by this mentioned tests.

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