Development of Knowledge Based Welding Inspection Data and Generate Report Format According to Standard Code

by

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4633

Dissertation submitted in partial fulfillment
of the requirements for the
Bachelor of Engineering (Hons)
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CERTIFICATION OF APPROVAL

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Approved by,

(Mr. Mohd Faizairi Mohd Nor)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK DARUL RIDZUAN
December 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(Winnie Vong Chin Joo)

ABSTRACT

The project for this final semester is to generate a report format for the welding inspection forms.

The two standards that had been selected are American Petroleum Institute (API) standard and International Organization for Standardization (ISO).

The American Petroleum Institute (API) publishes specifications, bulletin, recommended practices, standards and other publication as an aid to procurement of standardized equipment and materials. These publications are primarily intended for use by the petroleum industry.

The ISO 9606 part specifies requirements, ranges of approval, test condition, acceptance requirements and certification for the approval testing of welder performance for the welding of steels.

During the approval test, the welder is required to show adequate practical experience and job knowledge of the welding processes, materials and safety requirements for which the welder is to be approved.

The welding processes referred to in the part of ISO 9606 include those fusion welding processes which are designated as manual or partly mechanized welding. The International Standard does not cover fully mechanized and fully automatic processes.

The part of ISO 9606 covers approval testing of welders for work on semi finished and finished products made from wrought, forged or cast material.

The certificate of approval testing issued under the sole responsibility of the examiner or test body.

ACKNOWDLEDGEMENT

I would like to express my greatest thanks to my project supervisor, Mr. Mohd Faizairi Mohd Nor for his advice, guidance and understanding throughout the development of this project. This project development would not have been possible without the assistance and guidance of certain individuals whose contributions have helped in its completion.

Also, to my beloved parents who always provide me with a lot of supports and prayers that strengthen me. Not forgotten, to my friends and peers for their unconditional support and love for me. Special thanks to Stephen, Diana, Adia and Rohana, Wong Jan Wen, Foo Yoke Kuan, Foo Win Lim, Teng Jit Yuen and Wong Siew Mee for your advices and motivations in giving me strength to face all problems.

Last but not least, I would like to thank all persons who have contributed to this project in one way or another.

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CHAPTER 1

1 INTRODUCTION

1.1 Background of Study

Welding is an important process especially to the industry nowadays. Welding process is needed in industry such as automotive industry, pipeline industry, construction industry, oil and gas industry and many other industries.

Welding inspection plays an important role in the welding industry. Welding inspection is needed in order to determine a good welding process.

This project concentrates mainly on the improvement on the data of welding inspection. Nowadays, most of the welding inspection is recorded manually. After the welding inspection has been done, the data is usually recorded by using handwriting.

The project is to generate a report format and a program so that all the data from the inspection can be seen and the result of the welding can be determined through the program that had been created. The program that had been determined to be used in the project is Visual Basic Programming.

1.2 Problem Statement

The recording that is done manually will take longer time when compare to the recording that is done by using program in the computer. This is because if the recording is written manually on the welding inspection form, the inspector has to check from the welding handbook in order to determine whether the welding defects are acceptable or not.

But if the welding inspection data is being keyed into to program that has been generated, it will show the result of the inspection quickly without wasting a lot of time. Times for searching for the acceptable tolerance from the inspection can be saved.

Apart from that, there are three welding standards that had been chosen and will be included in the Visual Basic program. The welding standards are American Petroleum Institute (API) standard and International Organization for Standardization (ISO).

The standards can be viewed and the welding inspection results can be known in a very short time. This will save a lot of time and work of the welding inspectors.

1.3 Objective and Scope of Study

The objective of this project is to gather all the information that had been researched during the last semester. Then the information will be arranged according to the two standards.

The information will later be used in generating the format report and the Visual Basic program. The Visual Basic program will include interfaces that can be used to check on the results of the welding inspection.

The scope of study of this project covers a wide range of scope as follow:

1. Research on items regarding welding inspection.
2. Arrangement of the information into various standards.
3. Generation of a report format.
4. Creation of a Visual Basic program.

CHAPTER 2

2 LITERATURE REVIEW AND THEORY

2.1 Welding Codes and Standards

Welding Codes and Standards play a major role in the welding inspection process. The codes and standards determine the results of the welding inspection.

At first, the three standards that are emphasized on this project are American Society of Mechanical Engineers (ASME) standard, American Petroleum Institute (API) Standard and American National Standard Institute (ANSI).

But after deep consideration and suggestion by supervisor and the student, two standards had been selected and the standards are the American Petroleum Institute Standard (API) and the ISO standards.

2.1.1 American Petroleum Institute (API) Standard

The standard covers the gas and arc welding of butt, fillet, and socket welds in carbon and low-alloy steel piping used in the compression, pumping and transmission of crude petroleum, petroleum products and fuel gas.

Apart from that, fuel gases also using this standard. The welding may be done by a shielded metal-arc welding, submerged arc welding, gas tungsten-arc welding, gas metal-arc welding, flux-cored arc welding, oxyacetylene welding, or flash butt welding process or by a combination of these processes using a manual, semiautomatic, or automatic welding technique or a combination of these welding techniques.

This standard also covers the acceptance standards to be applied to production welds tested to destruction or inspected by radiography. It includes the procedure for radiographic inspection.

Persons who wish to have other processes included shall submit, as a minimum, the following information for the committee's consideration.

a. A description of the welding process
b. A proposal on the essential variables
c. A welding procedure specification
d. Weld inspection methods
e. Types of weld discontinuities and their proposed acceptance limits
f. Repair procedures

2.1.2 ISO Standard

This part of ISO 9606 specifies requirements, ranges of approval, test condition, acceptance requirements and certification for the approval testing of welder performance for the welding of steels.

During the approval test, the welder is required to show adequate practical experience and job knowledge of the welding processes, materials and safety requirements for which the welder is to be approved.

The welding processes referred to in this part of ISO 9606 include those fusion welding processes which are designated as manual or partly mechanized welding. The International Standard does not cover fully mechanized and fully automatic processes.

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All standards were subjected to revision, and parties to agreements based on the part of ISO 9606 were encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

Table 2.1: ISO Standard Specification

ISO 857:1990	Welding, brazing and soldering processes
ISO 1106-1:1984	Recommended practice for radiographic examination of fusion welded joints Part 1 : Fusion welded butt joints in steel plates up to 50 mm thick
ISO 1106-2:1985	Recommended practice for radiographic examination of fusion welded joints. Part 2: Fusion welded butt joints in steel plates thicker than 50 mm and up to and including 200 mm in thickness.
ISO 1106-3:1984	Recommended practice for radiographic examination of fusion welded joints. Part 3: Fusion welded circumferential joints in steel pipes up to 50mm wall thickness.
ISO 2560	Specification for carbon-manganese steel electrodes for shielded metal arc welding
ISO 3452:1984	Non destructive testing
ISO 3580:1975	Covered electrode for manual arc welding of creep-resisting steels

ISO 3581:1976	Covered electrodes for manual arc welding of stainless and other similar high alloy steels.
ISO 4063:1990	Welding, brazing. Soldering and braze welding of stainless and other similar high alloy steel.
ISO 5173	Welding – Welded butt joints in metallic materials.
ISO 5817:1992	Arc-welded joints in steel
ISO 6520:1982	Classification of imperfections in metallic fusion welds, with explanation
ISO 6497:1990	Weld- working position
ISO 9956-2	Specification and approval of welding procedures for metallic materials.
ISO 9956-3	Specification and approval of welding procedures for procedure test for arc welding.

2.2 Duties of Welding Inspector

Literature review on the duties of welding inspector had been done in order to prepare for the information of the whole project. Before the welding process, the welding inspector has to obtain information from the fabricator, purchaser or owner.

The information that the welding inspector has to obtain is regarding the application standard, record of material, heat treatment requirement and the Non-destructive Test party.

Apart from that, the welding inspector has to obtain understanding with the client regarding material and consumable choice, joint preparation and details, design, service condition and level of acceptability. The other information is type of non destructive test to be used, repair procedure and procedure qualification.

The welding inspector has to do inspection of material regarding the grade, type and size. Purchaser specification and supplier record, mill certificate and test report also have to be taken into consideration.

Besides, the welding inspector has to take care and do inspection of consumables such as the choice of consumable that produce the desired weld metal properties, verification by metallurgical and chemical testing reports.

The welding inspector has to check the consumable identification, storage and preparation. The welding inspector has to check the type and handling of shielding gases and also check the application back shielding and purging gas.

Inspection of welding and other related equipment also have to be done by the welding inspector. The things that the welding inspector has to take into consideration are the capacity and limitation of machine, the accuracy of instrument, and the suitability of process for the root run.

Apart from that, the welding inspector has to take care of welding process for the hot and cap passes and adherence to safety and quality procedure.

The welding inspector has to do inspection of joint design and preparation work. The work that is done is by checking the quality of assembling the butt, socket, branches and flange. The backing ring or consumable insert have to be made sure that they are correctly used. The position of the weld seam is also has to be inspected.

The welding inspector also has to make sure of the cleanliness of joint surface and the accuracy of joint preparation. The quality of the tack welding also has to be checked by the welding inspector.

The welding inspector has to inspect the application of preheating with respect to the material and thickness, the preheating temperature and the method of correct application. The other duties of the welding inspector are to verify the welding procedure by studying the record and specification and verification of welder qualification and skill.

During welding process, the welding inspector supervises the compliance toward welding procedure and welding condition. The adherence toward quality welding practices is also being supervised.

While the welding process is in progress, the welding inspector inspects the inter-pass weld treatment and does the in-process inspection on the root pass, cleaning of joint and weld preparation flaws.

After the welding process, the welding inspector performs the visual inspection on the completed weld to identify visual defect on both the external and internal walls. The quality and acceptability of the weld defects, profile and accuracy are also being evaluated.

Table 2.2: Welder's Troubleshooter

Trouble	Cause	Cure
Distortion	• Shrinkage of deposited metal pulls parts together and changes relative positions. • Nonuniform heating of parts during welding causes them to distort before welding is finished. Final welding of parts in distorted position prevents the maintenance of proper dimensions. • Improper welding sequence.	• Clamp or tack parts properly to resist shrinkage. • Separate or perform parts to compensate for shrinkage of welds. • Distribute welding to prevent excessive local heating. Preheating is desirable in some heavy structure. • Removal of rolling or forming strains before welding is sometimes helpful.
Warping (Thin Plates)	• Shrinkage of deposited weld metal. • Excessive local heating at the joints. • Improper preparation of joint. • Improper welding procedure. • Improper clamping of parts.	• Select electrode with high welding speed and moderate penetrating properties. • Weld rapidly to prevent overheating the plates adjacent to the weld. • Do not have wide spaces between the parts to be welded. • Clamp parts next to the joint properly. Use backup strip to cool parts rapidly.

		• Hammer joint edges thinner than rest of plate before welding. This elongates edges, and the weld shrinkage causes them to pull back to the original shape.
Welding Stresses	• Joint too rigid. • Improper welding procedure. • Stress occurs in all welds, especially in heavy parts.	• Slight movement of parts during welding will reduce welding stresses. • Make weld in as few passes as practical. • Peen each deposit of weld metal. • Heat finished product at 1.100-1.200 Fahrenheit for one hour per inch of thickness. • Develop welding procedure that permits all parts to be free to move as long as possible.
Scatter	• Characteristics of some electrodes. • Excessive welding current for the type or diameter of electrode used. • Coated electrodes produce larger spalls than bare type electrodes.	• Select proper type of electrode. • Do not use too much welding current. • Paint parts next to weld with whitewash. This prevents spalls from welding to parts and they can be removed easily.

Cracked welds	• Joint too rigid. • Welds too small for size of parts joined. • Improper welding procedure. • Poor welds. • Improper preparation of joints.	• Design the structure and develop a welding procedure to eliminate rigid joints. • Do not use too small welds in string beads. Make weld full size in short section 8 to 10 inches long. • Plan welding sequence to leave ends free to move as long as possible. • Insure welds are sound and the fusion is good.

2.3 Setting Up A List or Database In Visual Basic

Structuring a list is the most important part of the creation process because it ultimately determines what the program wants and be able to extract from the list. Then from the list, the effectiveness of the list can be found while in generating a report format.

The architectures of the plan had been planned at the first place. The correct planning of architecture will ensure an effective result from the program.

In the system, it will be divided into two main sheets which were the sheet regarding welding inspection according to the American Petroleum Institute (API) standard and the other one is the welding inspection for International Organization for Standardization (ISO) standard.

The system or program should capture data from users and comparing the data to the standards. The system will give the result whether it is acceptable according to the standards or not.

Then the data will be stored in database for future use. The welding inspector or users can retrieve data from the system for reference at any time.

2.4 Shielded Metal Arc-Welding of pipe

Shielded metal-arc welding is the principal process for welding pipe both in the shop and in the field. Welds of X-ray quality are produced on a production basis. This process may be used for nearly all ferrous and nonferrous piping.

Standard welding power sources which produce alternating or direct current such as a rectifier, transformer, motor generator or an engine-driven machine may be used.

Welding may be done in all positions, and the direction of welding may be up or down.

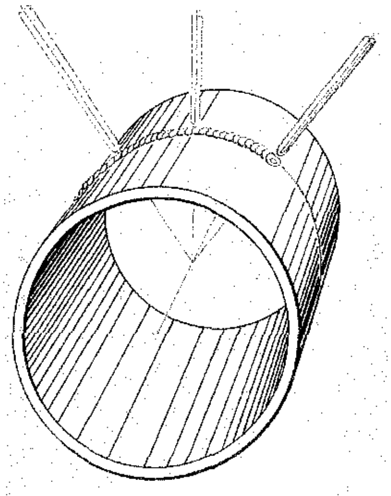


Figure 2.1: Welding position of pipe using Shielded metal-arc welding

2.5 Welding Test

Table 2.3: Test Requirement for Procedure qualification in Pipeline according to API code

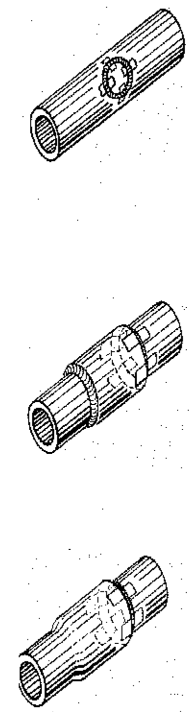
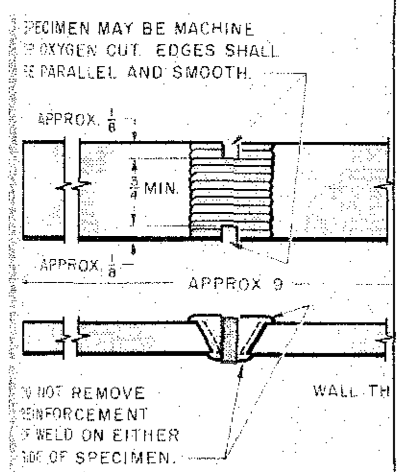
Test requirements for procedure qualification in pipeline according to the API code.

Type and Number of Test Specimens for Procedure Qualification Test

Pipe size, outside diameter—inches	Tensile	Nick-break	Root-bend	Face-bend	Side-bend	Total
	Wall thickness—½ Inch and under					
Under $2\frac{3}{8}$	0	2	2	0	0	4*
$2\frac{3}{8}$ to $4\frac{1}{2}$ inclusive	0	2	2	0	0	4
Over $4\frac{1}{2}$ to $12\frac{3}{4}$ inclusive	2	2	2	2	0	8
Over $12\frac{3}{4}$	4	4	4	4	0	16
	Wall thickness—over ½ inch					
$4\frac{1}{2}$ and smaller	0	2	0	0	2	4
Over $4\frac{1}{2}$ to $12\frac{3}{4}$ inclusive	2	2	0	0	4	8
Over $12\frac{3}{4}$	4	4	0	0	8	16

American Petroleum Institute

Table 2.4: Nick-Break Test

TEST	FEATURES	FIGURE
Nick-Break Test	• Test specimen shall be approximately 230 mm long and approximately 25 mm wide and may be machine cut or oxygen cut. • Shall be notched with a hacksaw on each side at the center of the weld. • Each notch shall be approximately 3.17 mm depth. • Prepared in this manner from welds made with certain automatic and semiautomatic processes may fail through the pipe instead of the weld.	 

	• External reinforcement may be notched to a depth of not more than 1.59 mm, measured form the original weld surfaces. • The exposed surfaces of each nick-break specimen shall show complete penetration and fusion. • The greatest dimension of any gas pocket shall not exceed 1.59mm. • The combined area of all gas pockets shall not be more than 0.79 mm in depth. • Shall not be more than 3.17 mm or one-half the nominal wall thickness in length, whichever is smaller. • Shall be at least 12.7 mm of sound weld metal between adjacent slag inclusions.	

Table 2.5: Root Bend Test

TEST	FEATURES	FIGURES
Root Bend Test	• The root bend test specimens shall be approximately 230 mm long and 25 mm wide. • Long edges shall be rounded.	

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- They may be machine cut or oxygen cut.
- The cover and root-bead reinforcement shall be removed flush with the surfaces of the specimens.
- These surfaces shall be smooth, and any scratches that exist shall be light and transverse to the weld.
- The root test shall be considered acceptable if no crack or other defect exceeding 3.17 mm or one-half the nominal wall thickness, whichever is smaller.
- In any direction is present in the weld or between the weld and the fusion zone.
- Cracks that originate on the outer radius bend along the edges shall not be considered unless obvious defects are observed.

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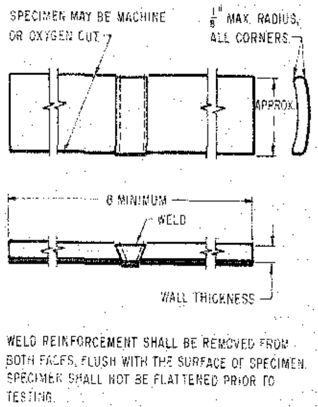

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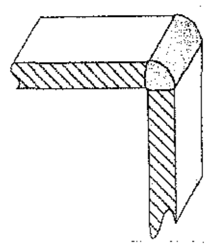
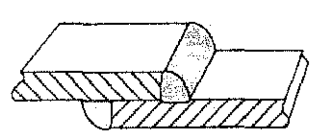
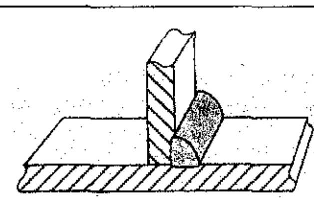
2.6 Welding design

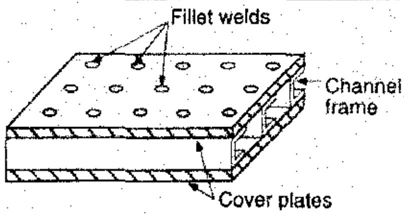
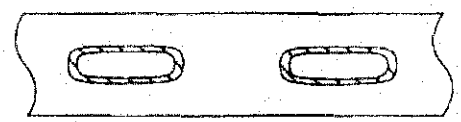
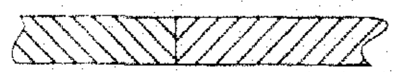
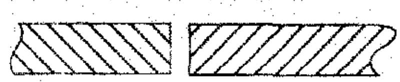
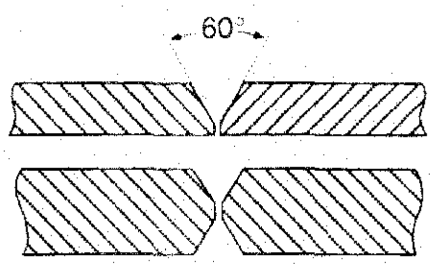
Without a standard terminology, welding instructions would be very difficult to follow, and confusion and unsafe practices could easily occur. Welder and welding inspector need to know the different types of welds, their parts and the terms used to identify unacceptable weld conditions.

The welding terminology that had been studied is similar to that used in literature produced by the Standards Association of Australia and counterpart organizations overseas.

Below are the types of welding that are normally used in industry nowadays:-

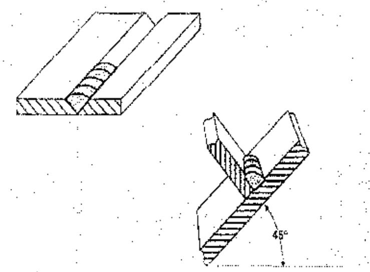
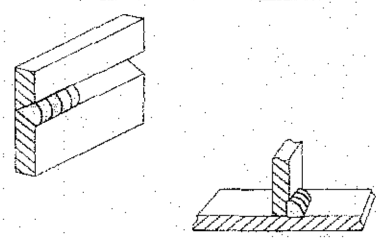
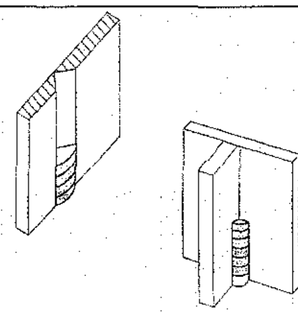
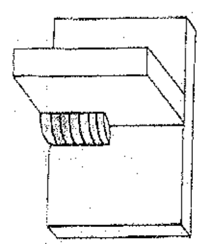
Table 2.6: Welding Design

Type of weld	Features	Figures
Corner fillet weld	• Used to join plates when their ends meet at an angle to each other (usually 90°) • For example, the corners of rectangular tanks	
Lap fillet	• Used to join plates together in a continuous fillet weld line • Commonly used for thin metal, because it is easier and often stronger than placing the parts end-to-end. • It can be used on thicker plates if the step it creates is acceptable	
Tee fillet	• Common in metal structures • Fillet is occur when the end of one plate meets the surface of another tee	

Plug fillet	• Used to join two flat surfaces together • Fillet welds is allowed around the circumference of the hole when joining the plate to the frame • Also used when two plate surfaces are joined together to produce a thicker plate	
Slot fillet	• Used to plug fillet welds, however, instead of holes, round ended slots are made (generally by flame cutting)	
Close-square butt joint	• Used to join metal up to 1.5 mm thick.	
Open Square butt joint	• used to join up to 3 mm thick	
V butt joint	• May be from one side (single V) or from both sides (double V) depending on the plate thickness	

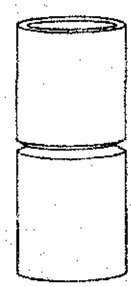
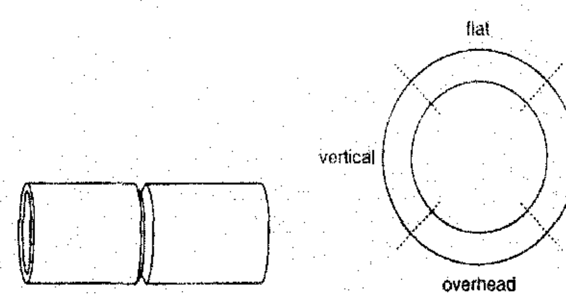
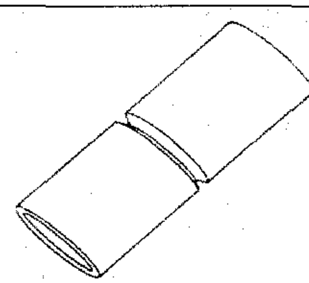
2.7 Position of welding

Table 2.7: Welding Position

Types	Features	Figures
Flat position	• done from above the joint while its axis is approximately horizontal	
Horizontal position	• done from the side (or in front) of the joint while its axis is approximately horizontal	
Vertical position	• done from the side or the front of the joint, while its axis is approximately vertical	
Overhead position	• done from below the joint while its axis is approximately horizontal	

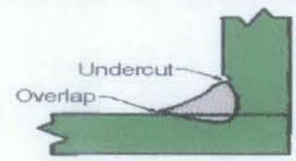
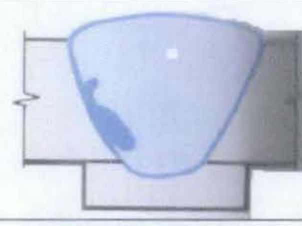
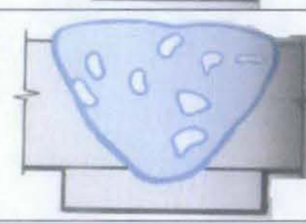
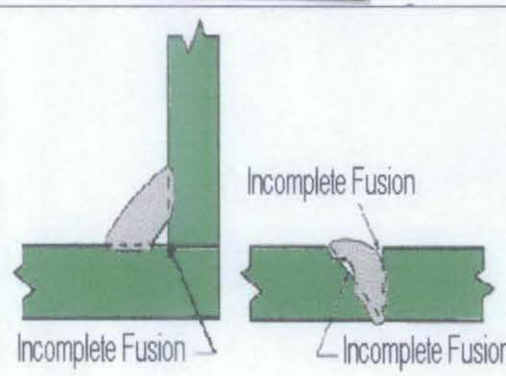
2.8 Pipe joint positions

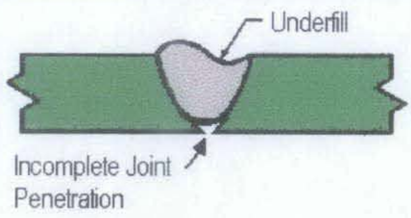
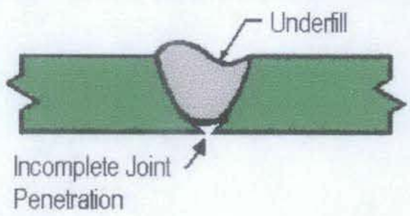
Table 2.8: Pipe Joint Position

Type	Feature	Figure
Horizontal Position	• pipe axis is vertical are the same as those in plate and are identified as a horizontal pipe join	
Fixed Position	• joint changes from overhead to vertical to flat, when the weld is started from underneath the joint	
Pipe axis inclined	• Differentiate d from ether pipe joints as it can present some difficulty to weld.	

2.9 Types Of Welding Defect

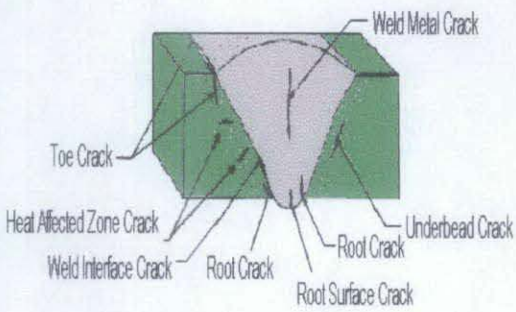
Table 2.9: Type of welding defects

Type	Reason of Occurrence	Figure
Undercut	• A groove melted into the base metal adjacent to the weld toe. • Weld root and left unfilled by weld metal.	
Overlap	• Protrusion of weld metal beyond the weld toe or weld root.	
Non metallic inclusion	• welding defect in the form of slag being trapped in the melt,	
Porosity	• caused by gases remaining entrapped in the melt	
Incomplete Fusion	• Weld discontinuity in which fusion did not occur between weld metal and fusion faces or adjoining weld beads.	

Underfill	• The weld face or root surface extends below the adjacent surface of the base metal.	
Incomplete Joint Penetration	• Fusion did not occur between weld metal and fusion faces or adjoining weld beads.	

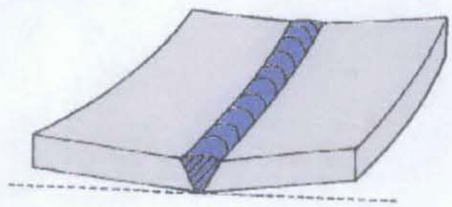
2.10 Welding Cracks

Table 2.10: Welding cracks

Type	Result of Occurrence	Figure
Cracks	• Localized stress which exceeds the ultimate strength of material. • Little deformation is apparent because the cracks relieve stress when they occur during or as the result of welding.	

2.11 Welding Distortion

Table 2.11: Welding Distortion

Type	Reason of Occurrence	Figure
Distortion	• Stress that remain after the welded members have cooled to normal temperature • Amount of restraint • Welding procedure • Parent metal properties • Weld joint design • Part fit up	

CHAPTER 3

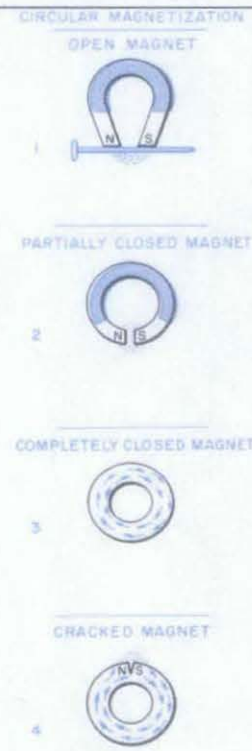
3 METHODOLOGY

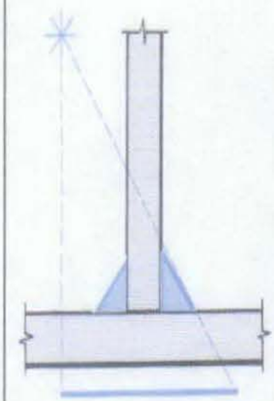
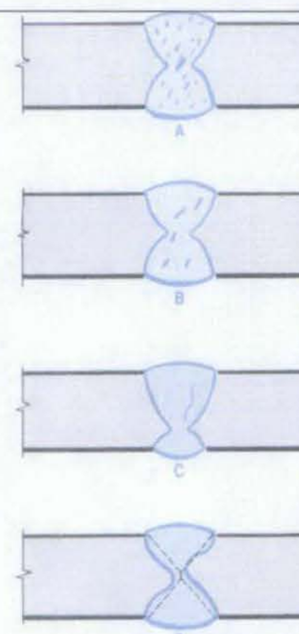
3.1 Literature Review

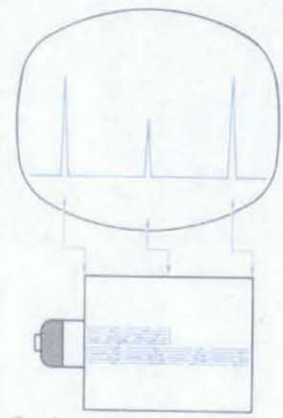
The literature research on background and theory of welding inspection were conducted throughout the project time frame. Handbooks, journals, books and web sites are important sources of information, where knowledge and findings needed to support the results of the project are available.

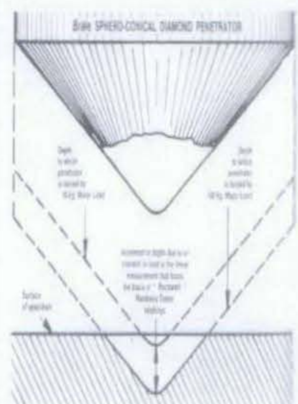
3.2 Non Destructive Testing

Table 3.1: Non destructive Test

Test	Features	Figure
Magnetic Particle Test	• Used to inspect plate edges before welding for surface imperfections. • Test weld for such defects as surface cracks, lack of fusion, porosity, undercut, poor root penetration and slag inclusion. • Use magnetic materials such as steels and cast iron. • The part to be examined must be smooth, clean, dry and free from oil and water. • The part is magnetized by using an electric current to set up a magnetic field within the material or by putting the piece in an electric coil.	

Penetrant Inspection	• Locating defect open to the surface. • Can be used on nonmagnetic materials such as stainless steel, aluminum and tungsten. • The surface to be inspected must be clean and free of grease, oil and other foreign materials. • The test part is sprayed with the dye penetrant which penetrates into the crack and other irregularities. • Evaporation of the liquid will leave the dry white powder which has a blotting paper action on the red dye left in the cracks. • Drawing out by the capillary action, the defects are marked clearly in red.	
Ultrasonic Inspection	• Ability to probe deeply without damaging the weldment. • Able to supply precise information without elaborate test setups. • Does by means of an electricity timed wave which is similar to a sound wave, but higher pitch and frequency. • Ultrasonic waves are passed through the material being tested and are reflected back by any density change.	

	• The waves are generated by a unit similar to a high fidelity amplifier, to which a search unit is attached.	
Eddy current Testing	• A coil that has been energized with alternating current at high frequency. • Is brought close to a conductive material. • Eddy current will be produced. • Any defect in the material distorts the magnetic field and is indicated on the recording instrument.	
Leak Test	• Made by means of pneumatic or hydraulic pressure. • Load is applied that is equal to or greater than that expected in service. • Water is usually used to test the leak. • Usually used to test the pressure vessels and pipelines. • Pressure is applied until the unit bursts.	
Hardness test	• Important to test the hardness of the weld deposit or the base metal in the area of the weld. • Most common test is Brinell, Rockwell, Vickers, and Scleroscope. • Brinell test consists of impressing a hardened steel ball into the metal to be tested at a given pressure for a predetermined time.	

	• Rockwell Test is similar to Brinell system but it doffers in that the readings can be obtained from the dial. • Vickers test consists of impressing a diamond penetrator into the surface of a specimen under predetermined load. • Shore Scleroscope is a portable machine which consists of a vertical glass tube in which a small cylinder with a diamond point slides freely. • The distance which it rebounds, measured on a scale on the glass.	 **Rockwell Tester**  Sphero-conical Diamond Penetrator

3.3 Destructive Test

Table 3.2: Destructive Test

Test	Features	Figures
Groove Welds Test	• Reduced-section tension test. • Determined Tensile strength. • Free Bend Test: determines ductility, used for procedure qualification. • Root-bend Test: determines soundness; used widely for operator qualification; also used for procedure qualification. • Face-bend test: determines soundness; used widely for operator qualification. • Side-Bend test: determines soundness; used widely for operator qualifications • Nick-Break Test: determines soundness.	

3.4 Reference used for Commercial Pipe Sizes and Wall Thickness

Table 3.3: Reference used for Commercial Pipe Sizes and Wall Thickness

The following table lists the pipe sizes and wall thicknesses currently established as standard, or specifically:

1. The traditional standard weight, extra strong, and double extra strong pipe.
2. The pipe wall thickness schedules listed in American Standard B36.10, which are applicable to carbon steel and alloys *other than* stainless steels.
3. The pipe wall thickness schedules listed in American Standard B36.19, and ASTM Specification A409, which are applicable *only* to corrosion resistant materials. (NOTE: Schedule 10S is also available in carbon steel in sizes 12" and smaller.)

ASA-B36.10 and B36.19

Nominal pipe size	Outside diameter	Nominal wall thickness for															
		Schedule 5S*	Schedule 10S*	Schedule 10	Schedule 20	Schedule 30	Standard†	Schedule 40	Schedule 60	Extra strong‡	Schedule 80	Schedule 100	Schedule 120	Schedule 140	Schedule 160	XX Strong
⅛	0.405	—	0.049	—	—	—	*0.068*	0.068	—	*0.095*	0.095	—	—	—	—	—
¼	0.540	—	0.065	—	—	—	*0.088*	0.088	—	*0.119*	0.119	—	—	—	—	—
⅜	0.675	—	0.065	—	—	—	*0.091*	0.091	—	*0.126*	0.126	—	—	—	—	—
½	0.840	0.065	0.083	—	—	—	*0.109*	0.109	—	*0.147*	0.147	—	—	—	0.188	0.294
¾	1.050	0.065	0.083	—	—	—	*0.113*	0.113	—	*0.154*	0.154	—	—	—	0.219	0.308
1	1.315	0.065	0.109	—	—	—	*0.133*	0.133	—	*0.179*	0.179	—	—	—	0.250	0.358
1¼	1.660	0.065	0.109	—	—	—	*0.140*	0.140	—	*0.191*	0.191	—	—	—	0.250	0.382
1½	1.900	0.065	0.109	—	—	—	*0.145*	0.145	—	*0.200*	0.200	—	—	—	0.281	0.400
2	2.375	0.065	0.109	—	—	—	*0.154*	0.154	—	*0.218*	0.218	—	—	—	0.344	0.436
2½	2.875	0.083	0.120	—	—	—	*0.203*	0.203	—	*0.276*	0.276	—	—	—	0.375	0.552
3	3.5	0.083	0.120	—	—	—	*0.216*	0.216	—	*0.300*	0.300	—	—	—	0.438	0.600
3½	4.0	0.083	0.120	—	—	—	*0.226*	0.226	—	*0.318*	0.318	—	—	—	—	—
4	4.5	0.083	0.120	—	—	—	*0.237*	0.237	—	*0.337*	0.337	—	0.438	—	0.531	0.674
5	5.563	0.109	0.134	—	—	—	*0.258*	0.258	—	*0.375*	0.375	—	0.500	—	0.625	0.750
6	6.625	0.109	0.134	—	—	—	*0.280*	0.280	—	*0.432*	0.432	—	0.562	—	0.719	0.864
8	8.625	0.109	0.148	—	0.250	0.277	*0.322*	0.322	0.406	*0.500*	0.500	0.594	0.719	0.812	0.906	0.875
10	10.75	0.134	0.165	—	0.250	0.307	*0.365*	0.365	0.500	*0.500*	0.594	0.719	0.844	1.000	1.125	1.000
12	12.75	0.156	0.180	—	0.250	0.330	*0.375*	0.406	0.562	*0.500*	0.688	0.844	1.000	1.125	1.312	1.000
14 O.D.	14.0	0.156	0.188	0.250	0.312	0.375	0.375	0.438	0.594	0.500	0.750	0.938	1.094	1.250	1.406	—
16 O.D.	16.0	0.165	0.188	0.250	0.312	0.375	0.375	0.500	0.656	0.500	0.844	1.031	1.219	1.438	1.594	—
18 O.D.	18.0	0.165	0.188	0.250	0.312	0.438	0.375	0.562	0.750	0.500	0.938	1.156	1.375	1.562	1.781	—
20 O.D.	20.0	0.188	0.218	0.250	0.375	0.500	0.375	0.594	0.812	0.500	1.031	1.281	1.500	1.750	1.969	—
22 O.D.	22.0	0.188	0.218	0.250	0.375	0.500	0.375	—	0.875	0.500	1.125	1.375	1.625	1.875	2.125	—
24 O.D.	24.0	0.218	0.250	0.250	0.375	0.562	0.375	0.688	0.969	0.500	1.218	1.531	1.812	2.062	2.344	—
26 O.D.	26.0	—	—	0.312	0.500	—	0.375	—	—	0.500	—	—	—	—	—	—
28 O.D.	28.0	—	—	0.312	0.500	0.625	0.375	—	—	0.500	—	—	—	—	—	—
30 O.D.	30.0	0.250	0.312	0.312	0.500	0.625	0.375	—	—	0.500	—	—	—	—	—	—
32 O.D.	32.0	—	—	0.312	0.500	0.625	0.375	0.688	—	0.500	—	—	—	—	—	—
34 O.D.	34.0	—	—	0.312	0.500	0.625	0.375	0.688	—	0.500	—	—	—	—	—	—
36 O.D.	36.0	—	—	0.312	0.500	0.625	0.375	0.750	—	0.500	—	—	—	—	—	—
42 O.D.	42.0	—	—	—	—	—	0.375	—	—	0.500	—	—	—	—	—	—

American Standards Association

All dimensions are given in inches.

The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions. The actual thicknesses may be as much as 12.5% under the nominal thickness because of mill tolerance. Thicknesses shown in light face for Schedule 60 and heavier pipe are not currently supplied by the mills, unless a certain minimum tonnage is ordered.

*Schedules 5S and 10S are available in corrosion resistant materials and Schedule 10S is also available in carbon steel.

†Thicknesses shown in italics are available also in stainless steel, under the designation Schedule 40S.

‡Thicknesses shown in italics are available also in stainless steel, under the designation Schedule 80S.

3.5 Project Flow Chart

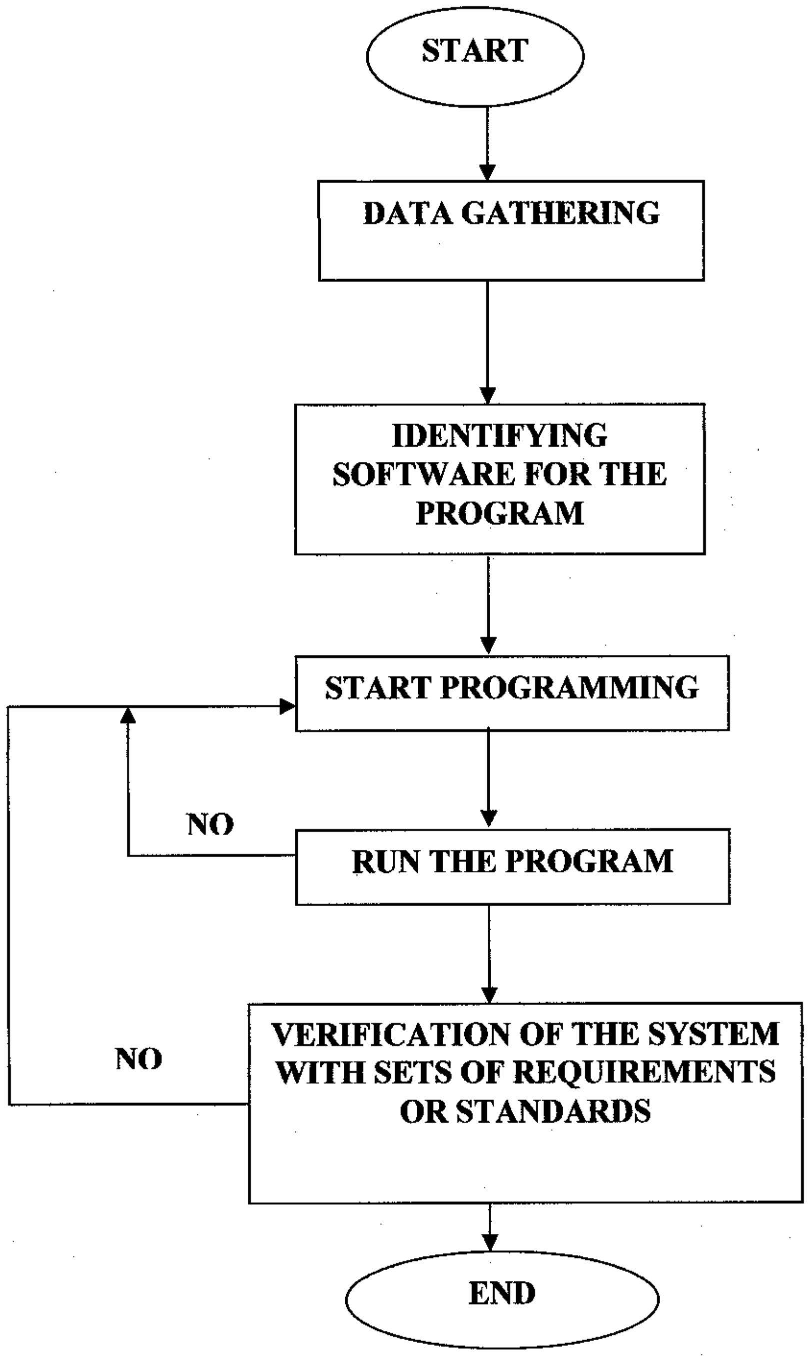


Figure 3.1: Project Flow Chart

CHAPTER 4

4 RESULTS AND DISCUSSION

4.1 Gathering and Arranging of Data According To Standards

After the gathering of the information, the data had been rearranged according to the two standards that are being studied. The data is being arranged to ease the process of creating or building a general database and other sub databases.

4.2 Program Layout

The program that had been generated was in a form order and had been named test report. In the test report, there were five main components for the insertion of data. The five components were insertion of report, test information, welder names, welding process and a column for the search program.

Table 4.1: Program layout

Part	Purpose
Insert Report	• The welding inspector could key in the report number, diameter, material, welders' identification number, result, coupon number and the remarks. • The remarks part was used to generate whether the standards were acceptable to the standard after the welding inspection.
Test Information	• The welding inspector could key in coupon number, test type, width, thickness and other welding specification

Welder information	• The welders' identification and the details would be keyed in. • This was for the ease of the welders to check for the welders' identification through the data that had been saved.
Welding Process	• The welding process and types of welding specifications could be inserted. • Apart from that, the trade name and brand name could also be inserted.
Search	• The welding inspector could search for the information within the criteria that had been determined in the first place. • ISO Standard for the thickness and the diameter could also be displayed in this part.

4.3 Program Function

4.3.1 Test Report

This test report is for the welding inspector to insert the material information regarding the test that had been carried out. Below is the interface for the test report.

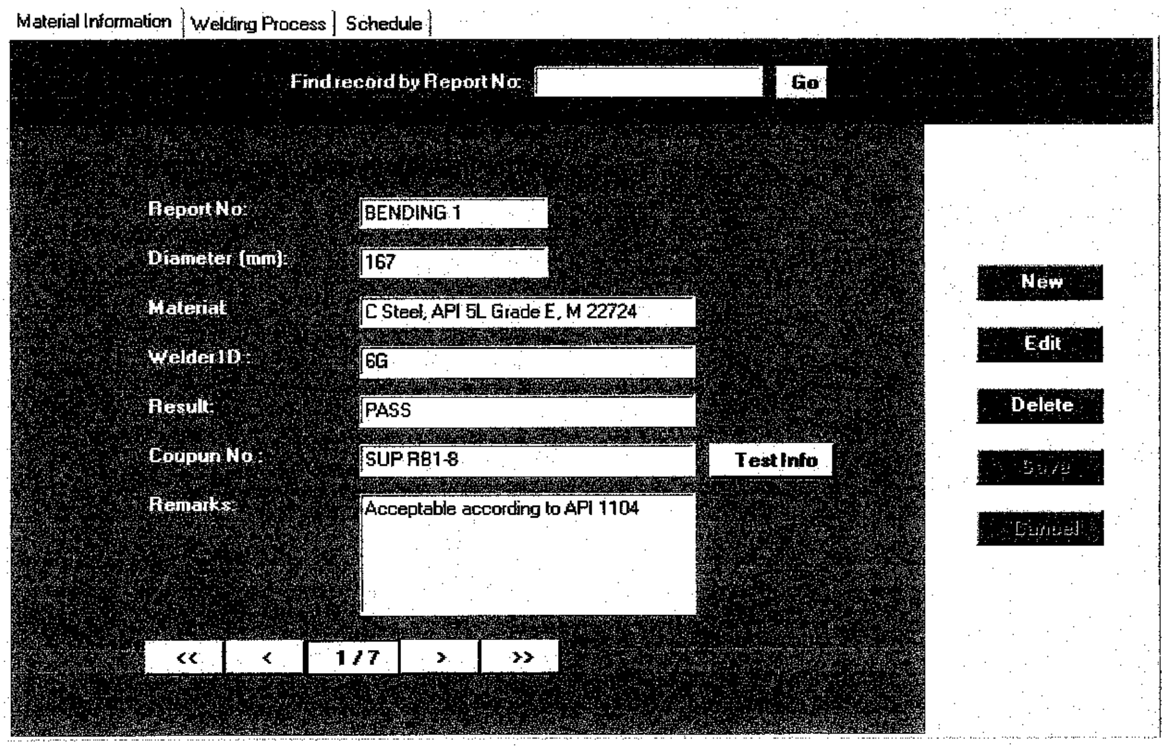


Figure 4.1: Test report

The test report consists of seven major components which are the report number, diameter, material, welder identification, result, coupon number and remark. The welding inspector can key in the data according to each of the column and save the data for reference.

4.3.2 Test Information

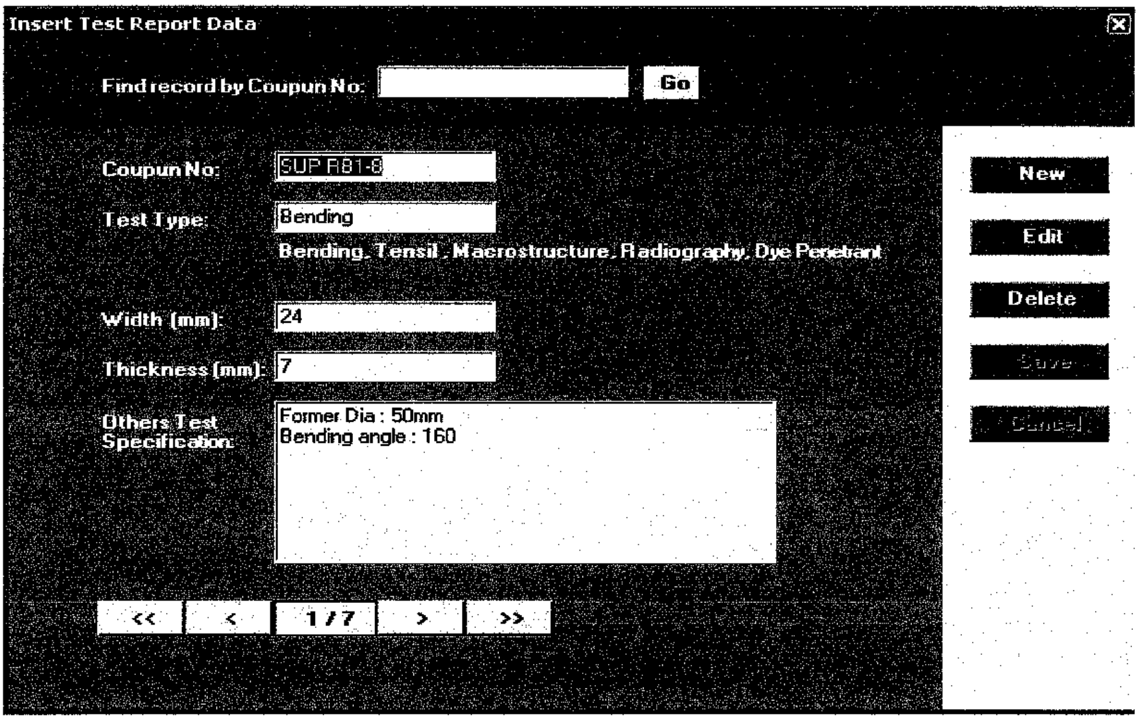


Figure 4.2: Test Information

The test information part consists of coupon number, test type, width, thickness and other test specification. The welding inspector can key in all the information that are needed after the welding inspector had done the welding inspection.

4.3.3 Welder Information

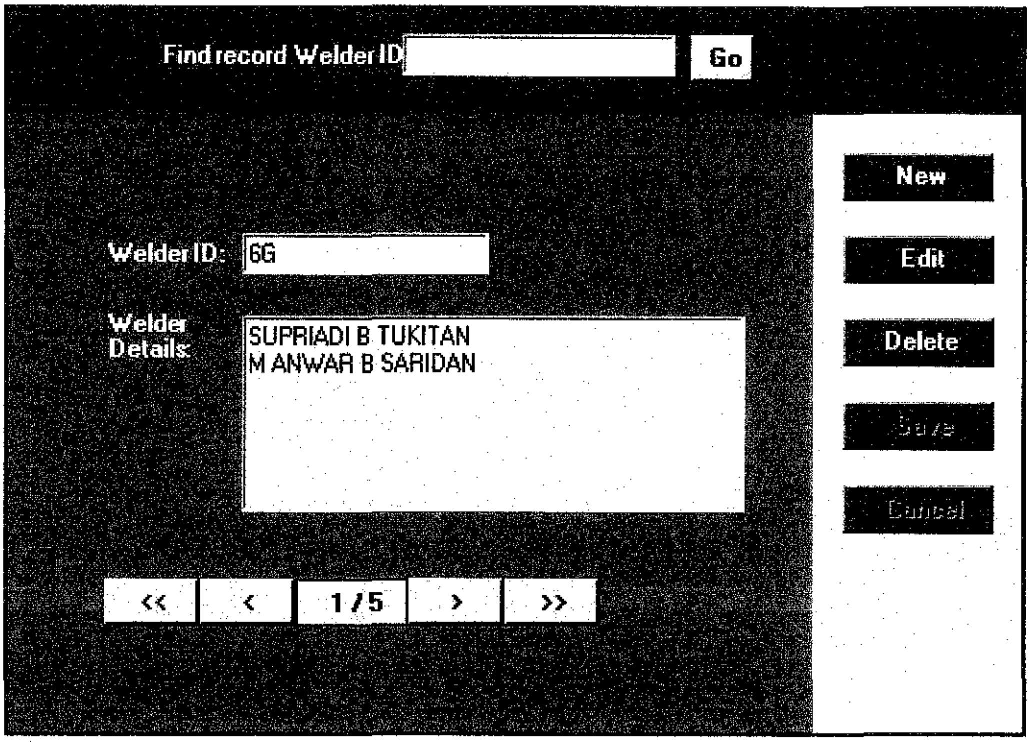


Figure 4.3: Welder Information

In the welder information part, welders' identification can be found after welder had keyed in the record. Welder identification can be seen after the inspector had keyed in the welder details.

4.3.4 Welding Process

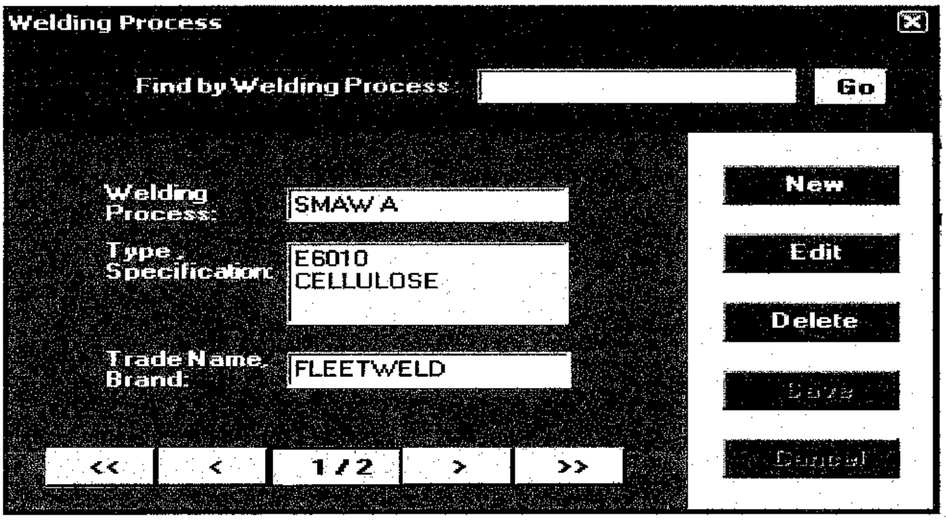


Figure 4.4: Welding Process

In this part, the welding process that is taken into consideration is the Shielded Metal Arc Welding. The welding inspector can key in the type or specification of the welding process. Apart from that, the trade name and brand can also be keyed into the program.

4.3.5 Search

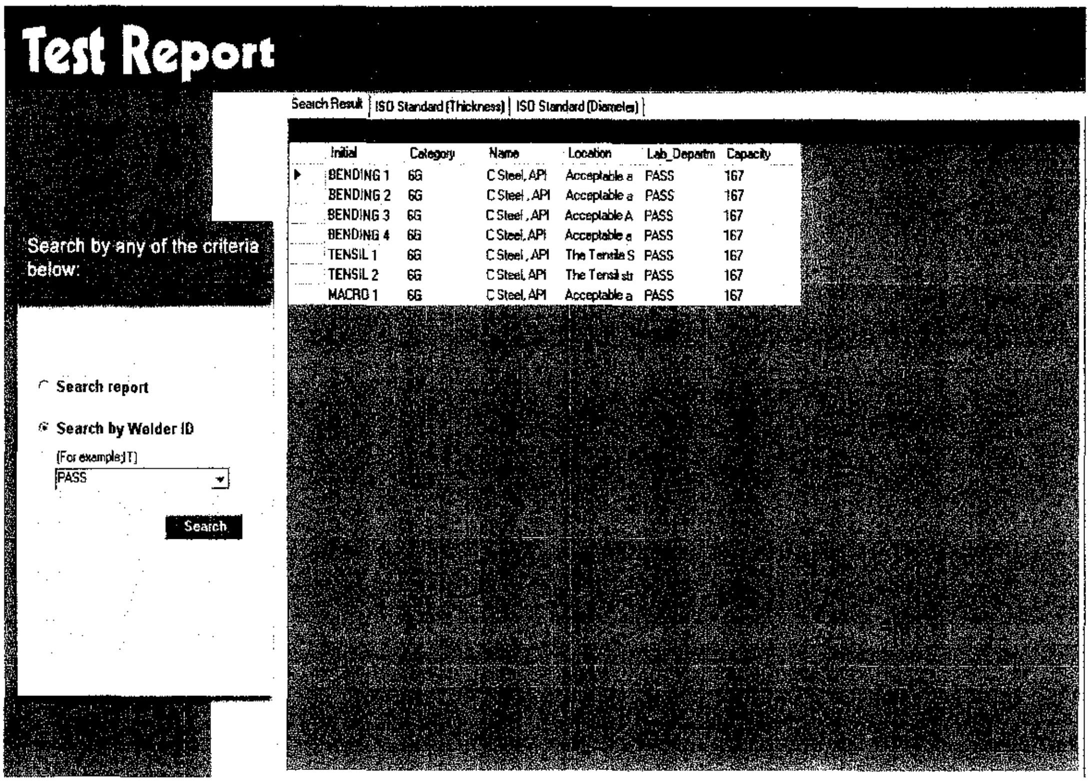


Figure 4.5: Search

The search part can be used to search for the information regarding the report and the welders' identification. ISO standards for the thickness and diameter can also be found in this page. The data can be stored and used for future reference.

4.4 Program layout for comparison

The second program that had been generated was the program for comparison of data to determine whether the data that had been keyed in was pass or fail. The two tests that had been generated were the Nick-break test and the Root bend test.

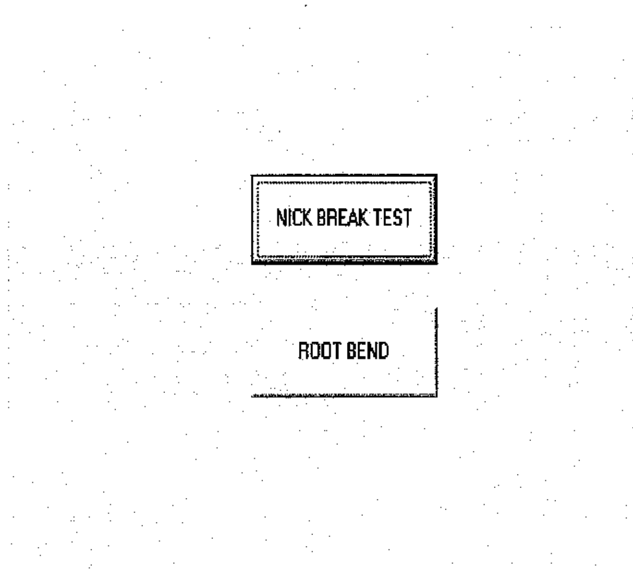


Figure 4.6: Program function for Nick-break test and Root Bend test

In this layout, two tests can be selected in order to determine whether the tests are passed or not. The two tests are Nick-break test and the Root Bend test. The welding inspector can click on the program to choose the test that is required in order to check for the information.

4.5 Nick-Break Test

The first test that had been chosen was the Nick-Break test. There are three conditions that had been taken into consideration which are the diameter of the gas pocket, slag inclusion and weld metal.

The other icons that can be keyed in data on the layout are the value and the remark. The result part had been set to the program. So when the welding inspector keyed in the data, the program will generate whether the inspection result is pass or fail.

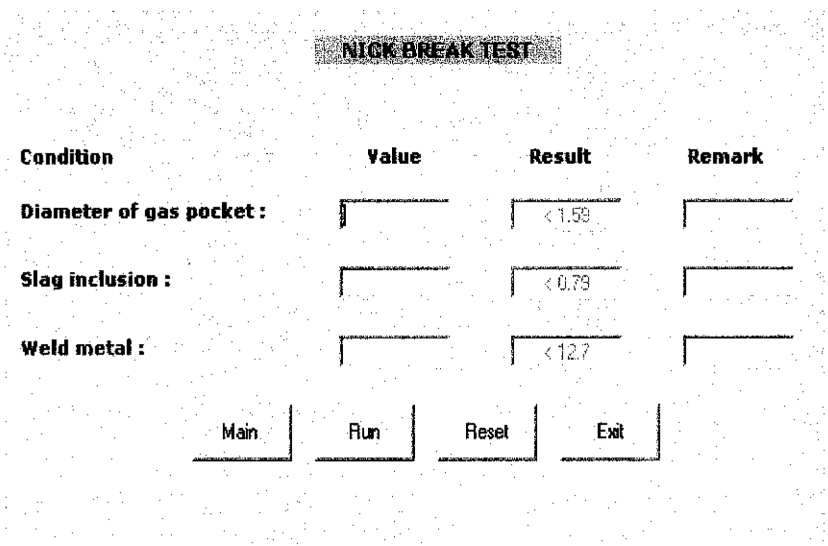


Figure 4.7: Nick Break test program function

4.6 Sample Program

Program for the Nick-Break Test and Root Bend Test had been run in order to generate the remark for the tests inspection. Below are the program samples for the two tests.

4.6.1 Nick-Break Test Program

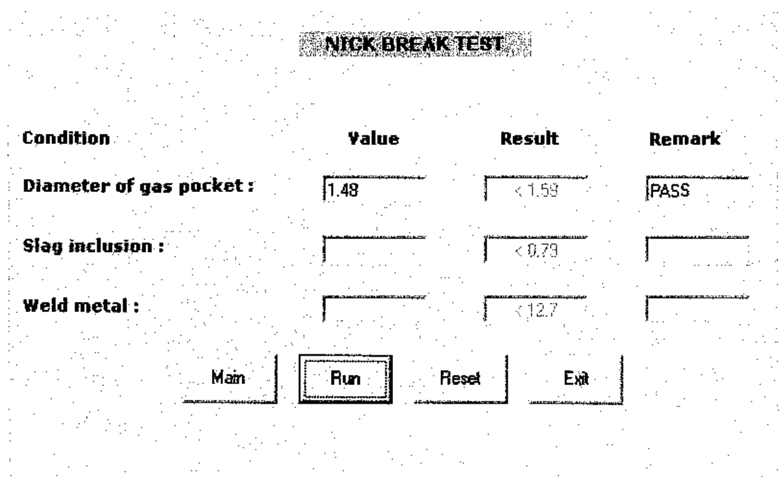


Figure 4.8: Pass Result for inspection of diameter of gas pocket for Nick-Break test

The first data that had been keyed in was to check for the diameter of gas pocket. The value that had been keyed in was 1.48 mm. The requirement for the diameter of the Nick-Break test is acceptable if the diameter is equal to or less than 1.59 mm.

The remark is passed because 1.48 mm is within the requirement of the Nick-Break test.

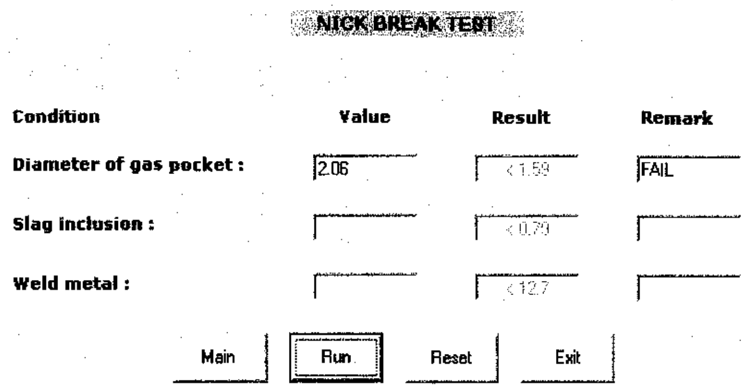


Figure 4.9: Fail result for inspection of diameter of gas pocket for Nick-Break test

The second data that had been keyed in to generate the result for the diameter of the gas pocket for Nick-Break test was 2.06 mm. The remark showed that the data had failed. This is because it had exceeded the requirements for the diameter, which was 1.59 mm.

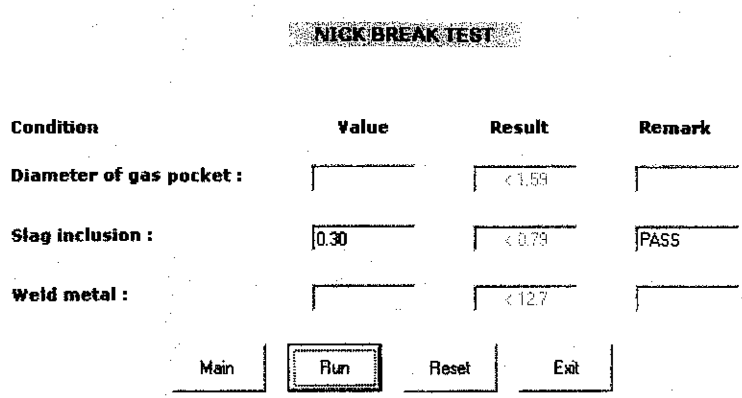


Figure 4.10: Pass Result for inspection of slag inclusion for Nick-Break test

The third data that had been keyed in to generate the result for the slag inclusion for Nick-Break test was 0.30 mm. The remark showed that the data had passed. This is because the requirement for the slag inclusion is equal to or less than 0.79 mm.

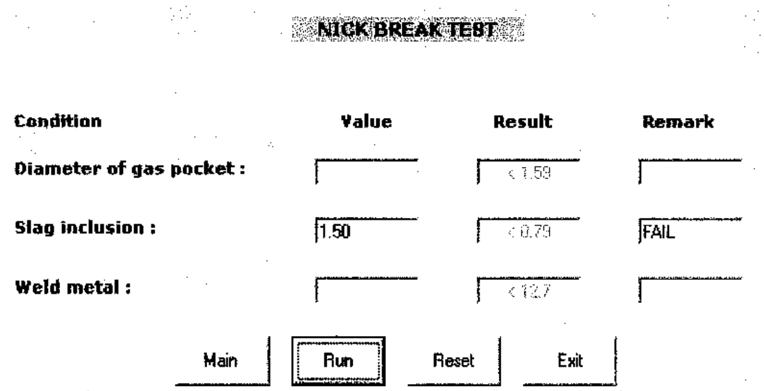


Figure 4.11: Fail Result for inspection of slag inclusion for Nick-Break test

The fourth data that had been keyed in to generate the result for slag inclusion for Nick-Break test was 1.50 mm. The remark showed that the data had failed. This is because it had exceeded the requirements for the slag inclusion, which was equal to or less than 0.79 mm.

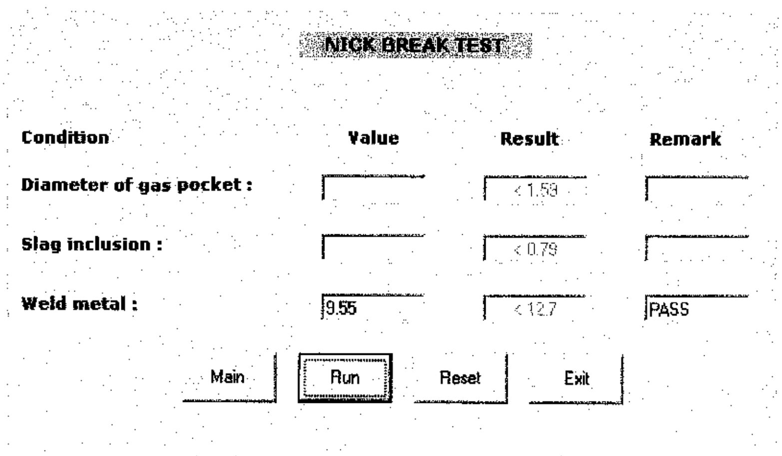


Figure 4.12: Pass Result for inspection of weld metal for Nick-Break test

The fifth data that had been keyed in to generate the result for the weld metal for Nick-Break test was 9.55 mm. The remark showed that the data had passed. This is because the requirement for the slag inclusion is equal to or less than 12.7 mm

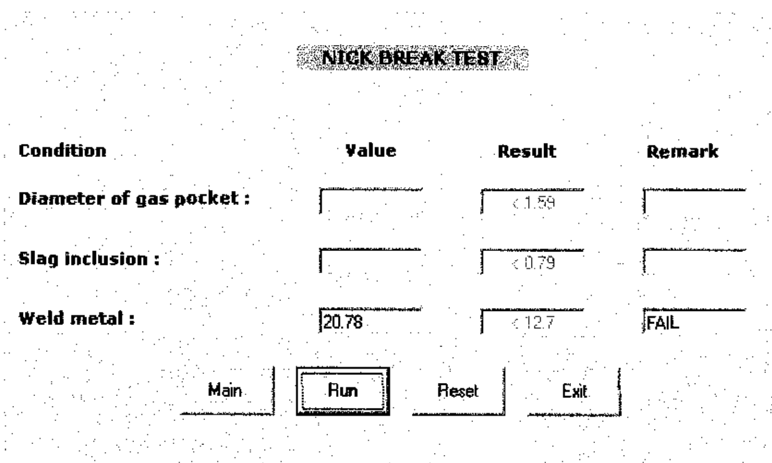


Figure 4.13: Fail Result for inspection of weld metal for Nick-Break test

The sixth data that had been keyed in to generate the result for weld metal for Nick-Break test was 20.78 mm. The remark showed that the data had failed. This is because it had exceeded the requirements for the weld metal, which was equal to or less than 12.7 mm.

4.6.2 Root Bend Test Program

The second test that had been chosen was the Root Bend test. There are two conditions that had been taken into consideration which are the defect and crack size of the specimen.

The other icons that can be keyed in data on the layout are the value and the remark. The result part had been set to the program. So when the welding inspector keyed in the data, the program will generate whether the inspection result is pass or fail.

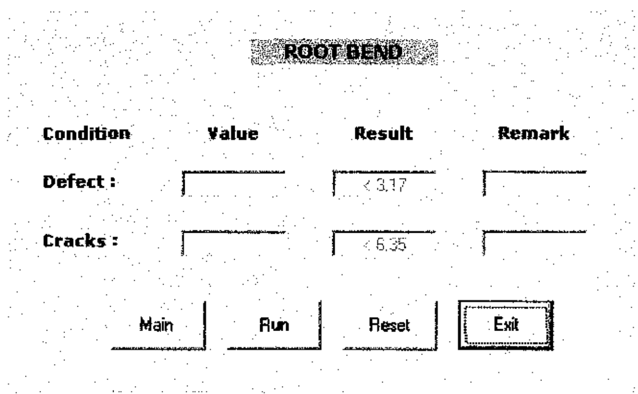


Figure 4.14: Root bend test program function

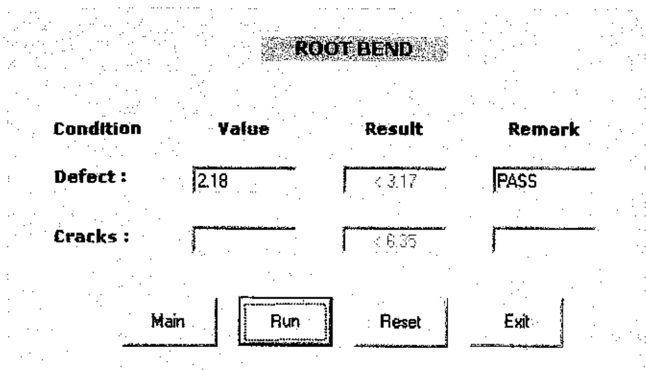


Figure 4.15: Pass Result for inspection of defect for Root Bend test

The seventh data that had been keyed in to generate the result for the defect for Root Bend test was 2.18mm. The remark showed that the data had passed. This is because the requirement for the slag inclusion is equal to or less than 3.17 mm.

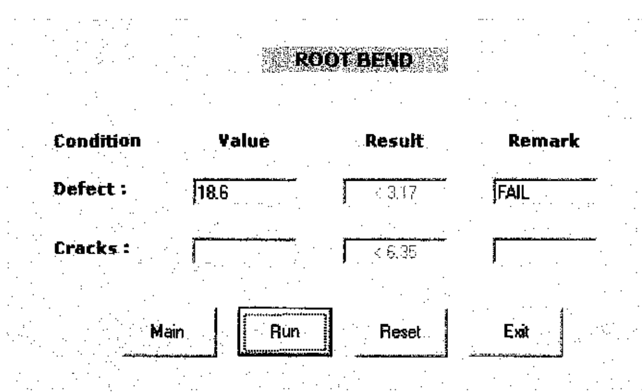


Figure 4.16: Fail Result for inspection of defect for Root Bend test

The eight data that had been keyed in to generate the result for defect for Root Bend test was 18.6 mm. The remark showed that the data had failed. This is because it had exceeded the requirements for the defect, which was equal to or less than 3.17 mm.

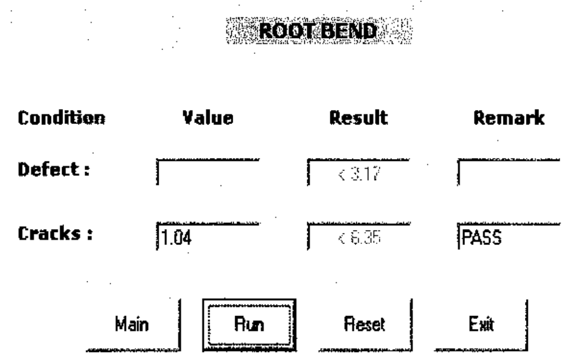


Figure 4.17: Pass Result for inspection of cracks for Root Bend test

The ninth data that had been keyed in to generate the result for the cracks for Root Bend test was 1.04 mm. The remark showed that the data had passed. This is because the requirement for the slag inclusion is equal to or less than 6.35 mm.

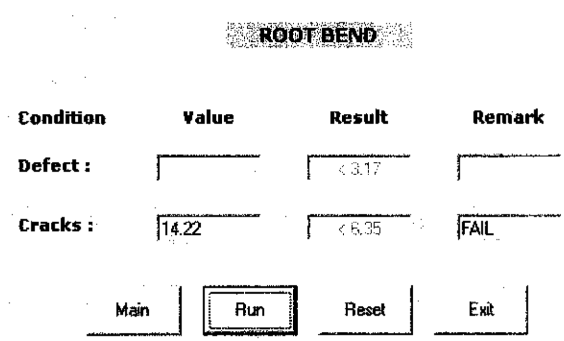


Figure 4.18: Fail Result for inspection of cracks for Root Bend test

The tenth data that had been keyed in to generate the result for cracks for Root Bend test was 14.22 mm. The remark showed that the data had failed. This is because it had exceeded the requirements for the defect, which was equal to or less than 6.35 mm.

CHAPTER 5

5 CONCLUSIONS AND RECOMMENDATION

At the point of the final dissertation, the project has been progressing according to the scheduled project schedule. All the activities have been carried out as plan. Few changes had been made in the last moment regarding the programming part and the dissertation.

Other activities, such as the literature reviews, and Visual Basic Programming were carried out. There were a few programs regarding the programming part. This was because it was not easy for the engineering student to do the coding of the programming. Few modifications had been made in the Visual Basic Programming in order to get the desired result of the project.

The main objective of the project was to generate report format for welding inspection. The project was recommended to be implemented in the company or organization to ease the generation of report format for welding inspection.

The project was recommended for further modification. It was recommended that the Visual Basic Programming could be linked together with other programming such as the Excel Programming in order to generate the format report.

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APPENDIX 1

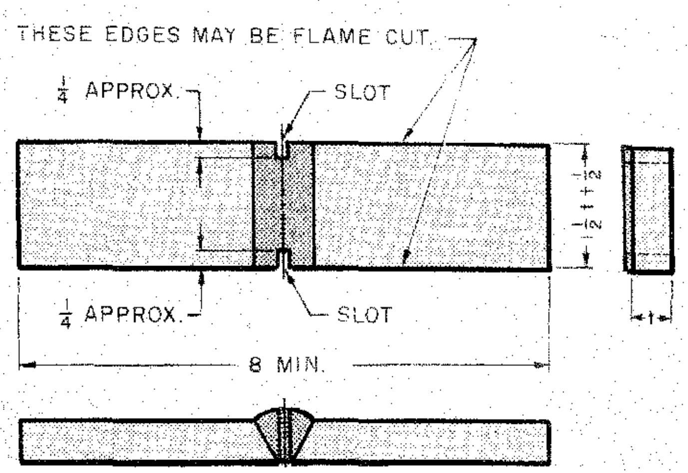

Figure 4.19: Nick Break Test specimen

APPENDIX 2

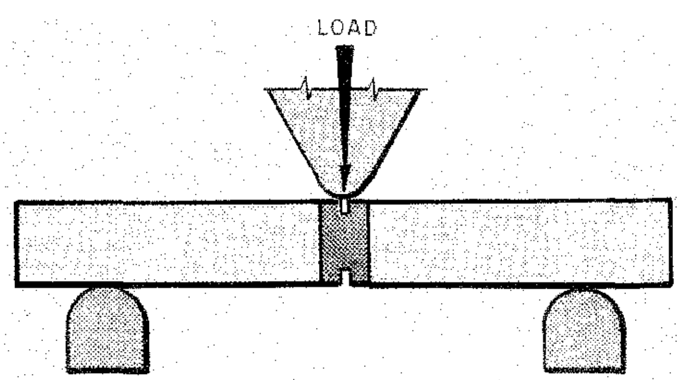

Figure 4.20: Nick Break Test specimen layout

APPENDIX 3

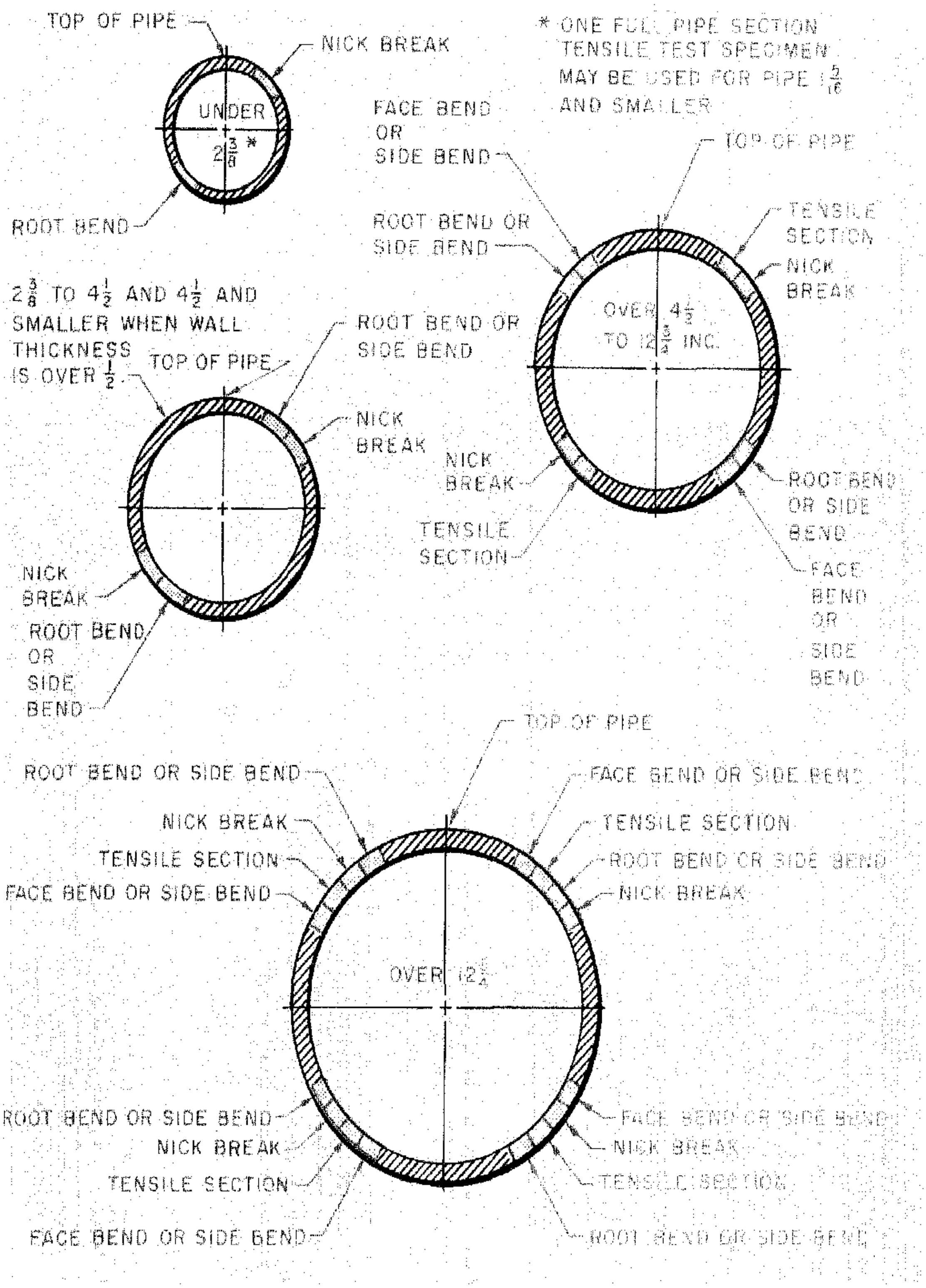

Figure 4.21: Test Section

APPENDIX 4

AMERICAN PETROLEUM INSTITUTION

The American Petroleum Institute (API) Standards Service includes manuals, training material, standards, specifications, recommended practices, bulletins and other publications. These documents address equipment and material, offshore production, drilling, transportation, structural pipe, nomenclature, valves, environmental effects, plus much more. The API Service is divided into these five sections with further sections available within the Measurement category:

- Exploration & Production
- Refining
- Transportation, Marketing and Safety
- Environmental and Safety
- Measurement
- Exploration & Production
- Marketing
- Pipeline
- Marine
- Refining
- Gas Processing Plants
- The API Collection includes the Technical Data books

Research Reports (Not part of complete service). The API Research Reports product includes exploration and production Research Reports relating to various petrochemical research projects sponsored by API.

ABOUT API

The oil and natural gas industry provides the fuel for life, warming our homes, powering our businesses and giving us the mobility to enjoy this great land. As the primary trade association of that industry, API represents more than 400 members involved in all aspects of the oil and natural gas industry. Our association draws on the experience and expertise of our members and staff to support a strong and viable oil and natural gas industry.

Today, API maintains more than 500 standards and recommended practices covering all segments of the oil and gas industry to promote the use of safe, interchangeable equipment and proven and sound engineering practices.

American Petroleum Institute

Australian Institute of Petroleum

Australian Petroleum Production and Exploration Association

AMERICAN PETROLEUM INSTITUTE

standards titles, document titles, document numbers, subject abstracts

API BULL E4

Environmental Guidance Document: Release Report for the Oil & Gas Exploration & Production Industry as Required by The Clean Water Act, The Comprehensive Environmental Response, Compensation & Liability Act, and The Emergency Planning & Community Right-To-Know Act

API COKE DRUM SURVEY

1996 Coke Drum Survey - Final Report

API MPMS 10.3

Sediment and Water - Standard Test Method for Water and Sediment in Crude Oil by the Centrifuge Method (Laboratory Procedure)

API MPMS 12.1.2

Calculation of Petroleum Quantities Section 1 - Calculation of Static Petroleum Quantities Part 2 - Calculation Procedures for Tank Cars

API MPMS 12.2 P2

Calculation of Petroleum Quantities Section 2 - Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors - Part 2 - Measurement Tickets

API MPMS 17.5

Management of Hazards Associated with Location of Process Plant Buildings

API MPMS 19.2

Evaporative Loss Measurement - Section 2 - Evaporative Loss from Floating-Roof Tanks

API MPMS 2.2D

Tank Calibration Section 2d - Calibration of Upright Cylindrical Tanks Using the Internal Electro optical Distance Ranging Method

API MPMS 4.2

Manual of Petroleum Measurement Standards Chapter 4: Proving Systems Section 2: Displacement Provers

API MPMS 5.7

Metering - Section 7 - Testing Protocol for Differential Pressure Flow Measurement Devices

API MPMS 9.2

Density Determination - Section 2 - Standard Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer

API OCCUPATIONAL INJURIES

Survey on Petroleum Industry Occupational Injuries, Illness, and Fatalities Summary Report: Aggregate Data Only

API PETROLEUM PIPELINES

API PUBL 4730 CD

Oil Spill Conference Proceedings

API RP 1004

Bottom Loading and Vapor Recovery for MC-306 & DOT-406 Tank Motor Vehicles

API RP 1109

Marking Liquid Petroleum Pipeline Facilities

API RP 13D

Recommended Practice on the Rheology and Hydraulics of Oil-Well Drilling Fluids

API RP 13L

Recommended Practice for Training and Qualification of Drilling Fluid Technologists

API RP 1639

Owner/Operators Guide to Operation and Maintenance of Vapor Recovery Systems at Gasoline Dispensing Facilities

API RP 2201

Safe Hot Tapping Practices in the Petroleum & Petrochemical Industries

API RP 2216

Ignition Risk of Hydrocarbon Liquids and Vapors by Hot Surfaces in the Open Air

API RP 2D

Operation and Maintenance of Offshore Cranes

API RP 44

Sampling Petroleum Reservoir Fluids

API RP 520 P2

Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries, Part 2: Installation

API RP 573

Inspection of Fired Boilers and Heaters

API RP 591
Process Valve Qualification Procedure

API RP 5A3
Recommended Practice on Thread Compounds for Casing, Tubing and Line Pipe

API RP 5C5
Recommended Practice on Procedures for Testing Casing and Tubing Connections

API RP 70
Security of Offshore Oil and Natural Gas Operations

API RP 752
Management of Hazards Associated with Location of Process Plant Buildings

API RP 85
Use Of Subsea Wet-Gas Flowmeters In Allocation Measurement Systems

API RP 945
Avoiding Environmental Cracking in Amine Units

API SECURITY
Vulnerability Assessment Methodology for the Petroleum and Petrochemical Industries

API SECURITY GUIDELINES
Security Guidelines for the Petroleum Industry

API SPEC 17E
Specification for Subsea Umbilicals

API SPEC 17F
Specification for Subsea Production Control Systems

API SPEC 7F
Oil-Field Chain and Sprockets

API SPEC 8C
Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)

API SPEC Q1
Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry

API STD 530
Calculation of Heater Tube Thickness in Petroleum Refineries

API STD 537
Flare Details for General Refinery and Petrochemical Service

API STD 610
Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries

API STD 612
Petroleum, Petrochemical and Natural Gas Industries – Steam Turbines - Special-Purpose Applications

API STD 613
Special-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services

API STD 660
Shell-and-Tube Heat Exchangers for General Refinery Services

API TR 17TR1
Evaluation Standard for Internal Pressure Sheath Polymers for High Temperature Flexible Pipes

API TR 17TR2
The Aging of PA-11 in Flexible Pipes

API TR 939-D
Stress Corrosion Cracking of Carbon Steel in Fuel Grade Ethanol: Review and Survey

APPENDIX 5

Non-destructive testing for ISO standard

- ISO/TTA 3, Polycrystalline materials -- Determination of residual stresses by neutron diffraction.
- ISO 1027, Radiographic image quality indicators for non-destructive testing -- Principles and identification.
- ISO 3057, Non-destructive testing -- Metallographic replica techniques of surface examination.
- ISO 3058, Non-destructive testing -- Aids to visual inspection -- Selection of low-power magnifiers.
- ISO 3059, Non-destructive testing -- Penetrant testing and magnetic particle testing - Viewing conditions.
- ISO 3452, Non-destructive testing -- Penetrant inspection --General principles.
- ISO 3452-2, Non-destructive testing -- Penetrant testing -- Part 2: Testing of penetrant materials.
- ISO 3452-3, Non-destructive testing -- Penetrant testing -- Part 3: Reference test blocks.
- ISO 3452-4, Non-destructive testing -- Penetrant testing -- Part 4: Equipment.
- ISO 3453, Non-destructive testing -- Liquid penetrant inspection -- Means of verification.
- ISO 3999, Apparatus for gamma radiography -- Specification.
- ISO 3999-1, Radiation protection -- Apparatus for industrial gamma radiography -- Part 1: Specifications for performance design and tests.
- ISO 5576, Non-destructive testing -- Industrial X-ray and gamma-ray radiology -- Vocabulary.
- ISO 5577, Non-destructive testing -- Ultrasonic inspection -- Vocabulary.
- ISO 5580, Non-destructive testing -- Industrial radiographic illuminators -- Minimum requirements.
- ISO 9712, Non-destructive testing -- Qualification and certification of personnel.

- ISO 9934-1, Non-destructive testing -- Magnetic particle testing -- Part 1: General principles.
- ISO 9934-3, Non-destructive testing -- Magnetic particle testing -- Part 3: Equipment.
- ISO 9935, Non-destructive testing -- Penetrant flaw detectors -- General technical requirements.
- ISO 10375, Non-destructive testing -- Ultrasonic inspection - - Characterization of search unit and sound field.
- ISO 11537, Non-destructive testing -- Thermal neutron radiographic testing -- General principles and basic rules.
- ISO 12706, Non-destructive testing -- Terminology - Terms used in penetrant testing.
- ISO 12710, Non-destructive testing -- Ultrasonic inspection --Evaluating electronic characteristics of ultrasonic test instruments.
- ISO 12713, Non-destructive testing -- Acoustic emission inspection -- Primary calibration of transducers.
- ISO 12714, Non-destructive testing -- Acoustic emission inspection -- Secondary calibration of acoustic emission sensors.
- ISO 12715, Ultrasonic non-destructive testing -- Reference blocks and test procedures for the characterization of contact search unit beam profiles.
- ISO 12716, Non-destructive testing -- Acoustic emission inspection -- Vocabulary.
- ISO 12721, Non-destructive testing -- Thermal neutron radiographic testing -- Determination of beam L/D ratio.
- ISO 15708-1, Non-destructive testing -- Radiation methods -- Computed tomography -- Part 1: Principles.
- ISO 15708-2, Non-destructive testing -- Radiation methods -- Computed tomography -- Part 2: Examination practices.

Radiographic films.

- ISO 11699-1, Non-destructive testing -- Industrial radiographic films -- Part 1: Classification of film systems for industrial radiography.
- ISO 11699-2, Non-destructive testing -- Industrial radiographic films -- Part 2: Control of film processing by means of reference values.

Non-destructive testing of metals.

- ISO 4986, Steel castings -- Magnetic particle inspection.
- ISO 4987, Steel castings -- Penetrant inspection.
- ISO 4993, Steel castings -- Radiographic inspection.
- ISO 5579, Non-destructive testing -- Radiographic examination of metallic materials by X- and gamma rays -- Basic rules.
- ISO 5948, Railway rolling stock material -- Ultrasonic acceptance testing.
- ISO 6933, Railway rolling stock material -- Magnetic particle acceptance testing.
- ISO 9302, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- electromagnetic testing for verification of hydraulic leak-tightness.
- ISO 9303, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- Full peripheral ultrasonic testing for the detection of longitudinal imperfections.
- ISO 9304, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- Eddy current testing for the detection of imperfections.
- ISO 9305, Seamless steel tubes for pressure purposes -- Full peripheral ultrasonic testing for the detection of transverse imperfections.
- ISO 9402, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of longitudinal imperfections.
- ISO 9598, Seamless steel tubes for pressure purposes -- Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of transverse imperfections.

- ISO 9915, Aluminium alloy castings -- Radiography testing.
- ISO 9916, Aluminium alloy and magnesium alloy castings -- Liquid penetrant inspection.
- ISO 10049, Aluminium alloy castings -- Visual method for assessing the porosity.
- ISO 10124, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- Ultrasonic testing for the detection of laminar imperfections.
- ISO 10332, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- Ultrasonic testing for the verification of hydraulic leak-tightness.
- ISO 10543, Seamless and hot-stretch-reduced welded steel tubes for pressure purposes -- Full peripheral ultrasonic thickness testing.
- ISO 11484, Steel tubes for pressure purposes -- Qualification and certification of non-destructive testing (NDT) personnel.
- ISO 11496, Seamless and welded steel tubes for pressure purposes -- Ultrasonic testing of tube ends for the detection of laminar imperfections.
- ISO 11971, Visual examination of surface quality of steel castings.
- ISO 12094, Welded steel tubes for pressure purposes -- Ultrasonic testing for the detection of laminar imperfections in strips/plates used in the manufacture of welded tubes.
- ISO 12095, Seamless and welded steel tubes for pressure purposes -- Liquid penetrant testing.
- ISO 13664, Seamless and welded steel tubes for pressure purposes -- Magnetic particle inspection of the tube ends for the detection of laminar imperfections.
- ISO 13665, Seamless and welded steel tubes for pressure purposes -- Magnetic particle inspection of the tube body for the detection of surface imperfections.

Welded joints and welds Including welding position and mechanical and non-destructive testing of welded joints.

- ISO 1106-1, Recommended practice for radiographic examination of fusion welded joints -- Part 1: Fusion welded butt joints in steel plates up to 50 mm thick.
- ISO 1106-2, Recommended practice for radiographic examination of fusion welded joints -- Part 2: Fusion welded butt joints in steel plates thicker than 50 mm and up to and including 200 mm in thickness.
- ISO 1106-3, Recommended practice for radiographic examination of fusion welded joints -- Part 3: Fusion welded circumferential joints in steel pipes of up to 50 mm wall thickness.
- ISO 2400, Welds in steel -- Reference block for the calibration of equipment for ultrasonic examination.
- ISO 2437, Recommended practice for the X-ray inspection of fusion welded butt joints for aluminium and its alloys and magnesium and its alloys 5 to 50 mm thick.
- ISO 2504, Radiography of welds and viewing conditions for films -- Utilization of recommended patterns of image quality indicators (I.Q.I.).
- ISO 5817, Arc-welded joints in steel -- Guidance on quality levels for imperfections.
- ISO 6520-1, Welding and allied processes -- Classification of geometric imperfections in metallic materials -- Part 1: Fusion welding.
- ISO 6520-2, Welding and allied processes -- Classification of geometric imperfections in metallic materials -- Part 2: Welding with pressure.
- ISO 7963, Welds in steel -- Calibration block No. 2 for ultrasonic examination of welds.
- ISO 9015-1, Destructive tests on welds in metallic materials -- Hardness testing -- Part 1: Hardness test on arc welded joints.

- ISO 9764, Electric resistance and induction welded steel tubes for pressure purposes -- Ultrasonic testing of the weld seam for the detection of longitudinal imperfections.
- ISO 9765, Submerged arc-welded steel tubes for pressure purposes -- Ultrasonic testing of the weld seam for the detection of longitudinal and/or transverse imperfections.
- ISO 10042, Arc-welded joints in aluminium and its weldable alloys --Guidance on quality levels for imperfections.
- ISO 12096, Submerged arc-welded steel tubes for pressure purposes -- Radiographic testing of the weld seam for the detection of imperfections.
- ISO 13663, Welded steel tubes for pressure purposes -- Ultrasonic testing of the area adjacent to the weld seam for the detection of laminar imperfections.
- ISO 13919-1, Welding -- Electron and laser-beam welded joints -- Guidance on quality levels for imperfections -- Part 1: Steel.
- ISO 13919-2, Welding -- Electron and laser beam welded joints -- Guidance on quality levels for imperfections -- Part 2: Aluminium and its weldable alloys.

APPENDIX 6

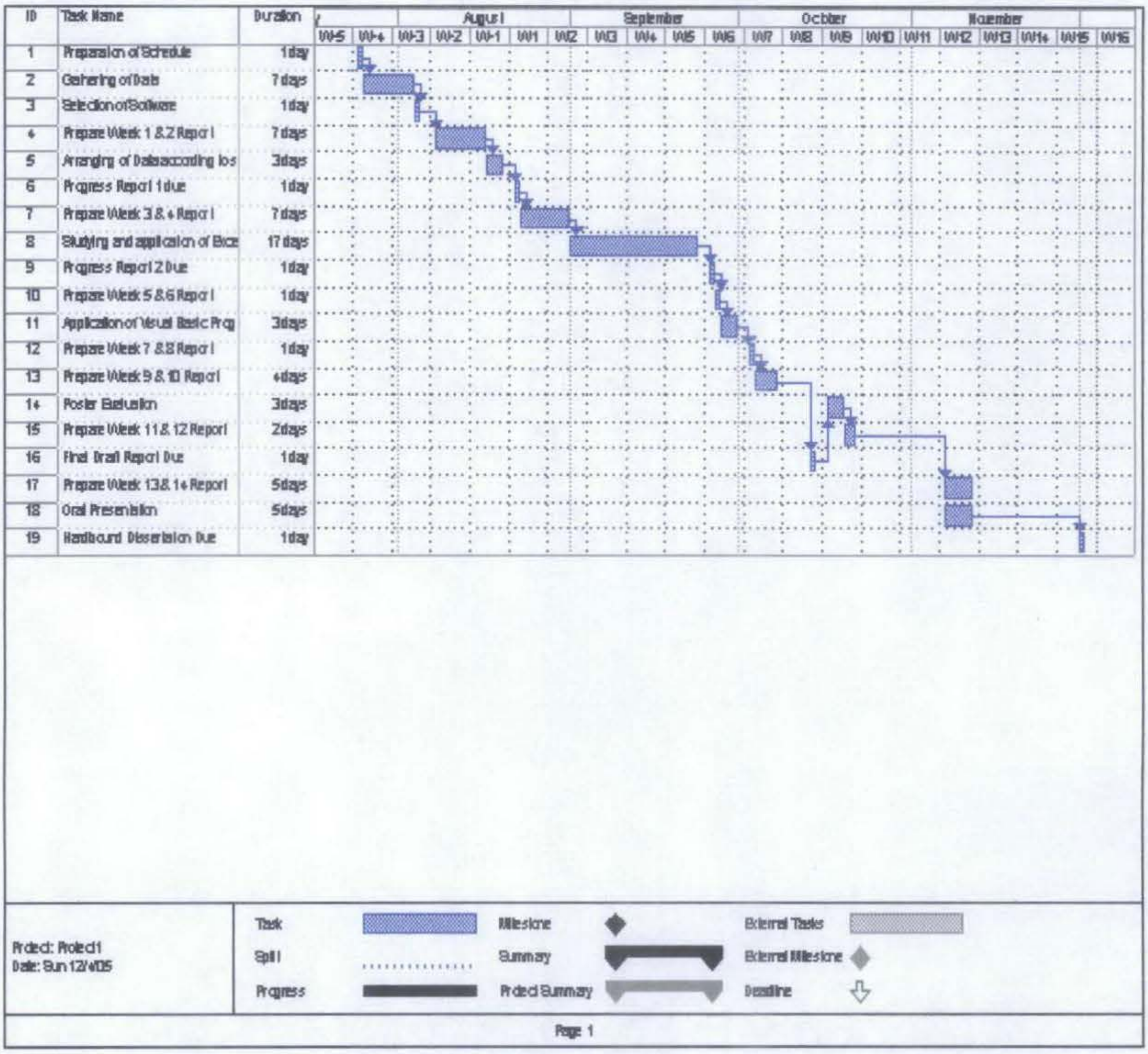

Figure 4.22: Gantt chart for project