



**KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN
MALAYSIA**

**A study the effectiveness of fitness
testing in pressure vessel fabrication
industry**

Thesis submitted in accordance with the requirements of the
National Technical University College of Malaysia for the Degree of
Bachelor of Manufacturing Engineering (Honors) (Manufacturing Process)

By

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Faculty of Manufacturing Engineering

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JUDUL: A STUDY THE EFFECTIVENESS OF FITNESS TESTING IN PRESSURE VESSEL FABRICATION INDUSTRY

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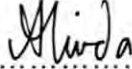
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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process). The members of the supervisory committee are as follows:

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ABSTRAK

Bekas dan tangki yang membawa, menyimpan ataupun yang menerima bendalir dipanggil bekas tekanan (pressure vessel). Bekas tekanan (pressure vessel) ini direka untuk beroperasi pada tekanan yang lebih tinggi (biasanya di atas 15 psig = 103.4214 kPa). Ini bermakna tekanan di dalam bekas tekanan (pressure vessel) lebih tinggi daripada tekanan di luar bekas tekanan. Bekas tekanan (pressure vessel) ini selalunya mengandungi tekanan dan suhu yang tinggi di dalamnya. Oleh kerana keadaan tekanan dan suhu yang tinggi di dalam bekas ini, kita seharusnya sentiasa beringat bahawa sekiranya bekas tekanan ini pecah, ianya boleh menyebabkan kecederaan fizikal yang teruk dan kerosakan harta benda. Pengujian bekas tekanan ini adalah penting untuk mengelakkan kecederaan dan kerosakan kerana pengujian ini dapat mengesan kecacatan yang wujud semasa proses pembuatan bekas tekanan (pressure vessel) ini.

Jenis-jenis pengujian yang selalu dijalankan di industri adalah Dye Penetrant Testing, Magnetic Particle Testing, Radiographic Testing, Ultrasonic Testing dan Visual Inspection. Penilaian keberkesanan pengujian ini diukur berdasarkan kekerapan penggunaannya di industri dan kesesuaiannya. Penilaian keberkesanan pengujian ini adalah berasaskan kepada data tentang Pemeriksaan dan Pengujian Pelan yang diperolehi daripada industri dan ini dapat ditunjukkan dengan mencatatkan kadar setiap jenis pemeriksaan dan direkodkan dalam bentuk jadual (rating table).

Dye Penetrant Testing dan Magnetic Particle Testing adalah jenis pengujian yang paling berkesan dan kerap digunakan di industri berbanding dengan pengujian yang lain. Ini

kerana dua jenis pengujian ini adalah jenis pengujian yang digunakan secara meluas dan dapat menguji sebarang jenis penyambungan dan kesesuaian pengujiannya terhadap sebarang jenis bahan yang mempunyai ketebalan yang berbeza. Kedua-dua jenis pengujian ini dijalankan pada suhu dan syarat yang normal tanpa memerlukan kepakaran juruteknik yang mempunyai sijil tahap II dan ke atas.

ABSTRACT

Vessels and tanks that carry, store or receive fluids are called pressure vessel. Pressure vessel has been designed to operate at pressures greater than normal (generally above 15 p.s.i.g). It means that the inside pressure of pressure vessel is higher than outside pressure of pressure vessel. Pressure vessel often has a combination of high pressures together with high temperature. It should be borne in mind that the rupture of a pressure vessel has a potential to cause extensive physical injury and property damage. Testing is an important factors to avoid injury or damage in pressure vessel because the testing can detect the defects that appear while fabrication process done.

The types of testing that always applied in industry are Dye Penetrant Testing, Magnetic Particle Testing, Radiographic Testing, Ultrasonic Testing and Visual Inspection. The effectiveness of these testing will be measured by its widely applied or used in industrial and its applicable. The evaluation of effectiveness these testing based on the data collection about Inspection and Test Plan that collected from industrial by showing it in rating table. Dye Penetrant Testing and Magnetic Particle Testing are most effectiveness testing that applied in industry rather than other inspection and testing because of their widely applied to test joining parts and their applicable to test any joints, any materials with different thickness. Both of these testing will be done at normal temperature and conditions without required Level II and above personnel technicians to do the testing.

DEDICATION

For my beloved father, mother and family

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May 2006

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

psig	-	pounds-force per square inch gauge
Pa	-	Pascal
F	-	Fahrenheit
PWHT	-	Postweld heat treatment
HAZ	-	Heat affected zone
H ₂ S	-	hydrogen sulfide
ASME	-	American Society of Mechanical Engineers
ft	-	feet
NDT	-	Nondestructive Testing
NDE	-	Nondestructive Examination
AC	-	Alternating current
DC	-	Direct current
H.W.D.C	-	Half Wave Direct Current
LCD	-	Liquid Crystal Display
CRT	-	Cathode ray tube
UT	-	Ultrasonic Testing
MT	-	Magnetic Particle Testing
RT	-	Radiographic Testing
PT	-	Penetrant Testing
VT	-	Visual Testing
PMI	-	Positive Material Identification
CSWIP	-	Certification Scheme for Welding Inspection Personnel
ACCP	-	ASNT Central Certification Program
PCN	-	Personnel Certification in Nondestructive Testing
ASNT	-	American Society for Nondestructive Testing

CHAPTER I

INTRODUCTION

1.1 Background of topic

Pressure vessel is a main component to hold and store metals, hydrocarbon, liquid, gases and miscellaneous solids. It has been designed to operate at pressure greater than normal (generally above 15 p.s.i.g = 103.4214 kPa). Most of the pressure vessel hold and store the hazardous chemical so that it is important to make sure that the pressure vessel is safe for continued use after fabricate and weld the pressure vessel.

According to the topic of a study the effectiveness of fitness testing in pressure vessel fabrication industry, the main point is to know the effectiveness of these testing. There have five common inspections and testing that applied in industry to inspect the quality of welded when joint two part. The testing consists of X-ray Radiographic Testing and Gamma-ray Radiographic Testing, Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing and Ultrasonic Testing. Entire of testing is important to check whether the welding area that joint two parts have defects or not.

The important factors to decide which testing more effectiveness that applied in industry is widely used and it applicable to test any type of material with any thickness. The criteria of effectiveness these testing are described in detail with comparison the theory and practical. Theories of these testing are summarized and analyzed by pressure vessel handbook and the actual practical analyzed by industrial application.

1.2 Objective

To study the effectiveness of fitness testing in pressure vessel fabrication industry.

1.3 Scope

The scopes of this project are:

1. Define the testing theory about pressure vessel construction. The theory consists of the effective of each testing to detect defects by their specific equipment, procedures and application.
2. Analyze the data of inspection and test plan of Kashagan Field Development Project, Kazakhtan that collected from KNM Process System Sdn Bhd at Bukit Rambai Free Trade Zone.
3. Determine the frequency use each testing that applied in industry by shows it in rating table. The evaluation of frequency testing that applied in industry based on the data from inspection and test plan of Kashagan Field Development Project, Kazakhtan that collected from KNM Process System Sdn Bhd at Bukit Rambai Free Trade Zone.

1.4 Methodology

Steps that applied when perform the project including:

1. Find out testing theory about pressure vessel construction by pressure vessel handbook and reference book.

2. Visit KNM Process System Sdn Bhd at Bukit Rambai Free Trade Zone to collect the data of inspection and test plan and implement two testing that are Dye Penetrant Inspection and Magnetic Particle Inspection. Both of these testing are done because it is more effective than other testing. The purpose of implementation the testing is to know how the effectiveness of these testing detected the defects and their frequency use in industry.
3. Evaluate the frequency use of testing by analyze the data from inspection and test plan of Kashagan Field Development Project, Kazakhtan that collected from KNM Process System Sdn Bhd at Bukit Rambai Free Trade Zone.
4. The analysis result of evaluation is shown in rating table and their effectiveness of these testing that applied in industry can be obtained.

CHAPTER II

LITERATURE REVIEW

2.1 What is pressure vessel

According to Carucci, V.A. (1999), pressure vessel means a vessel in which pressure is obtained from an external source, or by the application of heat from an indirect or direct source. It also means any receptacles that contain an expansible fluid under pressure. Pressure vessels are storage tanks or vessels that have been designed to operate at pressures greater than normal (generally above 15 p.s.i.g).

$$15 \text{ psig} = 15 \text{ lbf/in}^2 = 103.4214 \text{ kPa}$$
$$103.4214 \text{ kPa} = 1.0207 \text{ atm}$$

Pressure vessels are used to hold fluids such as fluids or gases that must be stored at relatively high pressures. Common materials held and maintained by pressure vessels include air, water, nitrogen, refrigerants (like Freon), and ammonia, propane, and reactor fuels. Due to their pressurizing capabilities, they are often used to store chemicals and elements that can change states (notably gases that have been liquidized). In most cases, the walls of pressure vessels are thicker than normal tanks providing greater protection when in use with hazardous or explosive chemicals.

Most pressure vessels have built-in temperature control characteristics (heating only, cooling only or both heating and cooling) in addition to pressurizing capabilities. This can help to keep volatile chemical (bhn kimia yg meruap) in relatively inert states, or when necessary, change the state of the material to prepare it for transportation or use in a connected system.

Pressure vessels with temperature controls have gauges to allow for reading of internal pressures and temperatures. These gauges are available with a variety of end connections, levels of accuracy, materials of construction, and pressure ranges. Pressure sources for pressure vessels are limited to the maximum allowable working pressure of the lowest rated system component. When sources cannot be limited, the use of pressure-relief devices is required. Common relief devices include a spring-loaded relief valves and rupture disc assemblies. Additional connections, such as audible alarms and computer regulation are often necessary in system where pressure relief is necessary, especially if the chemical being contained is hazardous in nature.

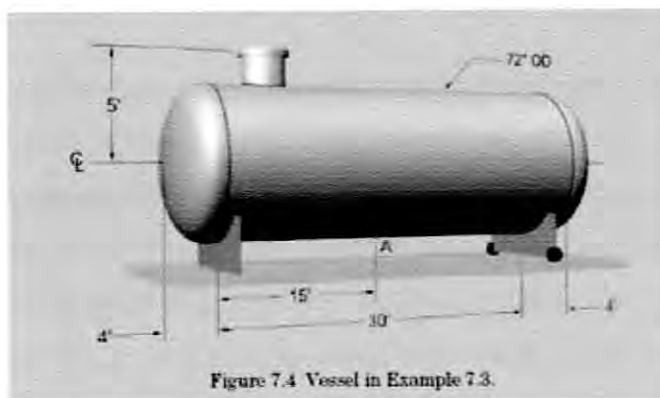


Figure 1: Figure of pressure vessel

2.2 Application of Pressure Vessel

Pressure vessel holds and storage the metals, liquids, hydrocarbons, gases and miscellaneous solids inside. Pressure vessel is used in variety of industries such as chemical, hydrocarbon processing, power, pharmaceutical and plastic processing, food, beverage, cosmetic, paper and pulp, power generation and oil or fuel. Pressure vessel as a stationary and unfired used as fired boilers. The pressure vessel that used for pressure processes containment of gases and liquids operate at high temperature normally above 315 degree C, 600 degree F or at low and cryogenic temperatures.

Most pressure vessel constructed of carbon transportable steel or low alloy steel which the vessel and containers used in systems. The pressure vessel that storage tanks that operate at nominally atmospheric pressure operated at temperature between 175 degrees and 315 degrees C (-100 and 600 degrees F). Pressure vessel is used for piping and pipelines or transfer equipment and for safety and pressure-relief valve. Special purpose of pressure vessel normally those for human occupancy. Specified application of pressure vessel will be discussed in detail as below.

Pressure vessel is used as deaeration. Deaeration refers to the removal of noncondensable gases, primarily oxygen, from the water used in a steam generation system. Deaerators are widely used in many industrial application including power generation, pulp and paper, chemical and petroleum refining and in many facilities such as hospital and schools where steam generation is required. In actual practice, the deaerator vessel can be separate from the storage vessel or combined with a storage vessel into one unit.

Pressure vessel is used in ammonia service. Commercial refrigeration systems, certain chemical processes, and formulators of agricultural chemicals will be sites of ammonia tanks. Careful inspections of vessels used for storage of ammonia (in either vapor or

liquid form) in recent years have resulted in evidence of serious stress corrosion cracking problems. The vessels for this service are usually constructed as spheres from one of the carbon steel grades, and they operate in the ambient temperature range. The water and oxygen content in the ammonia has a strong influence on the propensity of carbon steels to crack in this environment. Cracks have a tendency to be found to be in or near the welds in as-welded vessels. Cracks occur both transverse and parallel to the weld direction. Thermal stress relieving seems to be a mitigating procedure for new vessels, but its efficacy for older vessels after a period of operation is dubious partly because small, undetected cracks may be present.

The pressure vessel is used for wet hydrogen sulfide. Refer to The Hendrix Group (2005), wet Hydrogen Sulfide refers to any fluid containing water and hydrogen sulfide (H₂S). Hydrogen is generated when steel is exposed to this mixture and the hydrogen can enter into the steel. Dissolved hydrogen can cause cracking, blistering, and embrittlement. The harmful effects of hydrogen generating environments on steel have been known and recognized for a long time in the petroleum and petrochemical industries. In particular, sensitivity to damage by hydrogen increases with the hardness and strength of the steel and damage and cracking are more apt to occur in high strength steels.

Thermal stress relief (postweld heat treatment, PWHT) appears to reduce the sensitivity to and the severity of cracking. Wet hydrogen sulfide has also been found to cause service cracking in liquified petroleum gas (LPG) storage vessels. The service cracking in the LPG vessels occurs predominantly in the weld heat affected zone (HAZ). The vessels are usually spherical with wall thickness in the 20 mm to 75 mm (0.8 in to 3 in) range.

Pressure vessel is used in pulp digester service. According to The Hendrix Group (2005), the kraft pulping process is used in the pulp and paper industry to digest the pulp in the papermaking process. The operation is done in a relatively weak (a few percent) water solution of sodium hydroxide and sodium sulfide typically in the 110 degrees to

140 degrees C (230 degrees to 285 degrees F) temperature range. Since the early 1950s, a continuous version of this process has been widely used. Nearly all of the vessels are ASME Code vessels made using one of the carbon steel grades with typical design conditions of 175 degrees to 180 degrees C (350 degrees to 360 degrees F) and 150 psig.

These vessels had a very good service record with only isolated reports of cracking problems until the occurrence of a sudden rupture failure in 1980. The inspection survey has revealed that about 65% of the properly inspected vessels had some cracking. Some of the cracks were fabrication flaws revealed by the use of more sensitive inspection techniques but most of the cracking was service-induced. The inspection survey and analysis indicates the following features about the cracking.



Figure 2: Pressure vessel as Deaeration

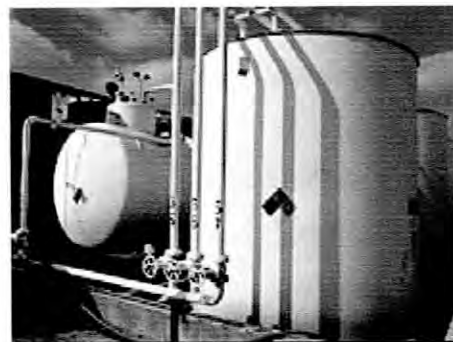


Figure 3: Pressure vessel with relief valve

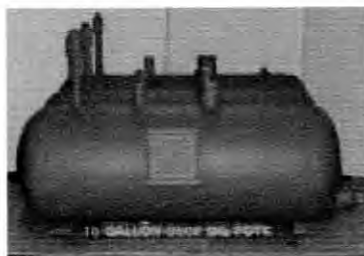


Figure 4: Pressure vessel with ammonia tank



Figure 5: Pressure vessel used to deliver via compressed air

Table 1: Most specified contain that storage in pressure vessel

Contains Type	Example
Metals	Aluminum, Antimony, Bismuth, Boron, Brass, Bronze, Cadmium, Cobalt, Gold, Iridium, Iron, Cast, Mercury, Nickel, Platinum, Silver, Tin, Steel, Sodium, Zinc, Vanadium, Steel, Mercury and so on.
Liquids	Alcohol, Benzine, Cotton-seed oil, Gasoline, Kerosine, Mineral oil, Palm oil, Olive oil, Whale oil, Rape oil, Water, Tar, Petroleum oil, Sulphuric acid, Linseed oil, Carbon disulphide, Ammonia and so on.
Hydrocarbons	Ethane, Propane, N-butane, Iso-butane, N-hexane, 2,2-dimethylbutane, Benzene, Toluene, Cyclopentane, N-octane, Methylcyclopentane and so on.
Gases	Air, Acetylene, Alcohol vapor, carbon dioxide, chlorine, ether vapor, Ethylene, Nitrogen, Oxygen, Sulphur dioxide, Mercury vapor, Illuminating gas, water vapor, Nitric oxide, Marsh gas, Nitrous oxide, Nitric oxide, Carbon monoxide, Carbon dioxide and so on.
Miscellaneous solids	Asbestos, Asphaltum, Borax, Brick, Cement, Chalk, Mica, Mortar, Ice, Iron slag, Gypsum, Quartz, Concrete, Charcoal, Brickwork, in mortar, Glass, Emery, Earth, Coal, Marble, Slate, Phosphorus, Gypsum, Tile, Sand, Sulphur, Soapstone, Tar, bituminous, Masonry and so on.

2.3 Criteria of Pressure Vessel

There have many parts consideration in Pressure Vessel such as: