

## Vocational Education Implementation in Mechanical Integrity: SKID Tank Testing and Occupational Safety Standards

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### Abstract

This study assessed the operational feasibility of a horizontal cylindrical pressure vessel used for liquefied petroleum gas (LPG) storage at PT. XYZ in Yogyakarta. The evaluation included data collection, visual inspection, thickness measurement, and the calculation of the Maximum Allowable Working Pressure (MAWP) following the ASME Section VIII Division I–UG–27 standard. Results indicated that the vessel's actual shell thickness of 14.8 mm exceeded the minimum required thickness of 14.66 mm, and the head thickness of 16.4 mm was above the required 14.57 mm, confirming structural adequacy. The calculated MAWP for the cylindrical shell was 1.78 MPa (18.14 kg/cm<sup>2</sup>) and 1.99 MPa (20.29 kg/cm<sup>2</sup>) for the ellipsoidal head—both higher than the design pressure of 1.765 MPa (18 kg/cm<sup>2</sup>). Additionally, hydrostatic testing at 23.40 Kg/cm<sup>2</sup> (about 30% above the design pressure) showed no leakage or deformation, validating the vessel's mechanical integrity. Additionally, the unit complied with Occupational Safety and Health (OHS) dan pressure vessel design regulations, ensuring its safety for continued use. This research underscores the importance of vocational education in technical engineering, particularly in pressure vessel testing and adherence to safety standards. By integrating comprehensive training, professionals are better equipped to ensure the structural integrity and safe operation of pressure vessels in industrial settings. The study provides essential insights into maintaining safety and operational efficiency in pressure vessel applications.

**Keywords:** LPG Storage, Operational Feasibility, Safety Compliance, Technical Engineering, Vocational Engineering.

### 1. Introduction

This manuscript presents an evaluation of the operational feasibility of a horizontal cylindrical pressure vessel used for LPG storage at PT. XYZ in Yogyakarta. The examination is crucial for ensuring the operational safety of the vessel and its compliance with established standards, particularly ASME Section VIII Division 1–UG–27. Pressure vessels are essential in many industrial applications, especially in the transport and storage of gases such as LPG. Ensuring that these vessels remain structurally sound and capable of withstanding operational pressures is key to maintaining both safety and efficiency [1].

The focus of this research aligns with the broader scope of vocational education in technical engineering, specifically regarding the implementation of pressure vessel testing and occupational safety standards [2]. In the context of vocational education, students in technical engineering programs must be trained to apply theoretical knowledge in practical, real-world scenarios [3], [4]. This research is part of an ongoing effort to bridge the gap between industry standards and vocational training, ensuring that students are well-equipped to meet the challenges of industrial safety and mechanical integrity [5], [6].

This study specifically examines the pressure vessel through a series of evaluations, including data collection, visual inspections, and calculations to determine the minimum required thickness and Maximum Allowable Working Pressure (MAWP) [7]. These evaluations not only ensure the vessel's operational viability but also serve as a learning model for vocational students [8]. The ability to

understand and perform such tests is vital for future engineers and technicians, reinforcing the importance of hands-on learning in vocational programs [9].

Through this research, we aim to contribute to the improvement of vocational education by demonstrating the practical application of technical engineering skills in real-world industrial environments, specifically focusing on pressure vessel safety and compliance with occupational health standards [10], [11].

The manuscript is structured into four main chapters: Introduction, Methods, Results and Discussion, and Conclusion [12], [13]. The Introduction provides a comprehensive background on the study and its significance to both industry and vocational education [14]. The Methods section will describe the procedures used in data collection and analysis, which are directly applicable to vocational training practices [15]. The Results and Discussion chapter presents the findings and their implications for both the industry and educational settings. Lastly, the Conclusion summarizes the key outcomes and suggests areas for further research and development in the field of vocational education and mechanical engineering safety standards [16], [17].

The main focus of this research is to evaluate the structural integrity and operational safety of the horizontal cylindrical pressure vessel through quantitative analysis, including actual thickness measurement, comparison with the minimum required thickness, and determination of the Maximum Allowable Working Pressure (MAWP) based on ASME Section VIII Division I–UG–27. This focus ensures that the study not only verifies compliance with technical and safety standards but also provides a concrete foundation for understanding the vessel’s design life and reliability. By emphasizing these aspects, the research aligns its objectives with the central discussion, which integrates engineering analysis, safety assurance, and the role of vocational education in applying practical technical competencies [18], [19].

**2. Method**

This research was conducted in order to evaluate the operational feasibility of a horizontal cylindrical pressure vessel used for LPG storage at XYZ, located in Sleman, Yogyakarta. The examination was performed through a combination of data collection, visual inspection, dimensional analysis, and technical calculations in accordance with ASME Section VIII Division 1–UG–27.

**2.1 Research Methodology**

The research methodology applied in this study is divided into several key stages, as detailed below:

**2.1.1 Data Collection**

Data collection was carried out at PT. XYZ, starting from February 25, 2025, to March 5, 2025. The first step in data collection involved gathering general information about the pressure vessel, including its specifications and operational conditions (Table 1). This was followed by technical data collection, where measurements such as the thickness of the vessel’s body, diameter, and length were recorded (Table 2 and Figure 1). Additionally, visual inspections were conducted to identify signs of wear, such as cracks, corrosion, and deformation, on the components of the pressure vessel.

Table 1. General Data

Owner	: PT. XYZ
Adress	: Kemloko, Caturharjo, Sleman District, Sleman Regency, Spesial Region of Yogyakarta
User	: PT. XYZ
Operator name	: -
Type of vessel	: Horizontal cylindrical
Manufacturer	: PT. ABC
Brand/ type	: MECO
Year of manufacture	: 2009
Manufacturing serial No.	: LPT 150309-03

Maximum allowable working pressure	: 18 kg/cm <sup>2</sup>
Capacity	: 15000 Kg
Medium used	: Gas LPG
Operating temperature	: Ambient 55 °C
Applicable standards	: Ministry of manpower regulation No.37 of 2016, ASME section VIII division 1
Purpose of use	: Storing LPG gas
Location of inspection and testing	: PT. XYZ

**Table 2.** Engineering Data

Component	Size/Dimension/Type	
Shell/Body	Number of roundshell	3 (Three)
	Joining method	Welding
	Material	SA 516 Gr.70
	Inner diameter (ID)	2,275 mm
	Thickness	14.8 mm
	Body length	6,870 mm
	Reinforcement	
	Type	Ellipsoidal
	Quantity	-
	Size/dimension	-
Head	Head (Top)	
	Front/Top	
	Type/shape	Ellipsoidal
	Length (R)	-
	Curvature (f)	-
	Tilt	Head
	Diameter	2,275.4 mm
	Thickness	16.4 mm
	Material	SA 516 Gr.70
	Head (bottom)	
	Back/bottom	
	Type/shape	Ellipsoidal
	Length (R)	-
	Curvature (f)	-
	Tilt	-
	Diameter	2,275.4 mm
Thickness	16.4 mm	
Material	SA 516 Gr.70	
Pipes/Channel	Type/shape	-
	Diameter	-
	Thickness	-
	Length	-
	Quantity	-
Pipe Installation	Diameter	Welding
	Thickness	-
	Valve type	-
	Quantity	-

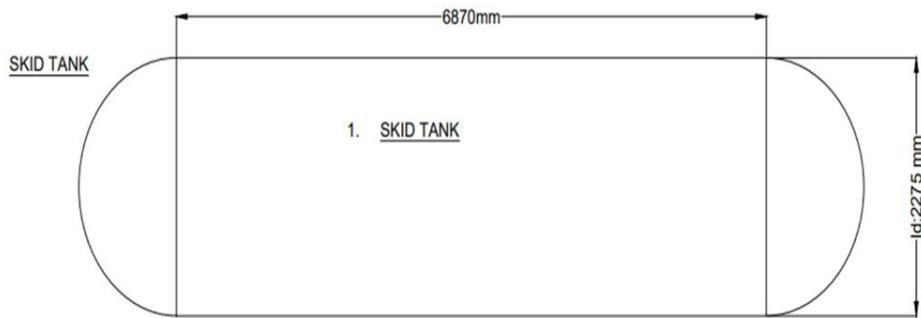


Figure 1. SKID Tank

### 2.1.2 Visual Inspection

A key part of the inspection process was the visual examination of the pressure vessel's components [18]. This step aimed to evaluate the physical condition of the vessel, including the shell, head, nozzles, and support structures [19]. The condition of the pressure vessel was categorized into "good" or "bad" based on the presence of damage such as cracks, corrosion, or any other form of degradation. Items such as the jacket, pipes, and other auxiliary components were also inspected, noting their availability and condition [20].

### 2.1.3 Dimensional Analysis and Thickness Measurement

The pressure vessel's dimensions were measured using precision instruments. The measurements taken included the thickness of the shell and head, as well as the internal diameter and the length of the vessel [21]. These measurements were crucial for calculating the minimum required thickness and the Maximum Allowable Working Pressure (MAWP) based on ASME Section VIII Division 1 standards. Random sampling of thickness at different points of the vessel was performed to ensure accuracy and consistency [22], [23].

### 2.1.4 Calculation of MAWP and Minimum Thickness

The calculated thickness values were compared with the actual measured thickness of the vessel to ensure compliance with safety standards [24]. The formula provided by ASME Sect. VIII Division I-UG-27 was used to calculate the minimum thickness required for the cylindrical shell and the ellipsoidal heads. The MAWP was determined using the formulas from ASME Section VIII Division I-UG-27, and the results were compared with the vessel's design pressure to assess its operational feasibility [25].

### 2.1.5 Hydrostatic Testing

As part of the testing process, hydrostatic tests were conducted to validate the pressure vessel's design and its capacity to withstand pressure safely [26]. The pressure was gradually increased to the test pressure of 23.40 kg/cm<sup>2</sup>, which is higher than the design pressure of 18 kg/cm<sup>2</sup>, and held for a specified duration to monitor any failure points. The test data were recorded, including the temperature and pressure during the test, to verify the vessel's suitability for continued use.

## 3. Result and Discussion

The research aimed to evaluate the operational feasibility of a horizontal cylindrical pressure vessel used for LPG storage at PT. XYZ. The findings from the tests and calculations are discussed below, providing an analysis of the vessel's compliance with safety standards and its operational viability. The significance of these results lies in their implications for both operational safety and the vessel's design life. The fact that the actual thickness exceeds the minimum required and that the MAWP is higher than the design pressure indicates a sufficient safety margin against potential mechanical failure, reducing the likelihood of rupture or leakage under normal or slightly elevated pressures. These findings confirm that the vessel can safely continue its operation within its intended service period as long as routine inspections and maintenance are conducted. Furthermore, the absence of notable

corrosion or deformation suggests that material degradation is minimal, contributing to a longer design life. Overall, this emphasizes the importance of consistent testing and maintenance in ensuring structural integrity, reliability, and long-term operational safety of pressure vessels in industrial applications.

**3.1 Visual Inspection Results**

The visual inspection revealed that the majority of the pressure vessel's components, including the shell, head, nozzles, and support structures, were in good condition (Table 3). There were no signs of cracks or significant corrosion that could compromise the vessel's integrity. However, some auxiliary components such as the jacket, pipes, and other attachments were found to be either missing or not functioning correctly, which could affect the overall performance if not addressed. These findings emphasize the importance of maintaining all components in optimal working condition for safe operation.

Table 3. Visual Inspection Result

No.	Part – Component	Condition	Remarks
	The components of the vessel		
1	Shell / Body	Good	-
	Head / Cover	Good	-
	Jacket / Sleeve	Good	NA
	Pipe	-	NA
	Nozzle	Good	-
	Completeness of the vessel		
2	Pressure gauge	Good	-
	Temperature gauge	-	NA
	Name plate	Good	-
	Drain valve	Good	-
	Ventilation valve	-	NA
	Safety valve	Good	-
	Pump valve	-	NA
	Vacuum valve	-	NA
	Filter	-	NA
	Steam trap	-	NA
	Support	-	-
	Pipe installation		
3	Valve	-	NA
	Support	-	NA

**3.2 Dimensional Analysis Result**

Dimensional measurements confirmed that the pressure vessel's shell had a thickness of 14.8 mm, which is slightly above the calculated minimum required thickness of 14.66 mm based on ASME Section VIII Division I–UG–27. Similarly, the thickness of the ellipsoidal heads (both front and rear) was measured at 16.4 mm, exceeding the calculated values, indicating that the vessel meets the required safety standards for wall thickness. The diameter and length of the shell were also in compliance with design specifications, further confirming the vessel’s structural integrity (Table 4).

Table 4. Dimensional Analysis Result

No.	Component	Size / Dimension	Remarks
1	Shell Body		

	a. Circularity	-	Measurement not performed
	b. Thickness	14.8 mm	
	c. Diameter	2275.4 mm	
	d. Length	6870 mm	
Head / End Cap			
2	a. Diameter	2275.4 mm	
	b. Thickness	16.4 mm	
Pipe / Channel			
3	a. Diameter	-	Measurement not performed
	b. Thickness	-	Measurement not performed
	c. Length	-	Measurement not performed
Pipe Installation			
4	a. Diameter	-	Measurement not performed
	b. Thickness	-	Measurement not performed
	c. Length	-	Measurement not performed

**3.3 MAWP Calculation Result**

The Maximum Allowable Working Pressure (MAWP) was calculated for both the cylindrical shell and the ellipsoidal heads. For the cylindrical shell, the calculated MAWP was 1.78 MPa (18.14 kg/cm<sup>2</sup>), which was slightly higher than the design pressure of 1.765 MPa (18 kg/cm<sup>2</sup>), indicating that the vessel is capable of safely operating under its intended working conditions. Similarly, the MAWP for the ellipsoidal heads was also calculated to be higher than the design pressure, further supporting the operational viability of the vessel.

**3.3.1 Shell (Sylindrical) Calculation**

Formula using ASME Section VIII Division I-UG-27.  $T_{required} = 14.66$  mm, because the actual thickness (14.8 mm) > the thickness calculation (14.66 mm) is declared ACCEPTABLE.

$$T_{shell} = \frac{P \cdot R_i}{SE - 0.6P} \tag{1}$$

**3.3.2 Ellipsoidal Head Front/Right) Calculation**

Formula using ASME Section VIII Division I-UG-32.  $T_{required} = 14.57$  mm, because thickness actual > thickness calculation, the head condition is also declared ACCEPTABLE.

$$T_{head} = \frac{P \cdot D}{2SE - 0.2P} \tag{2}$$

**3.3.3 Ellipsoidal Head (Back/Left) Calculation**

Formula using ASME Section VIII Division I-UG-32.  $T_{required} = 14.57$  mm, because thickness actual (16.4 mm) > calculated thickness (14.57 mm) then it is declared ACCEPTABLE. Then, the allowable MAWP calculation was performed with reference to ASME Sect. VIII Div. I-UG-27 as follows.

**3.3.4 MAWP Shell (Cylindrical) Calculation**

Formula using ASME Section VIII Division I-UG-27, because  $P_{design} = 1.765$  MPa (18 kg/cm<sup>2</sup>) <  $P_{Calculation} = 1.78$  MPa (18.14 Kg/Cm<sup>2</sup>) it is declared ACCEPTABLE.

$$P = \frac{SE(t-CA)}{R_i + .6(t-CA)} \tag{3}$$

where:

$$P = 1.78 \text{ Mpa,}$$

$$P = 18.14 \text{ kg/cm}^2, \\ \text{MAWP Design} = 1.765 \text{ Mpa}$$

### 3.3.5 MAWP Head (Front/Right) (Ellipsoidal) Calculation

Formula using ASME Section VIII Division I-UG-32, because  $P_{\text{design}} = 1.765 \text{ MPa}$  ( $18 \text{ kg/cm}^2$ ) <  $P_{\text{Calculation}} 1.99 \text{ MPa}$  ( $20.29 \text{ kg/cm}^2$ ) it is declared ACCEPTABLE.

$$P = \frac{2SE(t-CA)}{D_i + 0.2(t-CA)} \tag{4}$$

where:

$$P = 1.99 \text{ Mpa} \\ P = 20.29 \text{ kg/cm}^2 \\ \text{MAWP Design} = 1.765 \text{ Mpa}$$

### 3.3.6 MAWP Head (Back/Left) (Ellipsoidal) Calculation

Formula using ASME Section VIII Division I-UG-32, because  $P_{\text{design}} = 1.765 \text{ MPa}$  ( $18 \text{ kg/cm}^2$ ) <  $P_{\text{Calculation}} 1.99 \text{ MPa}$  ( $20.29 \text{ kg/cm}^2$ ) it is declared ACCEPTABLE.

$$P = \frac{2SE(t-CA)}{D_i + 0.2(t-CA)} \tag{5}$$

where:

$$P = 1.99 \text{ MPa} \\ P = 20.29 \text{ kg/cm}^2 \\ \text{MAWP Design} = 1.765 \text{ Mpa}$$

## 3.4 Hydrostatic Testing Result

Hydrostatic testing was conducted to verify the vessel’s ability to withstand pressures above the design limits (Table 5). The test pressure was set at  $23.40 \text{ kg/cm}^2$ , which is significantly higher than the vessel's design pressure. The vessel successfully withstood the test without any leaks or signs of failure, confirming that the vessel is capable of safely operating under extreme conditions. The results of the hydrostatic test further reinforce the vessel's suitability for continued use.

Table 5. Hydrostatic Testing Result

No.	Test Data	Symbol	Unit	Description
1	Design pressure	Pd	18 kg/cm <sup>2</sup>	
2	Operating pressure	Pw	18 kg/cm <sup>2</sup>	
3	Test pressure	Pt	23.40 kg/cm <sup>2</sup>	
4	Ambient temperature	T	NA	
<b>Holding Time</b>				
5a	Design pressure	T0	15 minutes	
5b	Test pressure	T1	30 minutes	
6	Temperature rise	ΔT	0 °C	

Figure 2 this result the relationship between time and temperature during the hydrostatic testing process of the LPG pressure vessel. The graph shows that the temperature remained relatively stable throughout the test period, with no significant fluctuations observed during both the 15-minute design pressure holding phase and the 30-minute test pressure holding phase. This stability indicates that external thermal effects did not influence the pressure readings, ensuring the accuracy and reliability of the hydrostatic test results. The constant temperature condition also demonstrates that the vessel maintained thermal equilibrium, preventing thermal expansion or contraction that could affect the test outcome. Consequently, the absence of sudden temperature changes supports the conclusion that the

vessel successfully withstood the applied test pressure of 23.40 kg/cm<sup>2</sup>—approximately 30% higher than the design pressure of 18 kg/cm<sup>2</sup>—without signs of leakage or deformation, confirming its mechanical integrity and safe operational performance.

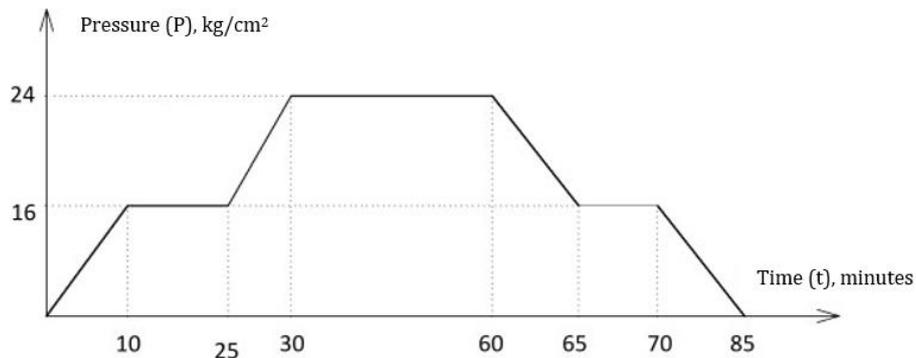


Figure 2. Graph Time versus Temperature

### 3.5 Discussion

The findings of this research demonstrate that the pressure vessel at PT. XYZ is in good condition and meets the required safety and pressure vessel design standards for continued operation. The combination of visual inspections, dimensional analysis, MAWP calculations, and hydrostatic testing provides a comprehensive evaluation of the vessel's structural integrity and operational viability. These results suggest that the vessel can continue to be used safely, provided that the missing auxiliary components are replaced and maintained. In addition, the results of this testing are communicated to the workers in the area to enhance their understanding and awareness of workplace safety.

The successful completion of the tests underscores the importance of regular maintenance and testing of pressure vessels in industrial applications. Furthermore, the study highlights the value of vocational education in technical engineering, where students can gain hands-on experience in performing such tests, which are crucial for ensuring the safety and efficiency of industrial equipment. This research contributes to the field of vocational education by providing a practical example of how theoretical knowledge can be applied in real-world settings, particularly in the context of pressure vessel testing and compliance with occupational safety standards [1].

## 4. Conclusion

This study shows that the horizontal cylindrical pressure vessel at PT. XYZ meets safety standards and is fit for use, with adequate actual thickness and a calculated MAWP higher than the design pressure. Visual inspection, dimensional analysis, and hydrostatic testing indicate that the vessel can safely withstand its operating conditions, although some missing or non-functioning auxiliary components need to be repaired promptly. This study emphasizes the importance of regular maintenance and testing of industrial equipment, as well as the value of vocational education in providing students with practical experience in addressing real-world engineering challenges.

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