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# Mechanically Operated Portable Hydrotesting Setup

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***Abstract***

*Hydrostatic testing is a crucial process in ensuring the integrity and safety of pressure vessels, pipelines, and various other industrial equipment. Traditional hydrostatic testing setups often require significant infrastructure and resources, limiting their accessibility and flexibility, especially in remote or constrained environments. This research paper presents the design, development, and implementation of a portable hydro testing setup tailored to address these challenges. The proposed setup offers a compact, versatile, and efficient solution for conducting hydrostatic tests on a wide range of industrial equipment. Through innovative engineering and utilization of modern technologies, this portable setup enhances the accessibility, accuracy, and safety of hydrostatic testing processes, thereby contributing to improved operational efficiency and risk mitigation in industrial applications.*

**Keywords:** Portable hydrotesting setup, industrial applications, hydrostatic pressure tests, equipment testing, pipeline integrity

## INTRODUCTION

Pressure vessels, particularly fuel tanks, boilers, gas cylinders, pipes, and pipelines, can be examined for leaks and strength using a hydrostatic test. The test entails increasing the vessel to the designated test pressure after filling the pipe system or vessel with a liquid, often water, that may be colored to help with visual leak identification. By closing the supply valve and looking for symptoms of pressure loss, one may check if something is pressure tight. If there is a colorant in the water, it will be easier to see where the leak is. Usually, permanent deformation of the package is used to test strength.

The most common method used to test pipelines and pressure containers is hydrostatic testing. This test aids in the long-term maintenance of a vessel's durability and safety requirements. The hydrostatic test is used to first certify newly produced parts. Subsequently, they undergo periodic revalidation in compliance with the respective standard. Pneumatic pressure testing might be a suitable substitute for hydrostatic testing in certain situations when it is not permitted [1].

In the oil, gas and pump industry, as well as other industries in which products are usually transported in pipelines or system at pressures much higher than the atmospheric pressures, hydrostatic pressure testing (hydro test) is very popular. Hydrostatic pressure testing is a way of verifying the integrity of the pipelines or pressure containing parts. It is a way of confirming that the pipelines or part can keep the product in containment at the normal operating pressure and even at pressures higher than the normal operating pressure. Contamination of the oil

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and gas haulage system in seaworthy environment has greatly affected aquatic life. This is due to corrosion of the pipelines steels in water ways which continue to contaminate the ocean leading to great damage of the oil and gas transportation system and aquatic organisms in high waters. Beyond exposing leaks and defects, hydrostatic pressure testing serves as the final validation of the integrity of the pipeline or parts. ASME B31.3 states that the test must occur to guarantee tightness and endurance [2].

The hydrostatic test pressure for a new pipeline system (pipeline or process piping) is usually between 1.25 and 1.5 of the Maximum Allowable Operating Pressure (MAOP) or Designed Pressure (DP) of the system, meaning that the minimum hydrostatic test pressure for a pipeline or part designed to operate at 2,00 kg/cm2 will be between 2,50 kg/cm2, and 300 kg/cm2. A specific MAOP, or deigned pressure, is designed for use by pipelines or items. According to, pipelines could be tested at pressures greater than 90% of the SMYS of the pipe material, but "special care shall be taken to prevent overstrain of the pipe". Actually, the vast majority of pipeline operators choose test pressures that fell between 90% and 110% of the pipe material's specified minimum yielding strength (SMYS).

In view of the above, pointed out that "the ratio of test pressure to operating pressure establishes the margin of safety; the higher the ratio, the greater the assurance of safety" Thus, increased test pressure gives greater assurance f safety. discussed the level of damage pipeline materials and exterior part of metals are subjected to as a result of high-level effect of corrosion and wear associated with multifarious electrochemical and mechanical devices. It was stated that the damage caused is extremely high on metal facade than amount of uncontaminated corrosion and wholesome erosion. In recent time, the subject of hydrostatic testing has always been one of great concern with varying arguments for and against the procedure. The various merits and demerits of the testing procedure and its impact on the integrity (positively or negatively) of the pipeline material has been the focus of valid debates. These arguments form the very core of the present investigation. While hydrostatic testing has already been used for a long time to assess and confirm the integrity of pipelines and can yield a variety of information, it is crucial to recognize the limitations of the testing procedure and the outcomes that can be developed [3].

Certain useful information can be gotten from the test; however, it is argued that the test has profound impact on the post-test behavior of these flaws. Hydrostatic testing widely regarded as a non-destructive evaluation of pipeline or parts hence it is important to determine the correct test pressure to avoid rupture and also utilize this predetermined pressure to get the desired results. Though, some school of thought believes that hydrostatic pressure testing alters the properties of the material to a significant degree, the present study, seeks to verify the validity of the above assertion and to know whether the test is nondestructive or destructive test procedure [4].

**Design Requirements and Specifications**

This section details the design process and development stages of the portable hydrotesting setup. It discusses the selection of components, including pumps, pressure gauges, valves, and fittings, with a focus on portability, accuracy, and reliability. Additionally, it covers the integration of control systems for automated operation and real-time monitoring

- Functional requirements for a portable hydro testing setup.
- Environmental considerations (e.g., temperature, pressure).
- Safety standards compliance.
- Ergonomic design for ease of use and transportability.

**Design and Components**

Each component of the portable hydrotesting setup is described in detail in this section. This includes the pump unit, pressure control system, fluid reservoir, pressure gauges, valves, fittings, and hoses. The functionality, specifications, and integration of each component into the system architecture are discussed comprehensively (Figure 1).

 

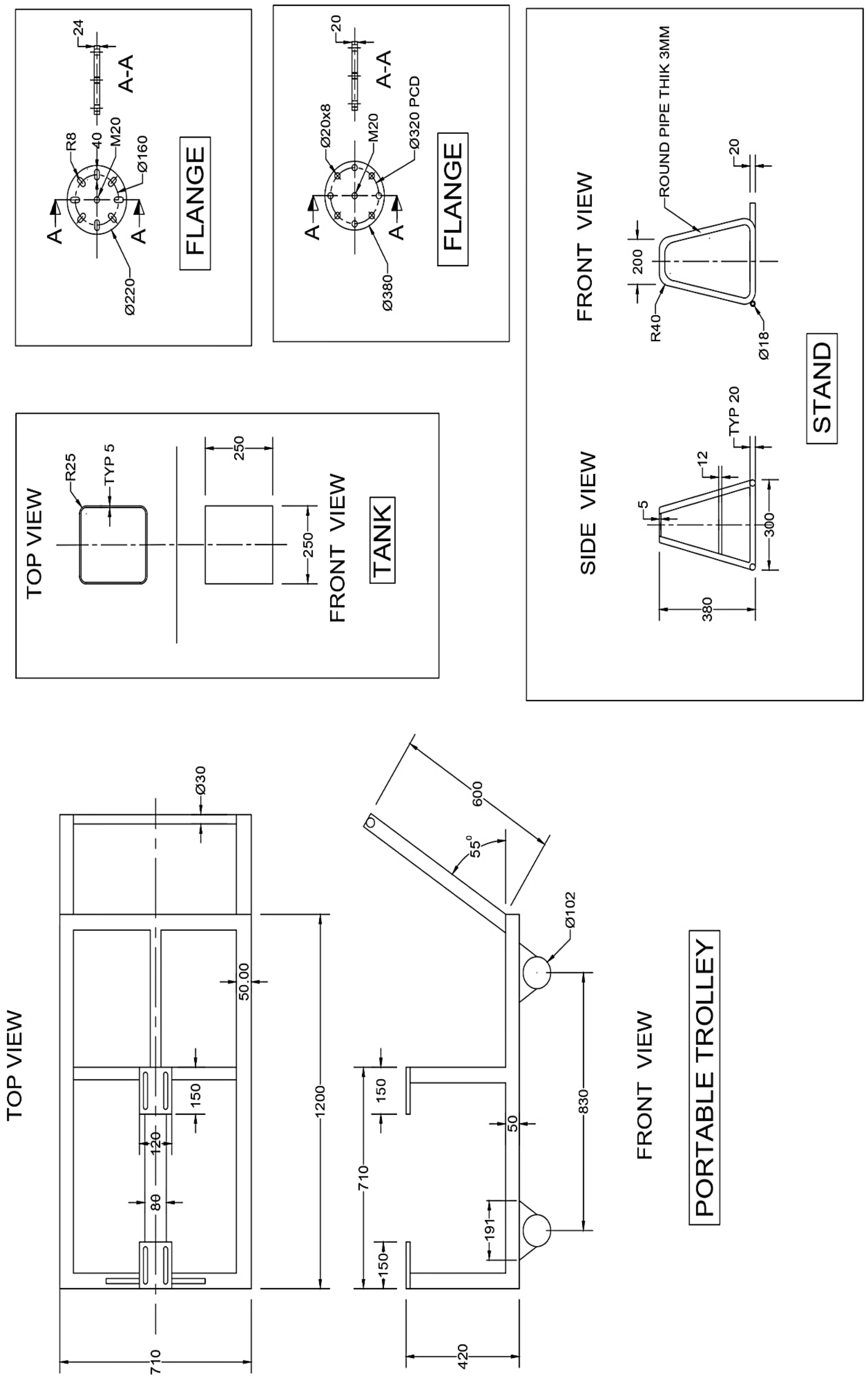


**Figure 1.** CAD drawings of setup.

**Cylinder Body**

It is a hollow cylindrical unit with a reciprocating actuator that creates a vacuum and pumps out water from the pipe as it descends through the hose.

**Hose Pipe**

A hose pipe is a hollowed out. flexible tube that is used to transport fluids from one place to another. It unites performance and applicability. Size, pressure, rating, weight, length, straight and coil hoses, and chemical composition are common thought [5].

**Pressure Gauge**

For measuring pressure of fluid, we have use bourdon pressure gauge. Bourdon tube pressure gauges have been picked because they are affordable, versatile, provide fast readings and responses, and are cheap to fix.

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**Handle**

Due to its more length compare cross section the operator has to apply less force to reciprocate plunger. Handle work on the principle of momentum.

**NRV Or Check Valve**

This is the most important component as it maintains pressure (Generated by pumping fluid) in closed system. It stops the back flow of pumped fluid.

**Plunger**

The component known as the plunger contains a length greater than its cross section. The plunger's cross section is cylindrical, and when it is reciprocated in the cylinder body using the handle, a vacuum creates in the cylinder body, drawing water from the tank and sucking it into the part in question [6].

**Hydro Test Pump**

Hydro test pump contains a pumping system and pressure measuring system. To pump liquid in closed system it maybe hand operated or motor operator. Burdon pressure gauge is generally used for measuring pressure of closed system. Test done by these kinds of pump is called as hydrostatic test.

## OPERATIONAL PROCEDURE

### Preparation

***Pressure Gauge***

Minimum of two pressure gauges shall be used for testing. The dial of the gauges shall be positioned in such a way that they are clearly visible to the operator controlling the pressure throughout the test. One of the gauges shall be located in the highest point.

***Range***

The pressure gauges used for testing have dials graduated over range of double the intended test pressure, but not in case less than the 1 1/2 nor 4 times test pressure.

**Calibration**

In cases when there is probable mistake, all gauges must be calibrated using a master dead weight tester. In no case, re-calibration frequency shall exceed six (6) months.5.3TEST MEDIUM Potable water shall be used as a test medium with water soluble Rust Proof Agent as specified in the drawing shall be adhered to [7].

**Test Temperature**

During the hydro test, it is recommended that the metal temperature during test be maintained at least 30° F (-1.1° C) above the minimum design metal temperature specified on the manufactures drawing, but need not exceed 120° F to minimize the risk of brittle fracture. The test pressure shall not be applied until the item and its contents are at about the same temperature. If the test temperature exceeds 120° F, it is recommended that the test shall not be conduct until temperature is reduced to 120° F or less.

**Filling of Test Medium**

Vents shall be provided at high points of the system; consideration shall be given to the test position of the system and geometric configurations while providing venting arrangements so as to ensure that air is not entrapped in the system while filling of water. The item must be filled with water using any applicable low pressure filling lines, and the topmost nozzles' vents must be used for ventilation. To prevent pocket entrapments, the filling pump's volume must be regulated to ensure optimum venting. The test operator must inspect the apparatus before applying pressure to ensure that all low-pressure filling lines and other accessories that shouldn't be exposed to the test pressure have been removed or isolated using valves or other necessary mechanisms [8].

**Application of Pressure**.

The pressure in the item shall be increased 163 psi per minute steadily until required test pressure specified in the manufacturing drawings has been reached. The valve between the pump and the pipe line inlet are required to be closed after the test pressure is attained. If not otherwise indicated on the manufacturing drawing, the test pressure must be in line with Digness, and the holding period must be kept for not less than of thirty (30) minutes. The test pressure will be lowered to two thirds of the test pressure when it has been managed for the holding period.

**Safety Precautions**

Signs are to be displayed at roped off areas indicating that hydro test is under progress. During testing, the test area must only be visible to authorized persons.

**Inspection**

The whole body of the item must be visually inspected for leaks, bulging, or other apparent faults at the pressure established in paragraph 5.6.all weld joints, connections, and high-stress areas, such as the area surrounding apertures, the thickness transition section, must undergo close inspection. Under the supervision of the client inspector, the QA/QC inspector will perform out the aforementioned inspection. The Inspector may carry out his own closure examination as considered necessary [9].

**Non-Conformance Control**

If during inspection leaks, cracks or any other defects are observed it shall be identified and handled in accordance with the non-conformance section of the QC manual. Any leaks detected shall be eliminated after which the item shall be re-hydro tested.

**Records**

The QA/QC Inspectors shall record the results of hydrostatic test on the Test Report andshall present to Customer Representative for his review. The hydrostatic test report and inspection check sheet must be signed and dated by the buyer's representative and the QA/QC Inspector if the test's outcome is effective.

**Calculations**

***Assumptions***

Fluid: Water
Testing Pressure: 10,000 psi (689.5 bar)
Flow Rate: 1 liter per second
Safety Factor: 1.5

***Pressure Gauge***

No calculations needed. The pressure gauge is used for measurement.

 

***Non-Return Valve (NRV) or Check Valve***
Pressure Rating: 10,000 psi (689.5 bar)

***Plunger (Assuming part of a hydraulic pump)***
Diameter: 1 inch (25.4 mm)
Stroke Length: 3 inches (76.2 mm)
Displacement Volume:
Displacement Volume = π * (Diameter/2)^2 * Stroke Length
= π * (25.4 mm / 2)^2 * 76.2 mm
≈ 1195.91 mm^3

**Handle**
No calculations needed. This component is for grip and manipulation

**Hose Pipe**
Diameter: 1/2 inch (12.7 mm)
Pressure Rating: 10,000 psi (689.5 bar)
Flow Rate: 1 liter per second

Flow Velocity (V): Q / A
= (1 liter/s) / (π * (12.7 mm / 2)^2)
≈ 127.23 mm^2/s
≈ 0.12723 m^2/s
Reynolds Number (Re): Re = (ρ * V * D) / μ

Where:
ρ = Density of water (assumed 1000 kg/m^3)
μ = Dynamic viscosity of water (assumed 0.001 Pa·s)
D = Hydraulic diameter (Diameter of the pipe) = 12.7 mm
Re ≈ (1000 kg/m^3 * 0.12723 m^2/s * 0.0127 m) / 0.001 Pa·s≈ 10152.77 (which indicates turbulent flow)

**Cylinder Body (Assuming part of the pressure vessel)**

Diameter:10 inches (254 mm) Length: 18 inches (457.2 mm) Wall Thickness: 1/4 inch (6.35 mm)

**Internal Volume**

Internal Volume = π * (Diameter/2 - Wall Thickness) ^2 * Length
= π * (254 mm / 2 - 6.35 mm) ^2 * 457.2 mm
≈ 17149213.3 mm^3
≈ 17149.21 cm^3
≈ 17.14921 liters

These calculations provide essential parameters for the design and operation of the hydro testing setup, ensuring that components are selected and sized appropriately to meet the desired pressure and flow requirements [10].

## RESULTS AND DISCUSSION

The performance evaluation section of the research paper focuses on assessing the effectiveness and efficiency of the developed portable hydrotesting setup. It involves empirical testing and analysis to evaluate various performance metrics such as accuracy, repeatability, reliability, and efficiency. The evaluation aims to determine how well the system performs its intended functions and to compare its performance with traditional stationary setups.

Key aspects covered in the performance evaluation may include:

- *Accuracy:* Assessing the degree to which the measured pressure values align with the expected or theoretical values. This involves comparing the actual test results obtained using the portable setup with known standards or calibrated instruments.
- *Repeatability:* Evaluating the consistency and reproducibility of test results when conducting multiple tests under similar conditions. Repeatability measures how closely the results match each other when the same test is repeated.
- *Reliability:* Examining the dependability and robustness of the portable hydrotesting setup in various operating conditions. This involves testing the system's ability to maintain performance over time and under different environmental factors.
- *Efficiency:* Analyzing the effectiveness of the portable setup in terms of time, cost, and resource utilization compared to traditional testing methods. Efficiency considerations may include the speed of setup, execution, and data collection, as well as the overall productivity of the testing process.
- *Comparative Analysis:* Comparing the performance of the portable hydrotesting setup with conventional stationary setups to identify advantages, limitations, and areas for improvement. This may involve conducting side-by-side tests or simulations to highlight differences in performance.

Overall, the performance evaluation provides valuable insights into the operational capabilities and limitations of the portable hydrotesting setup, helping to validate its effectiveness and inform potential refinements or optimizations for future iterations.

## CONCLUSION

In conclusion, the portable hydrotesting setup offers a versatile, efficient, and accessible solution for conducting hydrostatic pressure tests in industrial settings. Because of its precision, transportation, and credibility, it's a useful tool for improving both efficiency and security in a variety of applications. Future efforts may focus on further optimization and real-world implementation to maximize its potential impact on industrial testing methodologies.

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