Fueling Innovation: Pressure Vessels

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NREIP Internship Program & CSEP PIPELINES Program
NAVFAC EXWC, Capital Improvements, Petroleum, Oils & Lubricants (POL)

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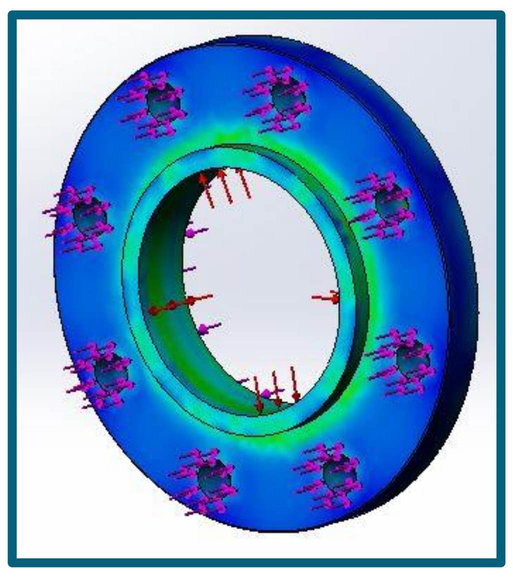
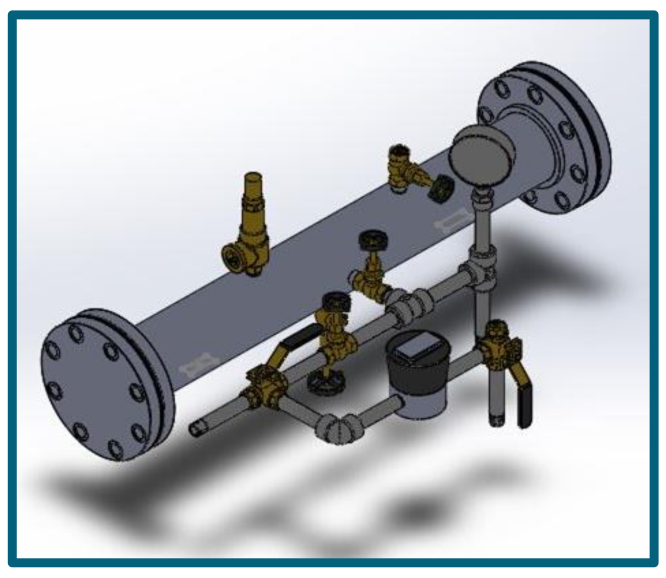
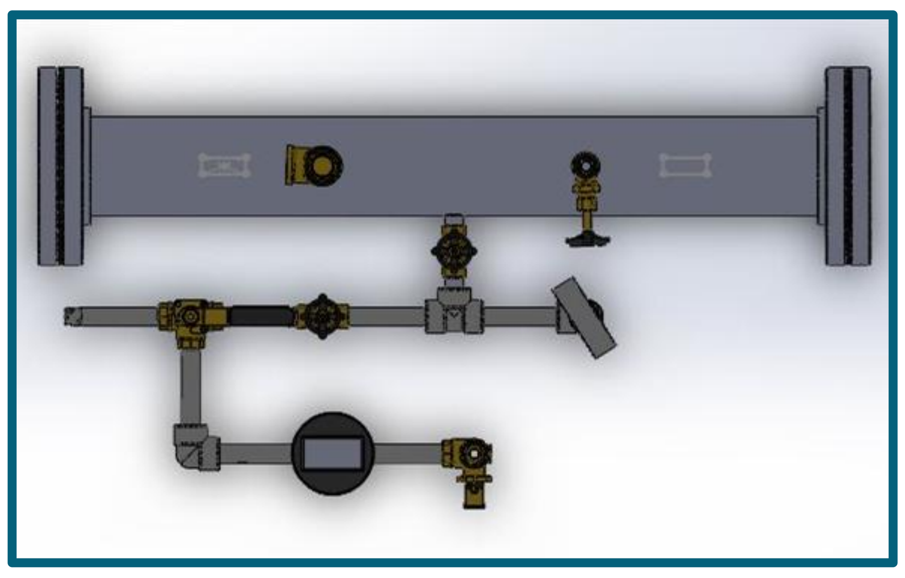
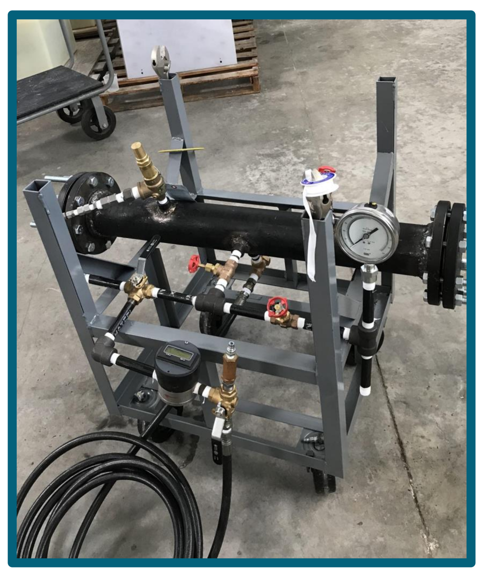
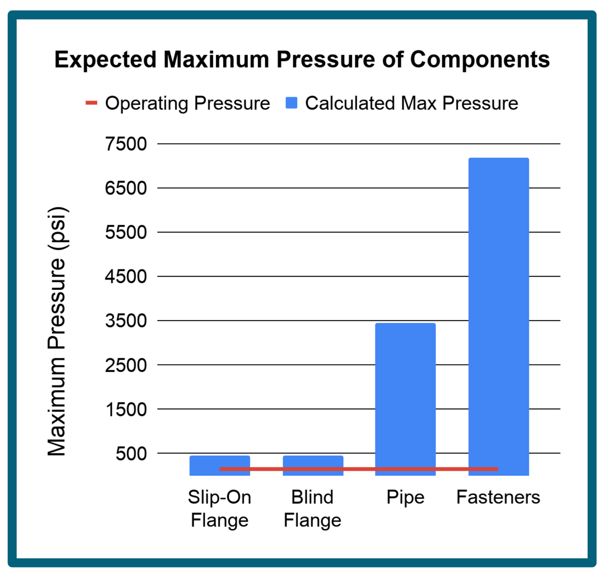
Introduction

This poster provides a brief overview of the work we have accomplished this summer. We put a lot of time and effort into this project and are proud of our final product. Our 10-week engineering internship has been a great learning experience and we are excited to know that our project will benefit the Navy.

Big Picture: Project Overview

Our project is to design, build, and test a small-scale fuel pipeline, using techniques such as hydrostatic testing. Our steel vessel is 3 feet long and has an average diameter of 4 inches.

The larger purpose of our project is to serve as a training and testing platform for future Petroleum, Oils, & Lubricants employees. Our pressure vessel can be used for a variety of non destructive testing techniques as well.

Design Requirements & Constraints

The main design requirements and constraints we faced include materials, durability, mobility, and time. We combined existing parts and new parts, making sure everything fit together properly. Durability and strength calculations were also important and above, you can see finite element analysis of a slip-on flange. Also picture above, we ordered the cart to support and mobilize our vessel. Our last constraint was to complete everything on time.

Proposed Solution

Our proposed solution can be seen in detail in the SolidWorks drawings above. Included in our design is a flow meter, to measure the volume of water we put in and take out of our pressure vessel. We also have several pressure gauges to ensure accurate pressure readings and a pressure relief valve to release excess water at 125 psi. Our solution will allow engineers to gain preliminary practice on hydrostatic testing equipment and procedures before going out to a job site.

Testing Methods

To evaluate the integrity of the pipeline, a hydrostatic test needs to be performed. The three instruments for recording data are a pressure gauge, a deadweight tester, and a flow meter. In order to predict the integrity, we evaluated the maximum pressure each component can withstand, the results can be seen in the graph above.

During the hydrostatic test, we will record the pressure over time. If no leaks occur, we should expect the pressure to be constant. We also will use the flow meter to ensure the same amount of water that has entered the vessel is also drained, which is a common procedure out in the field.

Project Goals

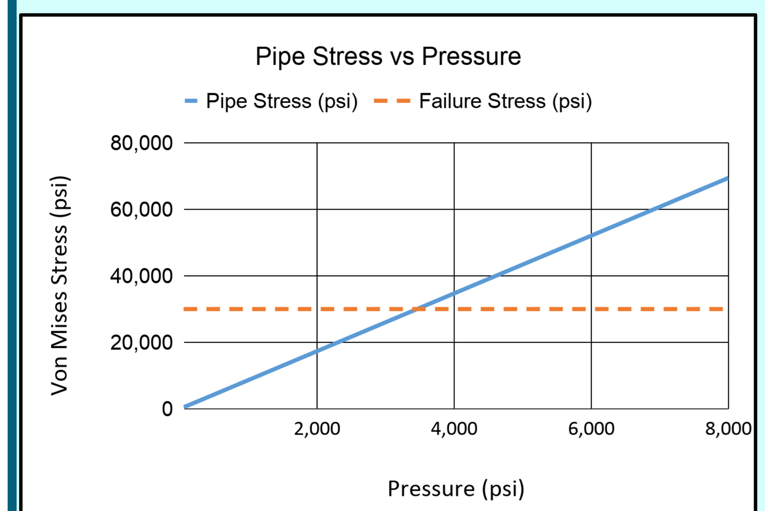
We have two main goals for our project. This first goal is to hydrostatically test our vessel. Hydrostatic testing involves filling a pipeline or vessel with water and pressurizing it to check for areas of leakage and pipeline strength integrity. We have designed and built our vessel to have the appropriate components for this type of test.

Our second goal is to leave our pressure vessel as a part of this larger non destructive testing facility that the Petroleum, Oils, & Lubricants Department at NAVFAC is currently developing. We are hoping that our project can be used for future non destructive testing, such as Ultrasonic testing (UT).

Project Analysis

As we progressed through our project, there were certain components that we changed along the way. The first change was from a compressed air-powered water pump to a manual hand pump. This allowed us to more easily control the pressure we put into our vessel. Another alteration was from dome-shaped end caps to flat end flanges. We opted for flanges because they are more easy to assemble and disassemble. Finally, we chose welded flanges over threaded flanges due to their increased resistance to corrosion and reduced stress concentrations.

Stress Calculations



In order to predict the integrity of the pressure vessel before hydrostatic testing, we performed stress calculations using failure theories. Below is a graph illustrating the linear relationship between the pressure of the vessel and the stress that the pipe experiences. The dotted line is the yield stress of the material, and the intersection indicates that the yield pressure is approximately 3,500 psi.

We also relied on Finite Element Analysis (FEA) to simulate the stresses on the flanges, which can be seen in the model above. Considering our flanges were the limiting factor in our stress calculations, we determined the test pressure to be 100 psi. This would allow for a factor of safety of 1.5.

Results

We are still in the process of testing and obtaining data for our results, however we are planning to record changes in pressure over time. This will allow us to determine any areas of leakage. During our tests, we will try various levels of pressure and for different lengths of time to see how our data changes as a result. We will also look for any areas of deformation on our pressure vessel. Since this vessel will be utilized for other non destructive testing than just hydrostatic testing, we will also test devices such as an ultrasonic testing scanner. This device sends sound waves through the material and checks for areas of material loss or corrosion. Our plan is to obtain some general data from our vessel that can be used for future reference by Petroleum, Oils, & Lubricants employees.

Conclusion

We are grateful for the opportunity to work on this important project and are excited to see how our vessel will be used in the future. We are hopeful that this testing and training platform will be effective and useful for the engineers at NAVFAC, and that our project addresses the problem successfully.