URI Dynamic Photo-Mechanics Lab: Underwater Implosion Research

Dr. Matos is a mechanical engineer at the University of Rhode Island (URI). He and his students examine the properties of materials to identify which materials are best suited for a specific task. Dr. Matos has been asked to investigate which material would make the best coating for an autonomous underwater sea vessel that operates without a crew. Underwater sea vessels that need a crew to operate, like submarines, only dive to depths of 300 m. The autonomous underwater sea vessels that Dr. Matos is testing, however, are designed to travel below 1000m, causing more water pressure to push on the vessel the deeper it goes. Therefore, the best coating will be one that can withstand the most pressure to help prevent the vessel from imploding, or being crushed.

Dr. Matos printed five models of undersea vessels at URI's Advanced 3D Printing Lab. The models were made out of a material called Base PLA. Four of the models were each coated with a different material. The fifth model was left without a coating. One at a time, the models were tested inside the High Pressure Implosion Facility. During each test, a vessel was placed in a tank that simulated undersea-like conditions (Figure 1). Different amounts of pressure were applied to simulate the water pressure at different depths. The researchers measured how much pressure was applied before the model imploded, or was crushed. The researchers also simulated tests to see if the materials would lose strength after being exposed to seawater over different periods of time.

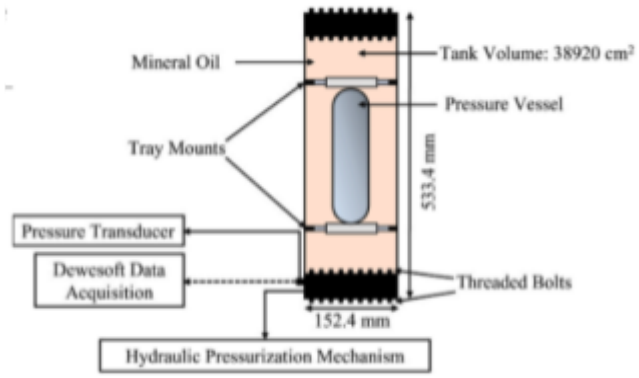

Figure 1: Schematic Diagram of High Pressure Implosion Facility

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The graph below shows the results of Dr. Matos' investigation (Figure 2). The Analytical Collapse Pressure (MPa) indicates the amount of force the model vessel could withstand before imploding. This pressure is related to how deep the vessel can go before the risk of implosion (Figure 3). The Weathering Days shows the number of days the vessel might be expected to stay underwater.

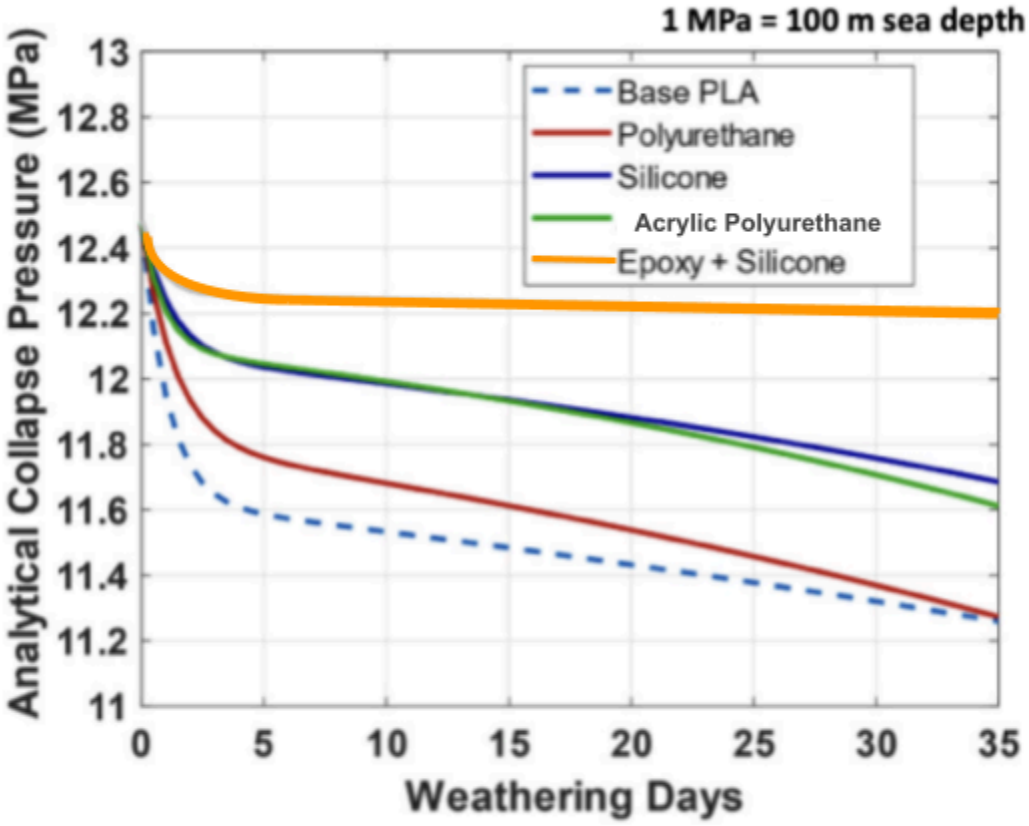

Figure 2: Analytical Collapse Pressure & Weathering Days

1 MPa = 100 Meters

Analytical Collapse Pressure (MPa)	Depth (meters)
11	1,100
11.2	1,120
11.4	1,140
11.6	1,160
11.8	1,180
12	1,200
12.2	1,220
12.4	1,240
12.6	1,260
12.8	1,280
13	1,300

Figure 3: Analytical Collapse Pressure (MPa) and Sea Depth (meters)

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Task 1: Based on the research from the Dynamic Photomechanics Lab, use the graph (Figure 2) and table (Figure 3) above to answer the following questions:

1)

a. At Day 35, what is the maximum amount of pressure a vessel coated with Acrylic Polyurethane could withstand before imploding?

b. What depth does that amount of pressure represent?

c. On a 35 day trip, would 1,140 m be a safe depth for a vessel coated in Acrylic Polyurethane to dive without the risk of implosion? Be sure to provide evidence to support your thinking.

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2) How many days could you expect a vessel coated in Polyurethane to stay at a depth of 1,160 meters without risk of imploding? Be sure to support your thinking with evidence from the graph.

3) Dr. Matos tested the model with no coating, called Base PLA, so he could compare its strength to the vessels that do have a coating. Based on the data, overall, do the coatings allow the vessels to withstand more pressure than they would without a coating? Be sure to support your thinking with evidence from the graph.

4) Write a letter to Dr. Matos, recommending which of the tested materials is best suited for coating a robotic underwater vessel exploring the ocean floor for over a month at depths between 1,180 m and 1,210. Be sure to include evidence to support your thinking.

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Task 2: Dr. Watwood is a biologist researching seasonal migration patterns of Beaked whales. To do so, she tags (attaches an indicator) Beaked whales with GPS trackers. The data from the trackers can be downloaded after they detach from the whales and float to the surface. Dr. Watwood expects the whales to dive up to 1180 meters into very cold waters.

1. If Dr. Watwood plans to collect the data from the trackers after two weeks, which materials can she consider using to coat the equipment without the risk that the equipment will implode? Use evidence from the data to explain your thinking.

2. Which one of the following additional criteria would you recommend Dr. Watwood consider to help her make a final decision about which coating material to use? Explain your reasoning.

   <u>Additional criteria to consider for coating material selection</u>
   - Cost
   - Ability to withstand extremely high heat
   - Ability to withstand high winds

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3. Consider the depth the whales will dive, the amount of time the equipment will be in the water, and the materials' cost shown in the table below. What coating material would you recommend for designing the most affordable equipment to perform the job effectively? Explain your thinking.

Coating Material	Cost
Epoxy and Silicone	Highest
Silicone	
Acrylic and Polyurethane	
Polyurethane	Lowest

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