Indian Institute of Technology Gandhinagar

ME 299: Project Course

Unmanned Underwater Vehicle

Structure Team

Vivek Kumar	23110361
USNV Mohana Krishna	23110345
Mukesh Dewangan	23110211
Kushagra Shahi	23110183
Kunala Thrisha	23110182
Atharva Prasad Suryarao	23110051

Professor :
Prof. Atul Bhargav
Prof. Ravi Sastri Ayyagari
Prof. Vinod Narayanan

Contents

1 Introduction

This project focused on building a prototype of an Unmanned Underwater Vehicle (UUV). The main body was made from a PVC pipe, with acrylic flanges and rubber gaskets used to create watertight seals at the ends. Since the electronics had to be accessible, both flanges were designed with a removable cover. To enable movement in the vertical direction, a ballast system was added, allowing the prototype to control its buoyancy and adjust depth in water.

2 Operating Instructions

- Always operate the submarine in controlled water bodies (test tanks, pools, or calm water).
- Do not expose electrical systems to water without proper sealing.
- Ensure all seals, flanges, and propeller fittings are checked before every use.
- Do not overload the submarine with additional weight beyond the design limit.
- Keep hands and clothing clear of the propeller while powered.
- Inspect the submarine for visible damage or loose fittings.
- Confirm that the propeller shaft rotates freely without obstruction.
- Ensure watertight seals are intact before deployment.
- Place the submarine gently into the water.

Buoyancy and Weight Limitations

- The submarine achieves neutral buoyancy when its total weight (vessel + components + payloads) equals 24.5 kg.
- Safe Operating Range: The submarine must weigh between 24.0 kg and 24.5 kg prior to deployment. If the weight exceeds 24.5 kg, the vessel will sink.
- The ballast system can intake up to 0.5 kg of water, enabling fine adjustments to buoyancy within the safe operating range.

Always verify the total weight of the submarine before operation to ensure it falls within this specified range.

3 Gasket Design and Selection

3.1 Sealing Requirements

- Issue: Preventing water leakage at the ends of the submarine prototype was critical. The design employed a hollow flange attached to the submarine body and a blind flange as a removable cover. Both were made of acrylic and joined using 12 bolts. Since the blind flange also served as the primary access point for electronics, it required frequent removal and reattachment. Consequently, the gasket material had to provide reliable sealing while also being reusable.

3.2 Initial Attempt – Thermal Gasket

- Issue: A thermal gasket was initially tested. However, its stiffness and lack of compressibility resulted in uneven clamping when the bolts were tightened sequentially. This caused stress concentrations in the brittle acrylic flanges, leading to cracking.
- Action Taken: The thermal gasket was rejected as unsuitable due to its inability to distribute stresses evenly and its tendency to damage the flange material.

3.3 Final Selection – PTFE Gasket

PTFE (Polytetrafluoroethylene) was identified as an ideal gasket material for the following reasons:

- Lightweight and elastic, providing adequate compressibility.
- Highly resistant to water, ensuring long-term sealing performance.
- Easy to fabricate using simple tools (e.g., thermocol cutter).
- Reusable, retaining its sealing properties after multiple installations.

3.4 Fabrication and Installation

- The PTFE sheet was cut to match the hollow flange geometry.
- Bolt holes were pierced slightly smaller than the bolt diameter. This allowed the material to compress tightly around the bolts, eliminating potential leakage through bolt clearances.
- The gasket was installed between the blind and hollow flanges, providing uniform stress distribution and protecting the acrylic from cracking.

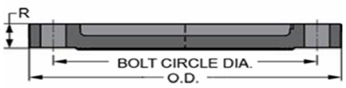
3.5 Performance Outcome

The PTFE gasket performed effectively, ensuring a watertight seal while enabling repeated removal and reinstallation without loss of performance. It offered a practical and reliable solution for both leakage prevention and maintenance access.

Schedule 80 PVC Technical

PVC Pipe Flange Dimensions & Information

Flange - Blind



Part Number	Size	O.D.	R	Bolt Circle Dia.	Bolt Size	Min. Bolt Length	No of Bolts	Approx. Wt. (Lbs.)
853-005	1/2	3-17/32	9/16	2- 3/8	1/2	2	4	.20
853-007	3/4	3- 7/8	5/8	2- 3/4	1/2	2	4	.28
853-010	1	4-1/4	23/32	3-1/8	1/2	2-1/4	4	.40
853-012	1-1/4	4- 5/8	11/16	3- 1/2	1/2	2-1/4	4	.37
853-015	1-1/2	5- 1/16	23/32	3-7/8	1/2	2-1/2	4	.52
853-020	2	5-31/32	27/32	4- 3/4	5/8	3	4	.81
853-025	2-1/2	6-15/16	1-1/16	5- 1/2	5/8	3-1/4	4	1.54
853-030	3	7- 1/2	1-3/16	6	5/8	3-1/4	4	1.76
853-040	4	9- 1/16	1- 5/32	7- 1/2	5/8	3-1/2	8	2.69
853-060	6	11-1/4	1- 3/8	9- 1/2	3/4	4	8	4.25
853-080	8	13- 1/2	1- 7/16	11- 3/4	3/4	4-1/2	8	7.30
853-100	10	16	1-11/16	14- 1/4	7/8	5	12	11.60
853-120	12	19	1-11/16	17	7/8	5	12	17.42

Figure 1: ASME Blind Flanges

Reference:
`https://parts.spearsmfg.com/sourcebook/SCH80TECH_80_FLANGES_T.pdf`

4 Flange Design and Selection

4.1 Sealing Requirements

- Issue: The ends of the prototype needed to be sealed reliably to prevent water leakage while still allowing periodic access to the internal electronics. A flange system was required to provide both watertight integrity and mechanical strength.

4.2 Material Selection – Acrylic Sheets

- Availability: Readily available and easy to procure (sourced from Maker Bhavan).
- Manufacturability: Can be precisely cut using a laser cutter, ensuring accurate dimensions and bolt-hole alignment.
- Weight: Lightweight and easy to handle during assembly.
- Pressure Resistance: Adequate to withstand hydrostatic pressure up to a water depth of 6 feet, which matched the operating conditions of the prototype.
- Limitation: Acrylic is brittle and prone to cracking if bolts are overtightened, leading to material wastage and sealing failure.

4.3 Bolt and Hole Specifications

- Issue: Using non-standard bolt sizes could compromise the seal and result in leakage, which would damage onboard electrical systems.
- Action Taken: The flange dimensions and bolt patterns were referenced from ASME standards (Size 8) to ensure proper fitment and sealing performance.

4.4 Design Modification

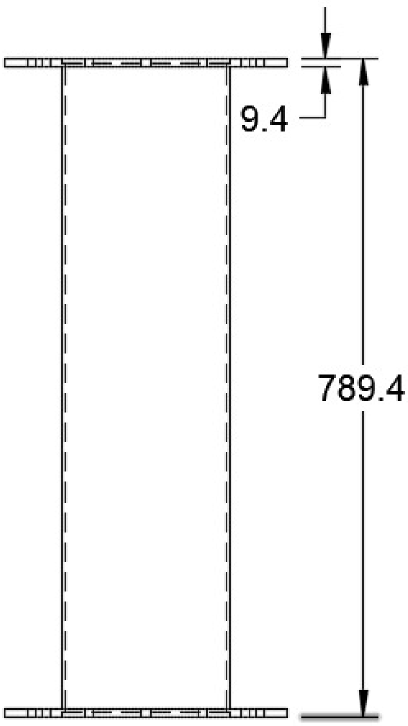
- Issue: Standard size 8 flanges typically use 8 bolt holes, which may not provide sufficient sealing security in a prototype made from brittle acrylic.
- Action Taken: Following advice from an industry expert, the design was modified to incorporate 12 bolt holes instead of 8. This increased the uniformity of clamping pressure, reduced the chance of leakage, and minimized the risk of localized stresses causing cracks.

4.5 Performance Outcome

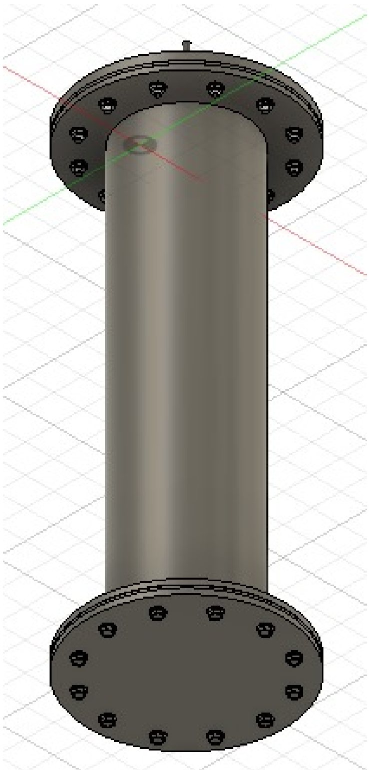
The acrylic flanges, when combined with the modified bolt-hole arrangement, provided a secure and repeatable sealing method for the prototype. Although material brittleness remained a limitation, proper bolt tightening and the use of a compressible gasket reduced the likelihood of failure and ensured watertight operation.

5 Design & Drawings

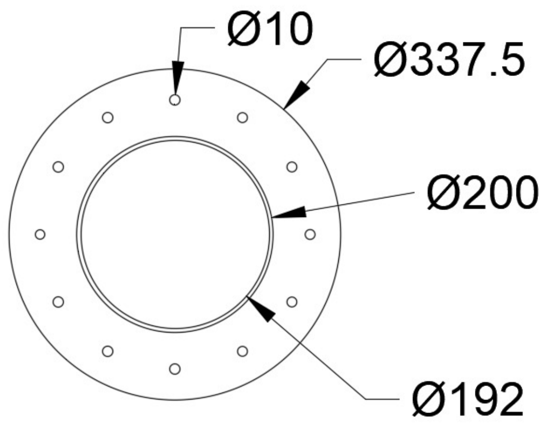
(All dimensions in mm)



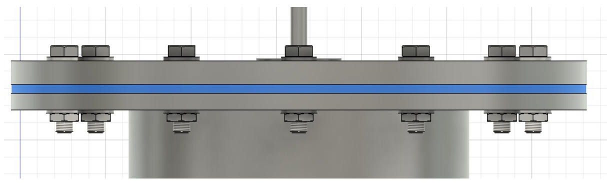
Side View of the Vehicle



Isometric View



Top View of the Vehicle (Flanges)



5mm Gasket

6 Repairs and Improvements

1. **Propeller Shaft Bearing**
   - Issue: The ball bearing connected to the propeller shaft has developed play due to repeated usage. This has resulted in water leakage through the bearing.
   - Action Required: Replace the existing bearing with a new one. Ensure the new bearing is properly aligned and securely seated. Apply an appropriate sealant to prevent water ingress from the propeller end of the submarine.
2. **Front-End Flange**
   - Issue: The hollow front-end flange attached to the submarine body has sustained damage.
   - Action Required: Remove the damaged flange and install a new hollow flange of the same dimensions. Verify that the new flange is securely fitted and sealed to maintain structural integrity and watertight performance.