

Team 520 VDR3 Prototype

December 5th, 2023

Current State of Selected Design

Team 520 has selected the sealed and insulated quick connect fuel coupler for the actively sealed cryogenic coupler project. It will involve a double poppet actuator mechanism, encapsulated seals, double wall vacuum, and multi-layer insulation. The double poppet actuator is implemented for the desired goal of quick connection and disconnection. It uses a spring-loaded actuator on each half of the coupler so that each side is sealed in the standby position, and upon mating will push open and align the flow channels to allow fueling. Encapsulated seals were chosen as they are common in aerospace applications, specifically those involving cryogenic fuels which may lead to failure in typical seals. A double-wall vacuum structure allows for the minimization of heat transfer into the coupler and cryogenic fuel by convective and conductive pathways. This features selection will help maintain the fuel at cryogenic temperatures, mitigating boil-off and any potential losses of fuel. Multi-layer insulation (MLI) was selected for the purpose of blocking radiation from entering the coupler. Radiation could augment heat transfer and potentially damage the coupler's seals. Thus, MLI will help extend the life of the seals and maintain the fuel at the desired temperature.

The current prototyping process involves a model of both coupler halves designed in SolidWorks, 3D printed, and assembled using commonly found springs. The prototype was printed at half scale and modified using sandpaper, a Dremel, drill and drill bits, super glue, and silicone-based lubricant. The prototype functions as intended, keeping the coupler halves closed at all times and only opening to align the flow channels upon mating of the two halves.

Future Work Ahead

In the upcoming weeks the team has set out a few tasks to complete to have a successful project. Firstly, we need to finalize the design. Based on the manufacturing, assembly, and testing of the first prototype, the team will further refine the design of the coupler. A second prototype incorporating seals

will be made and tested using room temperature water. Once the design is finalized, technical drawings will be produced for each part. Next task is ordering parts, our current design requires stainless steel, compression springs, Multi-Layer Insulation (MLI), and encapsulated O-ring seals. Once the material choices have been finalized and funds have been allocated, we will begin to order these parts. Next task is machining and fabrication, where we provide materials and technical drawings to the machine-shop and work with them to create our parts. From there on we will be able to assess any changes that need to be made so parts can be made. Finally cryogenic testing will need to be conducted. Our team's cryogenics engineer, Lauren Roche, is in contact with individuals at the National High Magnetic Field Laboratory (NHMFL) to coordinate testing with liquid nitrogen. Design modifications will be made if necessary to accommodate the cryostat pipe design.

Anticipated Problems

Our team expects to encounter a few possible problems that could delay our design process. To begin with, testing at the NHMFL. We anticipate it will be difficult to get the necessary training/clearance to work with liquid nitrogen. We are planning to start coordinating these tests as soon as possible to allow for this and ensure ample time for communication and planning. Another issue we predict will arise is the machine shop fabrication and turnaround time. Parts have complex geometry that will likely make it difficult to machine and fabricate as well as assemble after parts are made. Furthermore, insulation could be a problem because we will likely have to make our own insulation or locate some materials from a local laboratory, as multi-layered insulation (MLI) is expensive. Adding to that, MLI or any insulation we design will need to reflect at least 95% of the incident radiation and it could be difficult to determine how many layers are needed to fulfill that. Most MLI designs are made up of 5 to 30 layers of insulation, therefore the more layers needed would result in an increased cost.