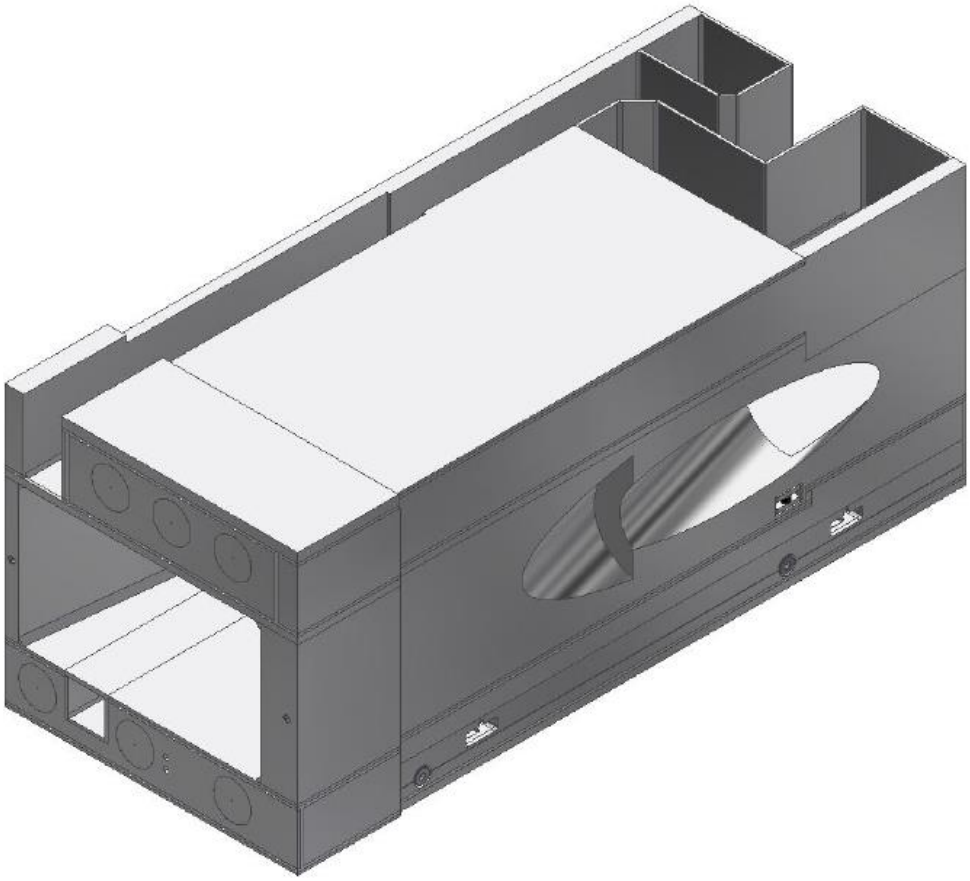
Deuterium Cryostat Plugs for NIST



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Introduction

A cryostat plug was designed for NIST's Neutron Beam Split-Core Reactor (NBSR) to hold liquid deuterium as a cool neutron source. This plug was a necessary step in NIST's shift from liquid hydrogen to deuterium to accommodate the new fuel type. The plug had to fit within the dimensions of the cool port in the reactor. The plug can be seen in the port below in figure 1. This cryostat plug, made of stainless steel, will serve as a support for the cryostat, but also as a radiation shield for the liquid deuterium source. The plug is also filled with an MS1-a mix to enhance the plug's radiation shielding capabilities. NIST required 2 of these plugs.

Figure 1. Cryostat plug in cold port

Specifications

The plug was constructed as 2 separate weldments (a top and bottom piece) that were joined by machined side pieces. Both the bottom and top weldment have channels or troughs to accommodate deuterium supply and return lines and the side pieces include channels for the neutron beam tubes. All of these materials were fabricated from 304 Stainless Steel. After welding, the plug was machined to size to meet specifications.

Once the plug fit the desired dimensions, the space between the two weldments was filled with MS1-a mix to increase radiation shielding effects. Concrete vibrators helped remove any excess water or air trapped in the mixture. The specific composition of this mix is listed below in table 2.

The plug was also designed with 4 wheels on the bottom so that the entire assembly could be rolled in and out of the cool port in the reactor and 1 guiding wheel on each side to ensure alignment with the port. Key specifications of the plugs can be viewed below in table 1. More detailed sales drawings can be viewed at the end of this report in figure 8(a-e).

Table 1. Key specifications of cryostat plug

Description	Value	Units
Height	663.5 [26.13]	mm [“]
Width	685.8 [27.00]	mm [“]
Length	1584.3 [62.38]	mm [“]
Weight (Empty)	~1300 [2866]	Kg [lbs]
Weight (w/ Concrete)	~1750[3858]	Kg [lbs]

Table 2. MS1-a fill composition, by weight

Material	Percent by Weight
Water	4.4%
Portland Cement	7.3%
Magnetite, 68% Min Fe, 400-500 avg. mesh	43.8%
S780 Steel Shot	44.5%

Assembly

The main criterion for the plug itself was that it fit the cold port in the reactor at NIST. During fabrication, dimension measurements for each part were constantly checked since size was so essential. Because these dimensions were predetermined and carefully adhered to, the plug fit, as expected, inside the cool port (this can be viewed in figure 1 above). Several iterations of measurements after the completion of assembly confirmed that the plug would fit the desired dimensional requirements. Real pictures of the plugs can be viewed in figures 2 and 3 below.

Figure 2. Cryostat plug suspended above ground

Figure 3. Second view of plug

The only other post-assembly procedure before shipping was to fill the plug with the MS1-a mixture. The process was simple enough. First, the mixture was created, and put into a concrete mixer. Once thoroughly mixed, the mixture was poured directly into the reservoir within the plug. The mix was allowed to sit overnight, and was dry by the next day. There was one complication in this filling. The calculations that determined how much mixture needed to be created resulted in ingredient weights that were slightly too low to yield sufficient mixture after hardening. Since the chamber in the plug was not entirely filled, more mixture was created and added the same morning that the first batch had hardened. This batch hardened within the day, but was left to sit until the next day. After the MS1-a mix had hardened in this second session, the plugs were ready to be shipped. A picture of the plug filled with the mixture can be seen below in figure 4.

Figure 4. Cryostat plug filled with MS1-a mixture

Conclusion

The cryostat plugs were fabricated successfully. Both have passed all quality assessment tests and been shipped to NIST. Special travelers were created to safely house the plugs as can be seen in figures 5 and 6. The plugs fit the size dimension requirements of the reactor's cool port, allowed a space for return and supply lines on the top and bottom weldments, and also had the desired channels for neutron beam tubing on the sides. The plug also had the wheels for sliding

in and out of the port and the wheels to align the plug with the port. Finally, the plug fulfilled the requirement of having eye screw holes so that it could be lifted by machinery into place at NIST. The MS1-a mixture was also created and an effective method was developed to reliably harden the filling within the plug. These plugs will effectively support the cryostat system and block radiation from the cold neutron experiments. The plug can be seen loaded with the fuel source in figure 7.

Figure 5. Plugs on a traveler

Figure 6. Plugs ready for shipment

Figure 7. Cryostat plug supporting fuel source

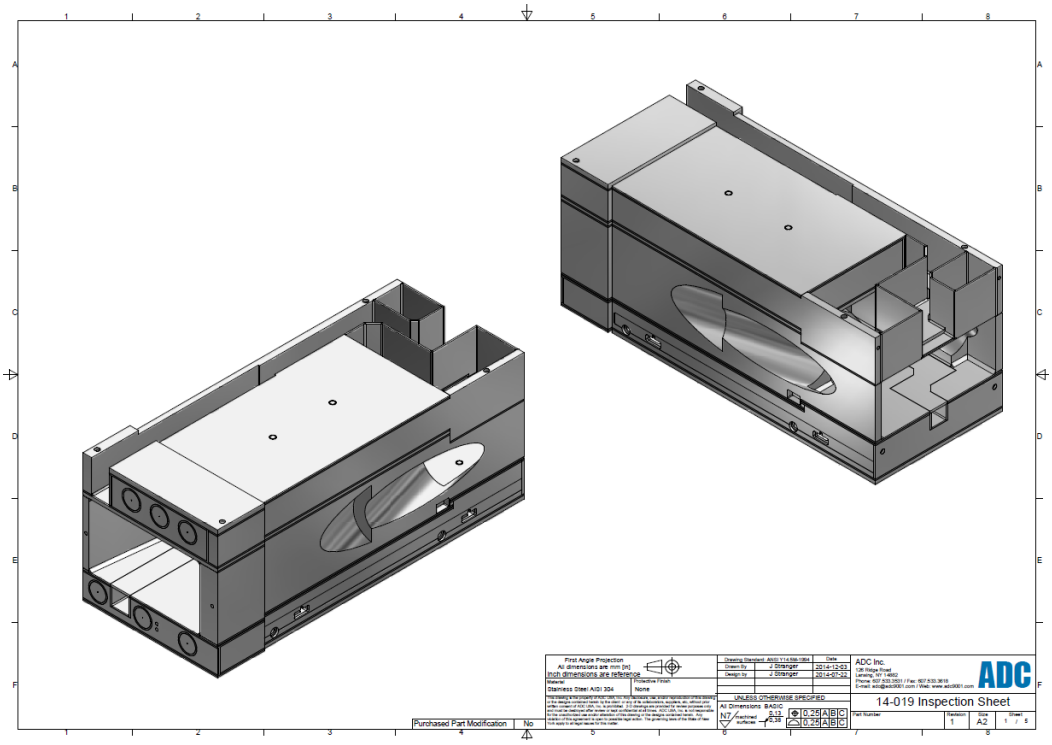

Figure 8a. Plug detailed drawings

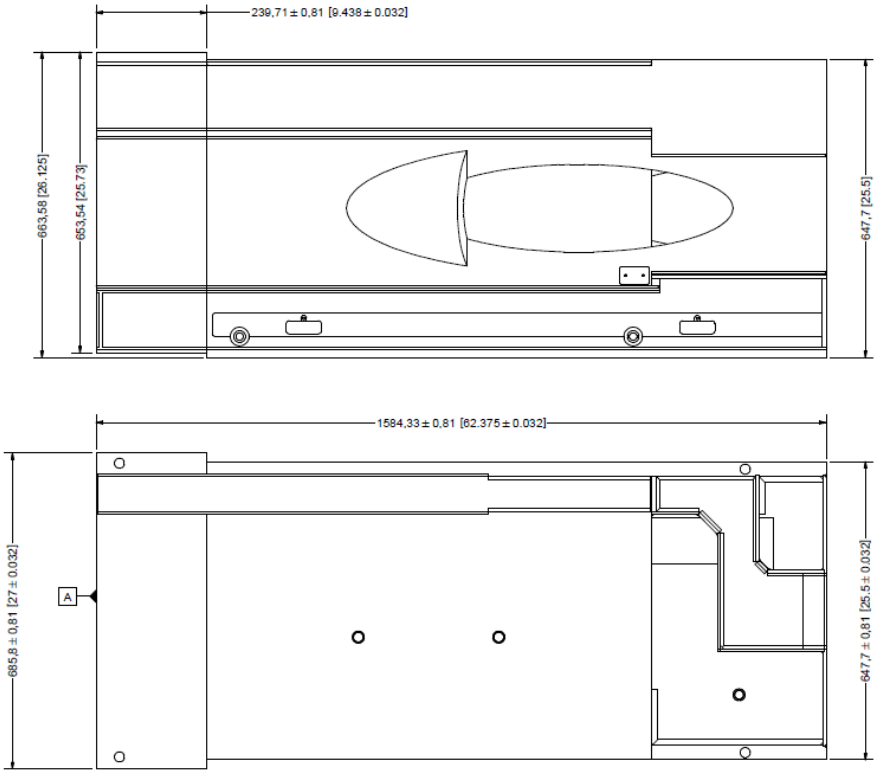

Figure 8b. Plug detailed drawings

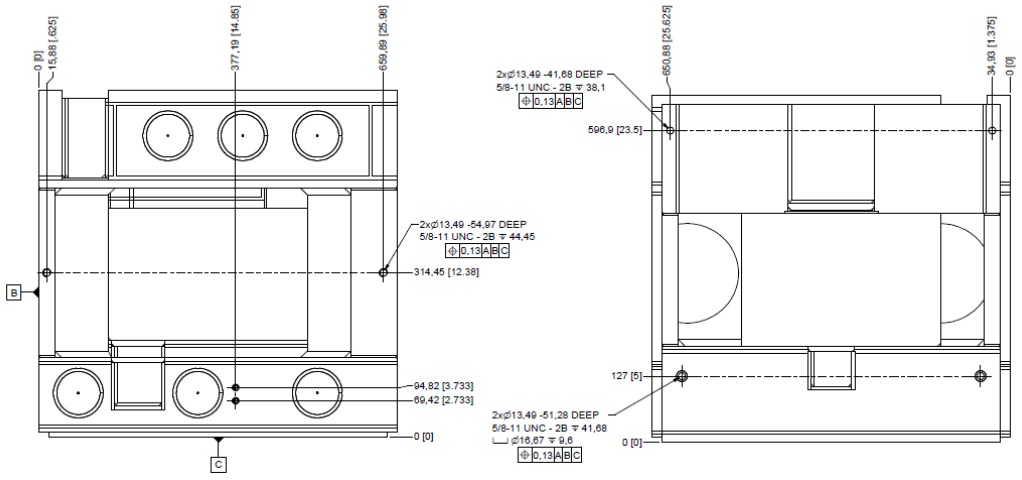

Figure 8c. Plug detailed drawings

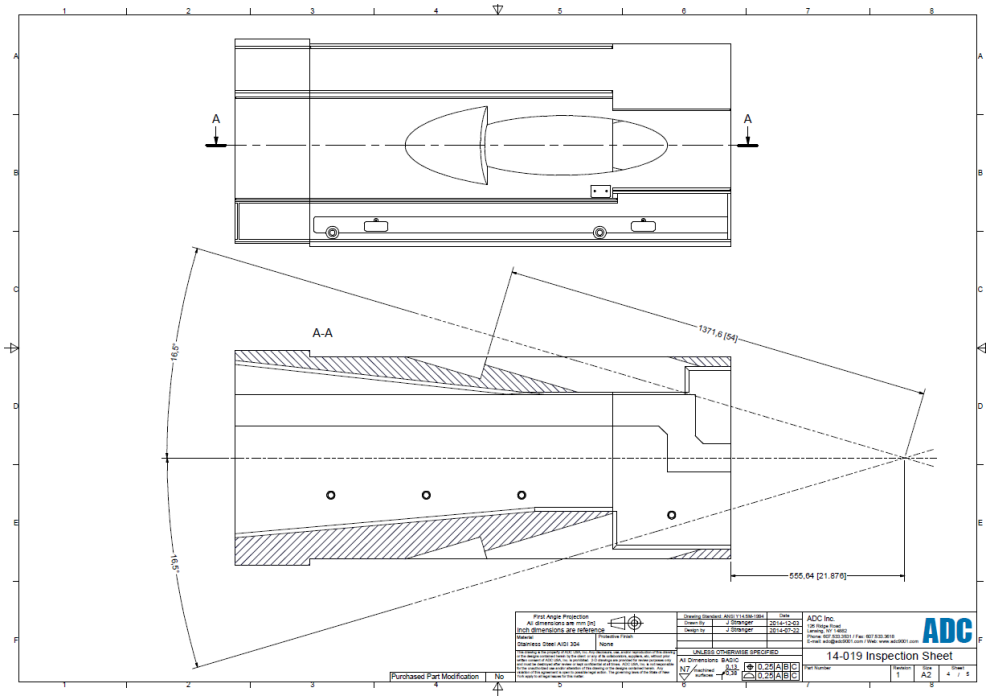

Figure 8d. Plug detailed drawings

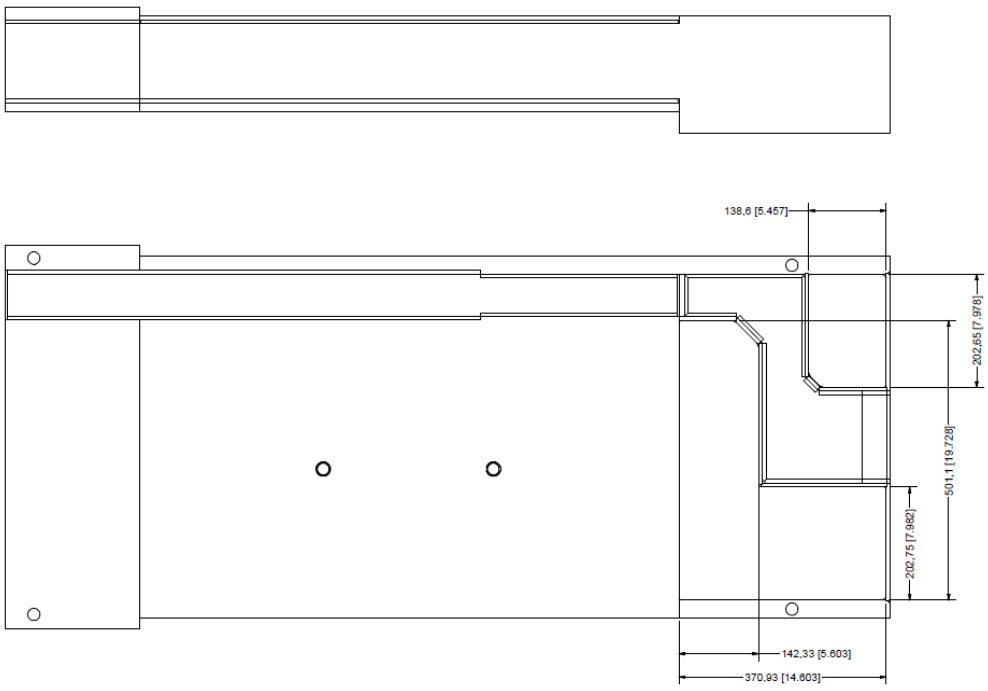

Figure 8e. Plug detailed drawings