INL/CON-22-67059-Revision-0

Dry Heatsink Capsule and Large Irradiation Test Vehicle Design for TREAT

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Changing the World's Energy Future

Idaho National Laboratory

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Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract 103710201

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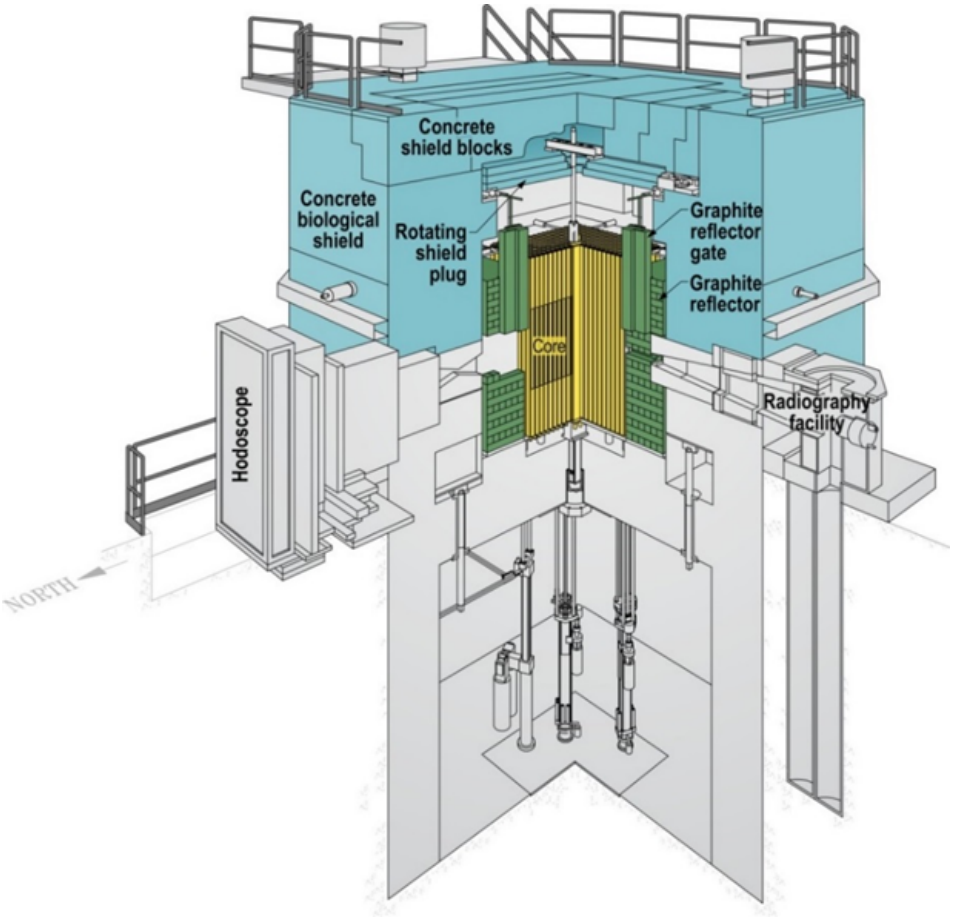
Dry In-Pile Fracture Test (DRIFT) Capsules

- Fracture is an important component of nuclear fuel behavior, and significant efforts have been invested into developing fuel performance models that are capable of accurately representing fracture. Usable data on the process of fracture propagation in nuclear fuel under realistic service conditions are very limited. To address this need, a series of separate-effects experiments were developed and performed at Idaho National Laboratory (INL)'s Transient Reactor Test (TREAT) facility.
- These experiments employ a heat sink to remove radial heat from the fuel in a manner that approximates the effect of coolant in an operating light-water reactor (LWR). The test holder for these experiments is known as the Dry In-pile Fracture Test (DRIFT).
- A series of experiments employing DRIFT and TREAT were performed to provide data on the extend and nature of the fracture in fresh fuel at various points during a ramp to full power. Novel aspects of these experiments include the way they employ a heat sink to replicate steady-state LWR conditions, as well as the use of fiber optic sensors for in-reactor thermal instrumentation.

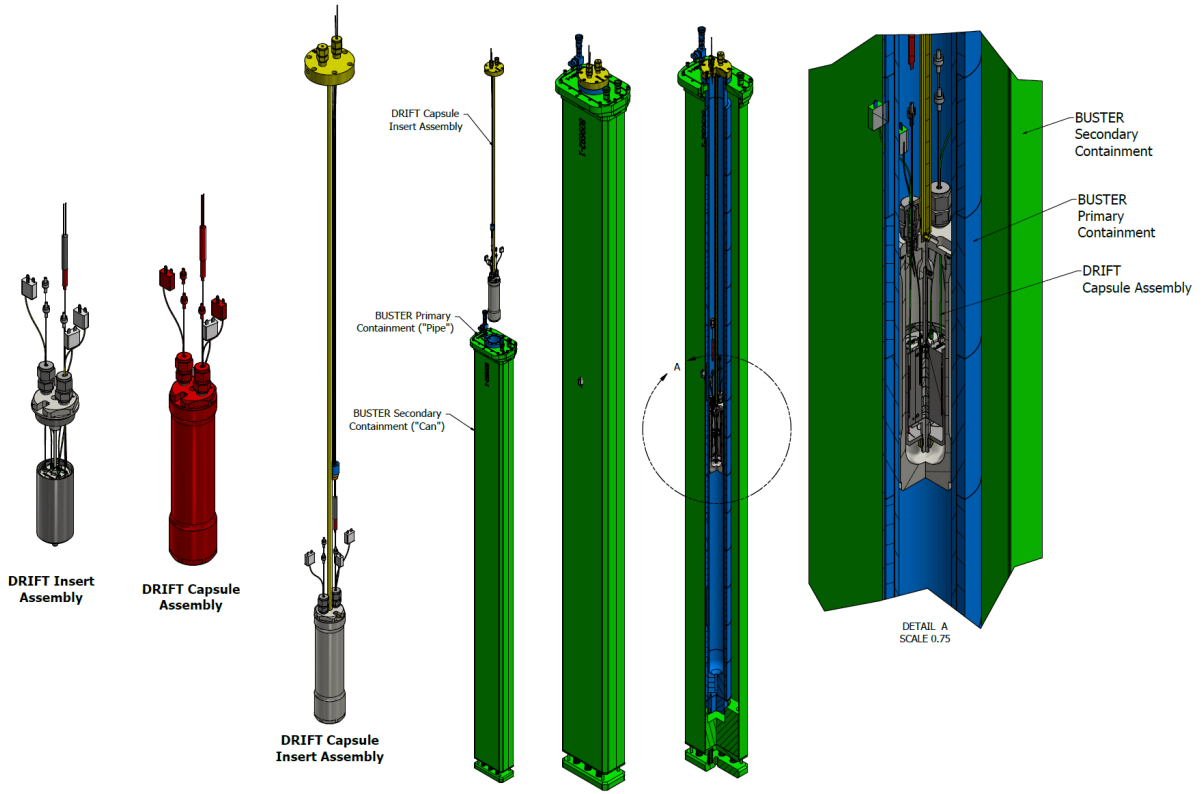
TREAT Reactor and Test Holders

- The TREAT reactor provides a unique environment that is well suited to the type of experiment conducted for this study.
- TREAT is an air-cooled reactor that uses fuel elements consisting of zirconium alloy canisters that contain graphite blocks with a dilute dispersal of UO_2 fuel.
- The graphite absorbs the heat from the fuel, and hydraulically driven control rods can be programmed to generate a wide variety of transients.
- Because the graphite matrix absorbs the heat from the transients there is no need for a liquid coolant to circulate through the core.
- This allows for experiments to be inserted into the core by removing a small number of fuel elements in the center of the core and then replacing them with a test holder along with the instrumentation.



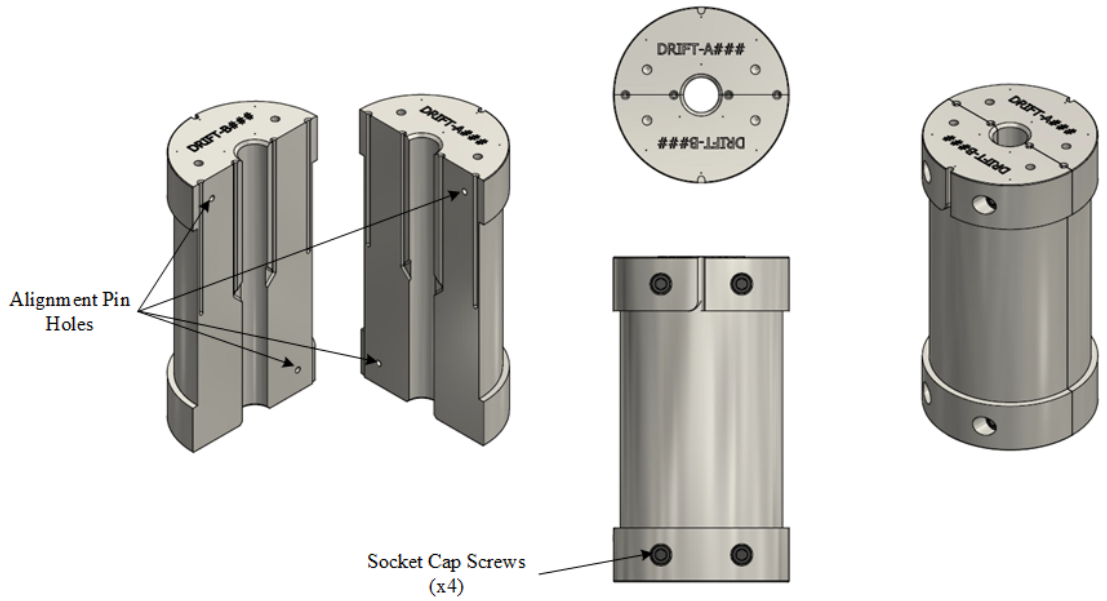
DRIFT capsules

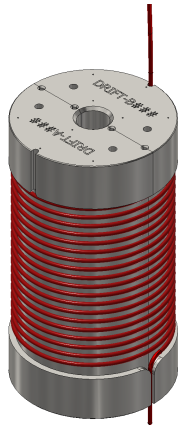
- The DRIFT capsule is a heat sink-based irradiation test device that contains a fueled specimen and instrumentation for fuel and heat sink temperature measurement.
- The DRIFT capsule will use the previously designed Separate Effects Test Holder (SETH) capsule top and bottom to encapsulate DRIFT-specific hardware.
- Therefore, the DRIFT capsule will be compatible with the Minimal Activation Retrievable Capsule Holder (MARCH) System at TREAT, which includes the Broad Use Specimen Transient Experiment Rig (BUSTER) containment system.



DRIFT capsule Heat Sinks

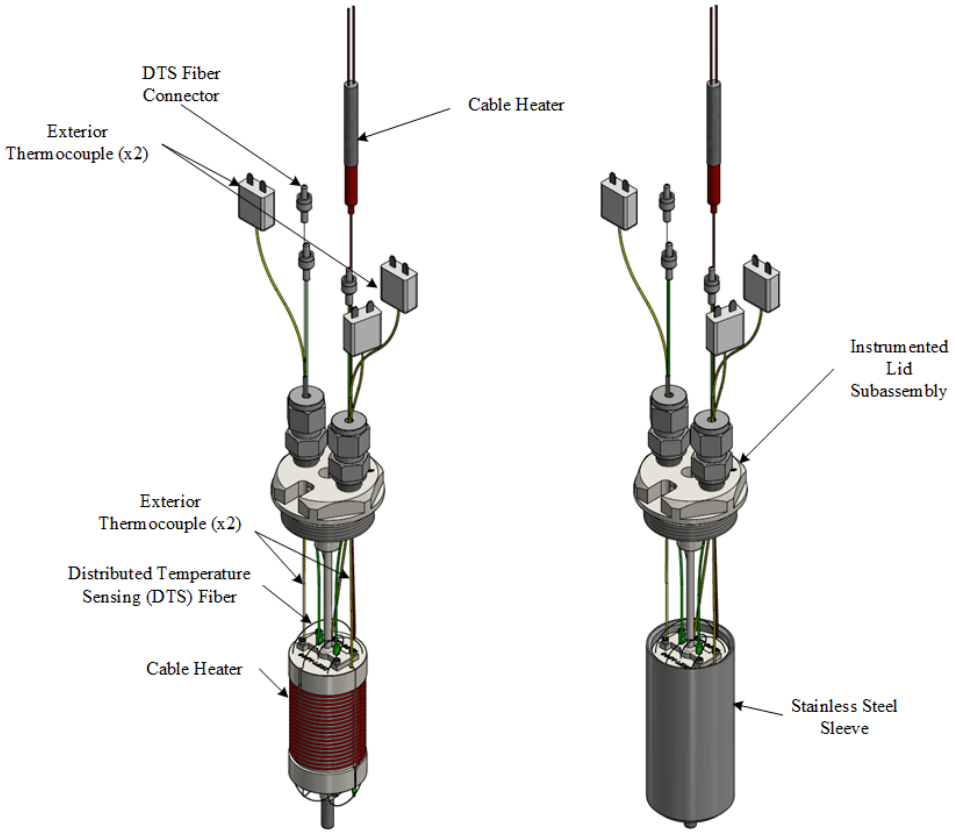
- The DRIFT test holder (heat sink) consists of a thick, annular, alloy 316 stainless steel cylinder
- Precision machined bore that is designed to contain a stack of UO2 pellets typical of those used in LWR Fuel
- The cylinder is split into two halves along its axis using wire EDM and held together by 4 cap screws and alignment dowel pin holes.
- Multiple wire EDM holes are “punched” through the heat sink for instrumentation as well as machined grooves for “windows” that allow the instrumentation to see the loaded fuel.
- The heat sink is machined on its outer diameter to provide an area for a 110W cable heater to be installed to allow uniform pre-transient fuel and heat sink temperatures.





DRIFT Capsule Instrumentation

- DTS Fiber
- Exterior Heater Type K thermocouples
- Centerline Type K thermocouple
- Pyrometers

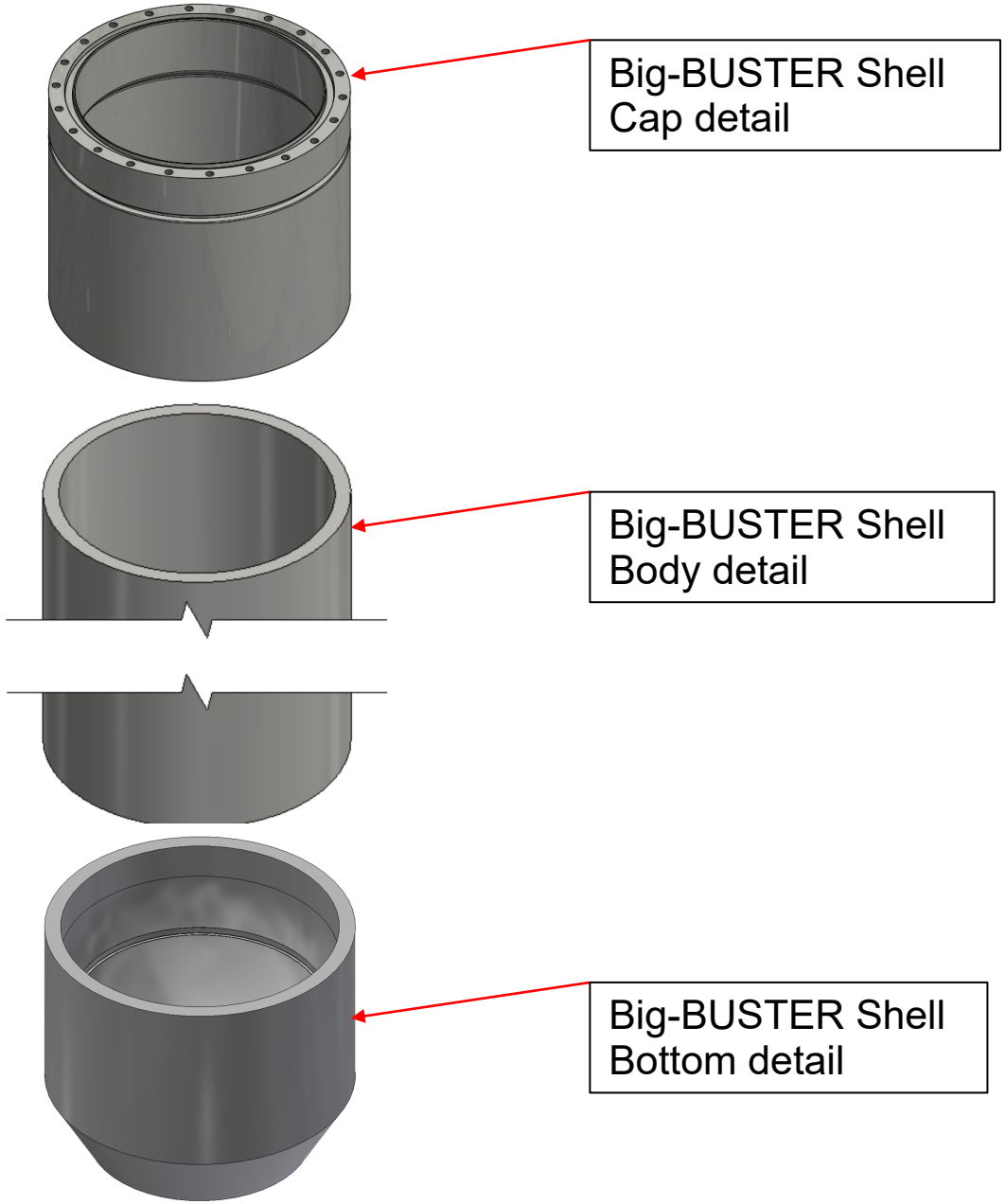


Large Irradiation Test Vehicle: Big-BUSTER

- The Transient Reactor Test facility (TREAT) successfully resumed reactor operations late 2017. Since then several irradiation experiments have been performed in TREAT using the Minimal Activation Retrievable Capsule Holder (MARCH) irradiation vehicle system.
- The foundation of the MARCH system is a stainless steel containment structure referred to as the Broad Use Specimen Transient Experiment Rig (BUSTER).
- Based on the success of the MARCH system, an enlarged containment structure referred to as Big-BUSTER has been designed to support TREAT experiments in need of larger test articles.
- Big-BUSTER is constructed primarily from nuclear grade zirconium 2.5% niobium (Zr-2.5Nb) alloy for neutronic reasons.

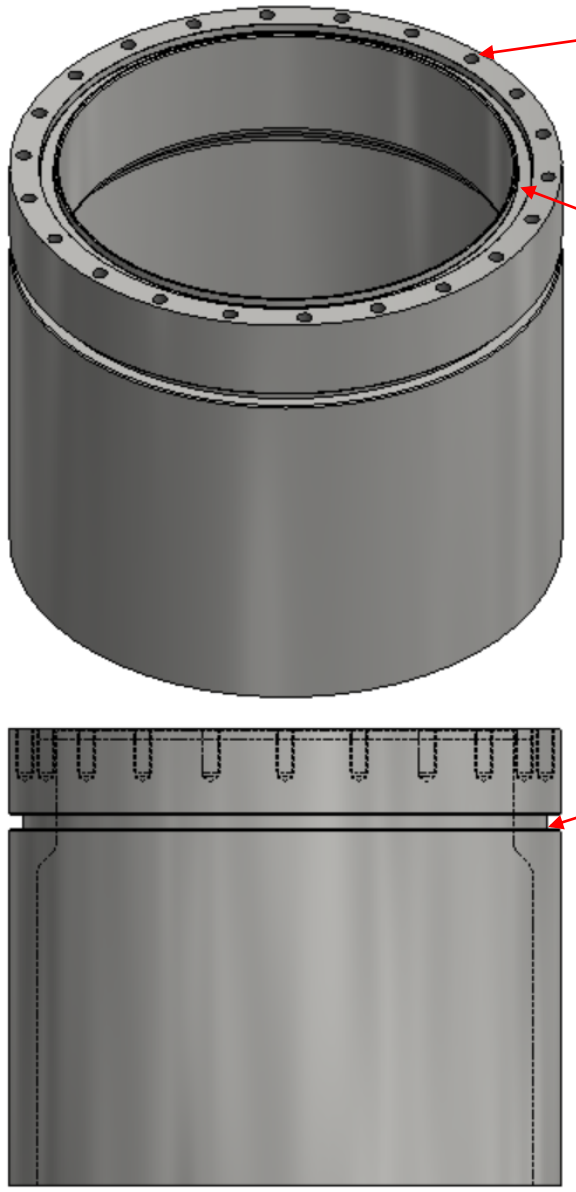
Big-BUSTER Shell Weldment

- Big-BUSTER's shell weldment is made from three separate machined and extruded parts, Shell Cap, Shell Body, and the Shell Bottom
- Material of use is Zr-2.5Nb
- Shell cap and shell bottom will be machined from Zr-2.5Nb barstock
- Shell body will be extruded into pipe form from Zr-2.5Nb
- Big-BUSTER's shell weldment will be Electron Beam (EB) welded together



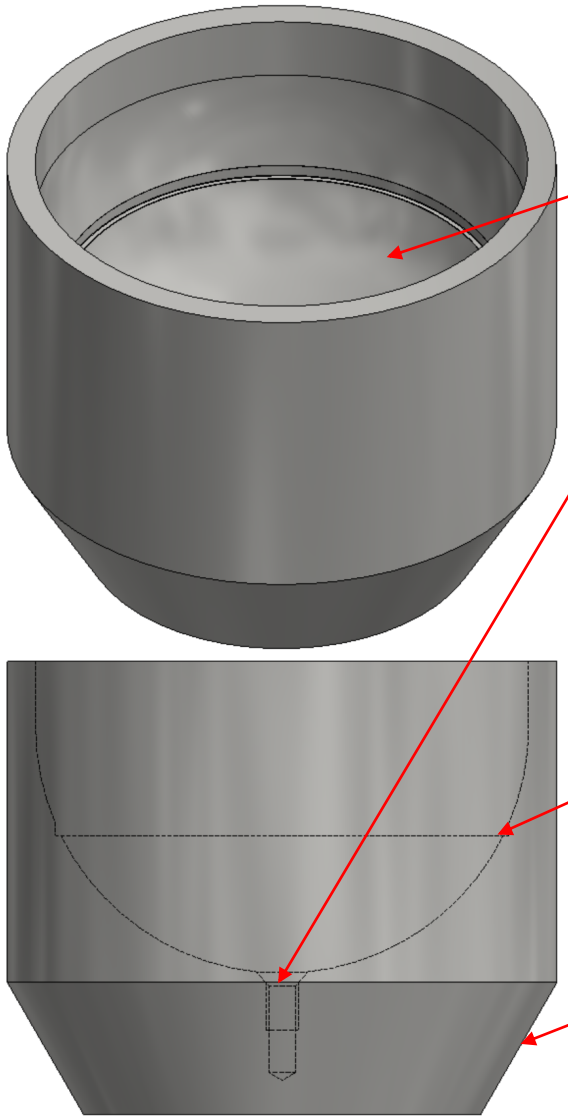
Big-BUSTER Shell Cap Details

- Big-BUSTER's shell cap has 22 5/16-24 UNF threaded holes for fastening the adapter flange and any future flange/hoods that may be used with Big-BUSTER
- A ¼" groove will be machined into the shell cap for future clevis type devices
- The O-ring groove that is machined into the Big-Buster Cap is capable of using either a Neoprene O-Ring, or a metal C-Ring dependent on thermal needs.



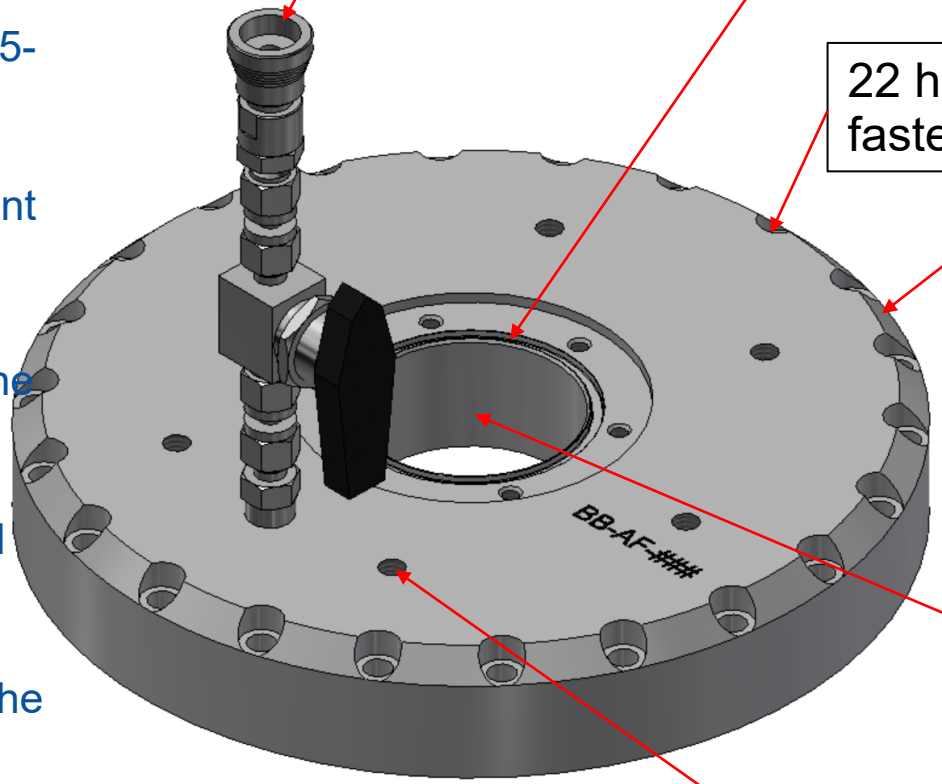
Big-BUSTER Shell Bottom Details

- Big-BUSTER's shell bottom has a conical interior with a 9/16-12 UNC threaded center hole for possible future alignment purposes.
- A notched section (a shelf) will be machined into place to provide an interface for other experiment-specific hardware.
- A large chamfer is machined into the shell bottom to allow for minimal hang ups as well as to sit flush with the grid plate and clearance for existing half-assembly grid plate inserts.



Big Buster Adapter Flange Details

- Big-BUSTER's adapter flange will be made from 1.5-in thick, 316/316L stainless steel.
- The adapter flange is used to complete hydrostatic and/or leak testing for Big-BUSTER's shell weldment
- The adapter flange will be held in place by 22 Inconel 718 fasteners
- There are an additional 6 ¼-20 threaded holes in the adapter flange for future hoisting and rigging.
- Big-BUSTER's adapter flange and test flange will both use quick connect fittings and a Swagelok ball valve (same valves used reliably with small-BUSTER)
- Big-BUSTER's adapter flange's center opening is the same size as existing small-BUSTER experiments and contains the same O-ring groove and dimensions for placement of existing small-BUSTER experiments



Plumbing fixtures

O-Ring Groove for Test Flange/existing small-BUSTER experiments

22 holes for Inconel-718 fasteners

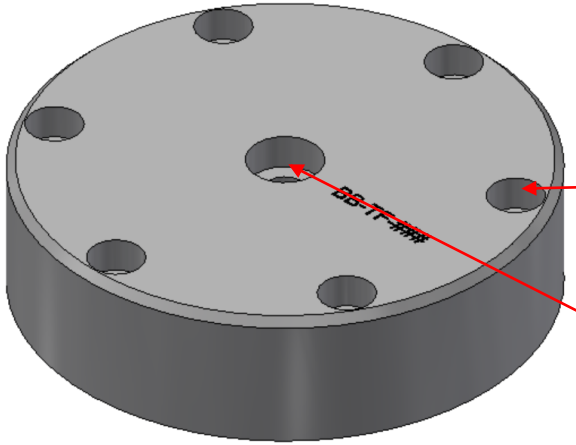
Chamfered edge

Large Center opening for Test Flange and possible use of existing small-BUSTER experiments

Additional ¼-20 threaded holes for hoisting and rigging

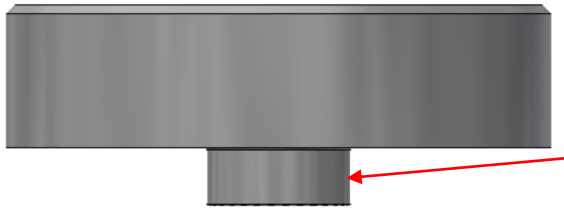
Big-BUSTER Test Flange

- Big-BUSTER's test flange's primary use is for hydrostatically and/or leak testing the Big-Buster Shell weldment and Adapter flange
- The test flange is made from 1-in thick 316/316L stainless steel.
- The test flange has six holes for mounting to the adapter flange
- A center opening will be machined to allow for plumbing fixtures to be affixed for hydro/leak testing

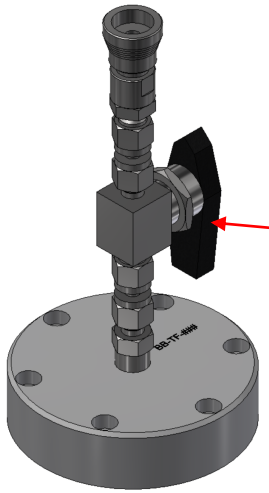


6 holes for connection to adapter flange

Center opening for plumbing fixtures



Extrusion to protect mating surface from marring or scratching



Plumbing Fixtures

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