**Environmental Impact Justification worksheet**

John Hansknecht, Center for Injectors and Sources. 8-9-2012

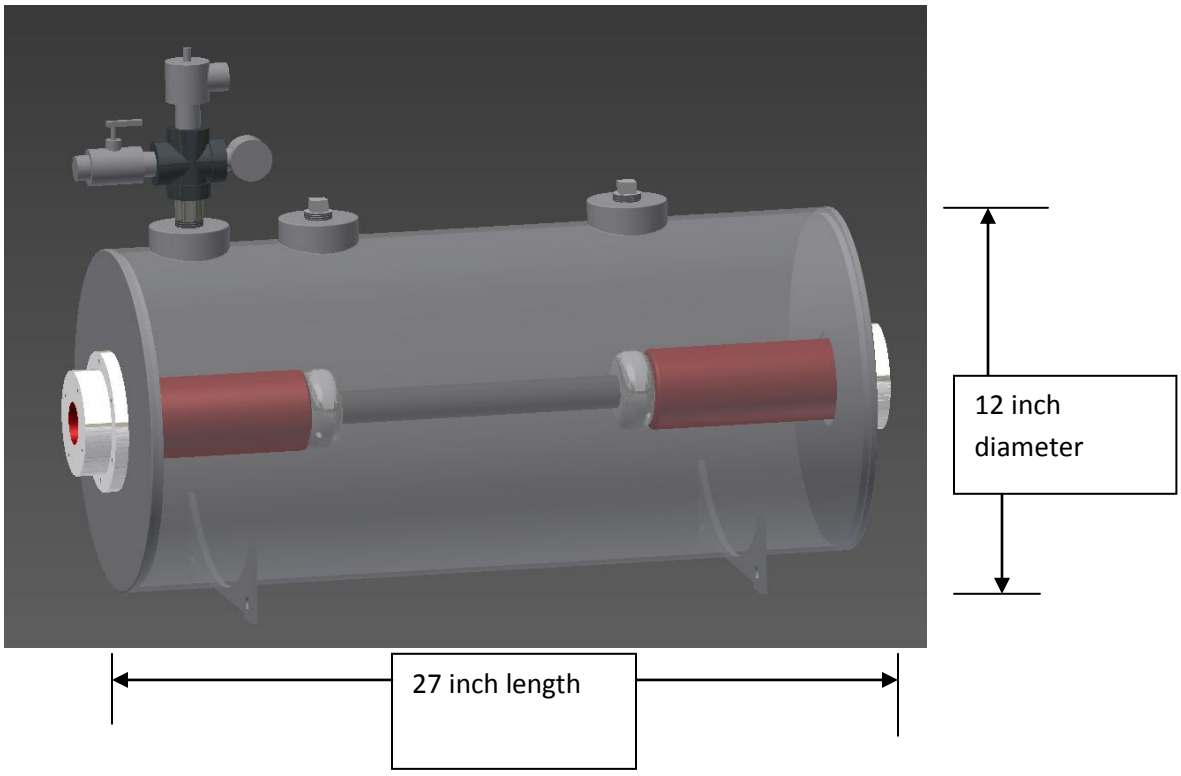
hansknec@jlab.org Phone extension 7096

We are preparing a tank that will hold a high voltage resistor rated for 150,000 volts. The chamber walls provide a grounded safety boundary that allows the resistor to sit in our test areas without an electrical safety concern. The tank is sealed and uses commercial R28 connectors that accept our standard high voltage cables.

Since our systems run up to 250,000 volts, we must fill this tank with 10psig of Sulfur Hexafluoride (SF6) to increase the effective path length of the resistor to prevent arc-over. In the past, our group has used Shell Diala high voltage oil, but we find the oil to be problematic in a number of ways.

1. The oil does not adequately increase the effective path length for surface tracking. SF6 is known to provide much better tracking resistance due to its electronegative properties.
2. The oil has a dipole moment that can cause large pressure waves when an arc occurs in a downstream test. These pressure waves have fractured resistors in some of our previous tests.
3. When a fracture has occurred, the oil is "burned" by the high voltage arc and must be discarded. This is likely a larger environmental impact than simply filling the tank with SF6 that is easily recovered and filtered.

The image below shows a drawing of the tank.



The tank is not a “Pressure Vessel” since it is protected from over-pressure with an ASME section IV rated pressure relief valve. Our tank will also be fitted with a compound gauge that can monitor the tank during pump-down, pressurization, and sealed storage.

Volume Data:

12” Diameter Cylinder 27” long = 3053cu-in

3” Diameter sockets 6.75” long = 48 cu-in each. (two = 96 cu-in volumetric displacement)

Aluminum resistor mounts total 13 cu-in volume displacement.

Resistor (hollow) displaces 3.6 cu-in.

Total internal volume = 3053-96-13-3.6 = 2940.4 cu-in.

1728 cu-in per cu-ft gives 1.7 cubic foot total internal volume.

Pressure of SF6 = 10psig (24.7 psia) The gas pressure correction factor at 10psig is 1.656, so total volume of SF6 at 10psig is (1.7 cu-ft * 1.656) = 2.82 cubic feet.

With a vapor expansion of 2.2 cubic feet per pound of weight, the weight of the 2.82 cubic feet of gas is 1.28 pounds.

Thermal Expansion concerns:

The tank will be at normal room temperature at all times. The resistor “heating” effect during operation would be minimal. The maximum current through the 100MOhm resistor will be 1 uA, corresponding to an electrical power load of 100W, comparable to the power produced from a tungsten filament light bulb. But even this condition would exist only briefly (minutes). Typical current passing through the resistor will be at picoampere levels, generating power at just fractions of a watt. It will not be possible to heat this gas volume to a point where it could reach a pressure to lift the relief.

SF6 ODH analysis:

SF5 is over 5.5 times heavier than air. If the pressure relief “leaked” or the valve were opened by accident, 1.7 cu-ft of SF6 would stay in the tank under its own weight and 1.12 cu-ft of gas would be released. This gas would fall to the floor and dissipate like water into the surrounding space forming a layer of gas that is virtually undetectable in thickness in a typical work space floor area of 12 by 12 feet. For that matter, even if the tank is turned vertically and dumped of its entire 2.82 cu-ft of volume, the resulting SF6 in the room is not an ODH hazard.

SF6 Environmental impact:

SF6 is a strong greenhouse gas and generally banned for use in all applications except for high-voltage switchgear where the benefits are known to outweigh the risk of damage to the environment. As with many other halogenated refrigerants, there are common safe practices that allow filling and recovery of

the gas without release to the environment. One such practice being employed by the JLAB FEL is the pumping of the SF6 as a gas into a large bag that can hold the gaseous volume. Another method we hope to use in the near future is a commercial recovery system that can evacuate the gas and pressurize it to the critical pressure of 37.59 Bar (530psig) where it will return to a liquid state for storage in a standard gas bottle. This method provides a purification and filtration ability that does not exist when using the bag method of storage.

**Our proposed operations:**

1. We will pressurize the tank with 10psig of air and ensure it is leak tight before performing additional steps.
2. We will evacuate the tank to 10 Torr to remove 99.9% of the air in the tank
3. The vacuum apparatus will be valved off.
4. We will use a cylinder of SF6 gas with a regulator attached.
5. The regulator will be adjusted for a local reading of 11psig
6. The valve will be opened to admit SF6 gas to the evacuated volume.
7. The valve will be closed to seal off the volume.
8. We anticipate operating the tank for years without venting the gas. Our installed pressure gauge will warn us of any gas loss.
9. If the tank must be vented for maintenance, we will use a proper recovery method to ensure gas is not released to the environment. We fully expect to own a recovery system within a year. If we must open the tank but do not own a recovery system, there are ways of connecting our tank to the FEL recovery system to move our gas volume into the FEL bag.

Attached below are details of some of the tank pressure validation and retention materials.

# APOLLO Safety Relief Valve, 3/4 x 3/4 In, 15 PSI

Plumbing > Valves > Relief Valves

☆☆☆☆☆ | Write a Review | Read all Reviews | Read all Ask & Answer

Safety Relief Valve, Inlet/Outlet 3/4 x 3/4 In, M x FNPT Connection, Material of Construction Cast Bronze, Preset Setting 15 PSI, Pressure Range 5 To 15 PSI, Disc Material EPDM, Spring Material SS, Seat Material EPDM, BtuH Rating 475, 000, Temp Range 250 F, Height 1 13/16 In, Standards ASME Section IV, CRN

| | |
|---|---|
| Grainger Item # | 3EEY2 |
| Price (ea.) | **$54.00** |
| Brand | APOLLO |
| Mfr. Model # | 13211B15 |
| UNSPSC # | 40141606 |
| Ship Qty. | 1 |
| Sell Qty. (Will-Call) | 1 |
| Ship Weight (lbs.) | 1.08 |
| Availability | **Ready to Ship** |
| Catalog Page No. | 4214 |
| Country of Origin<br>**(Country of Origin is subject to change.)** | USA |

# Compound Gauge, 1 1/2 In, Vac to 30 Psi

Test Instruments > Pressure and Vacuum Measuring > Pressure and Vacuum Gauges

☆☆☆☆☆ | Write a Review | Read all Reviews | Read all Ask & Answer

Compound Gauge, Dial Size (In.) 1-1/2, Range 30" Hg Vac to 30 psi, -100 to 200 kPa, Dial Size (mm) 40, Connection Size 1/8" NPT, Connection Location Back, Smallest Graduation (PSI) 1, Smallest Graduation (In. Hg) 2, Accuracy (%) +/-3-2-3, Case Material ABS Plastic, Case Color Black, Socket Material Brass, Tube Material Bronze, Lens Material Acrylic, Ring Material Crimped Stainless Steel, Operating Temp. Range (F) -40 Degrees to 150 Degrees , Manufacturers Warranty Length 1 Year

| | |
|---|---|
| Grainger Item # | 4FLZ3 |
| Price (ea.) | **$10.64** |
| Brand | GRAINGER APPROVED VENDOR |
| Mfr. Model # | 4FLZ3 |
| UNSPSC # | 23151820 |
| Ship Qty. | 1 |
| Sell Qty. (Will-Call) | 1 |
| Ship Weight (lbs.) | 0.12 |
| Availability | **Ready to Ship** |
| Catalog Page No. | 804 |
| Country of Origin<br>**(Country of Origin is subject to change.)** | China |


Enlarge Image

Qty.

# APOLLO Ball Valve, 1/2 In NPT, Cast Bronze

Plumbing > Valves > Ball Valves

☆☆☆☆☆ | Write a Review | Read all Reviews | Read all Ask & Answer

Ball Valve, FNPT Connection, Max. Pressure 600 psi WOG, 150 psi WSP, Material of Construction Bronze, Seats PTFE

| | |
|---|---|
| Grainger Item # | 6KK49 |
| Price (ea.) | **$12.06** |
| Brand | APOLLO |
| Mfr. Model # | 7010301 |
| UNSPSC # | 40141607 |
| Ship Qty. | 1 |
| Sell Qty. (Will-Call) | 1 |
| Ship Weight (lbs.) | 0.55 |
| Availability | **Ready to Ship** |
| Catalog Page No. | 4174 |
| Country of Origin<br>**(Country of Origin is subject to change.)** | USA |