



The region around the quartz jar and expansion chamber is filled with propylene glycol, a transparent, non-toxic alcohol, with low compressibility and low vapor pressure. The glycol serves triple duty as a hydraulic fluid, constant temperature bath and neutron moderator.

The pressure of the bubble chamber is controlled with a hydraulic compression skid that is connected to the top plate of the outer vessel through a 1.5" hydraulic hose. This mechanism allows the pressure of the Outer Vessel to be rapidly cycled by injecting or withdrawing small amounts of glycol. The pressure is transmitted into the inner vessel by motion of the dished head and bellows of the expansion chamber.

The outer vessel has viewing ports around the quartz jar for taking photographs with CCD cameras. After later consideration of optics, only one 6" window will be used with multiple cameras. The other two windows will be blanked. LED arrays are mounted inside the glycol volume opposite the camera window. A diffuser panel hangs between the LED array and the jar. The diffuser panel provides a uniform back lighting for the bubble photography.

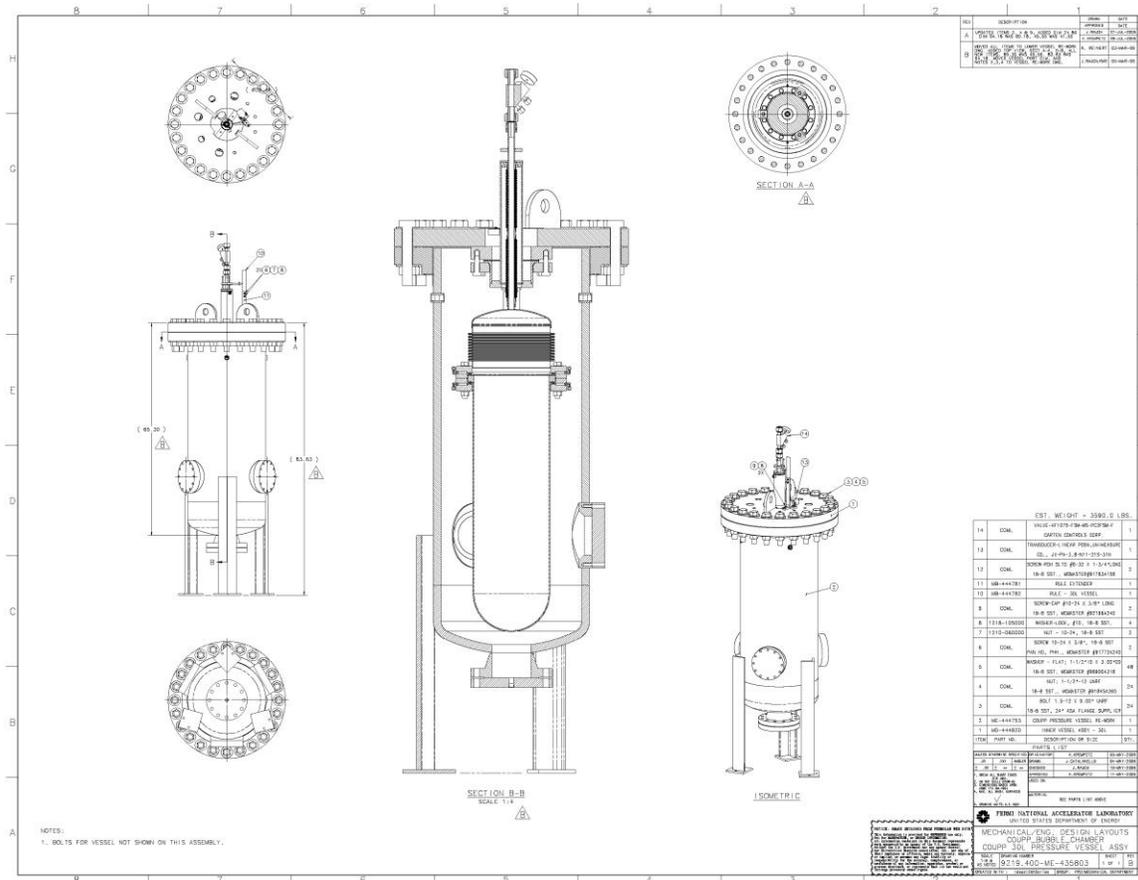


Figure 2. Engineering drawing of inner bubble chamber and Outer Vessel.

Note: This document is edited for 60kg version from 2 kg operating procedure written by Andrew Sonnenschein, April 9, 2005.



**Picture 1. Inner bubble chamber hanging from lid**

Note: This document is edited for 60kg version from 2 kg operating procedure written by Andrew Sonnenschein, April 9, 2005.



**Picture 2. Outer vessel assembly and Hydraulic recompression cart.  
(Process hoses are not attached.)**

## **2. Operation of the hydraulic system**

The bubble chamber is connected via a large diameter (1.5" ID) hydraulic hose to a hydraulic cylinder and a small hydraulic pump. The hydraulic cylinder is used for fast pressure cycling (< 100 msec). The small hydraulic pump is used for slow pressure control and piston positioning in the compressed state. The small hydraulic pump is needed to compensate for temperature/volumetric changes in the bulk glycol fluid and bubble chamber fluid, CF3I.

The hydraulic cylinder piston is mechanically driven by a larger diameter air cylinder. The area ratio of the air cylinder to hydraulic cylinder is 4:1. When the bubble chamber is in the compressed state, the compressed air pressure is maintained at 50 psig to yield 200 psig hydraulic pressure. When the bubble chamber is decompressed, the air pressure is released from the air cylinder and the hydraulic glycol system decompresses to a lower pressure. The hydraulic piston is fully retracted at this decompressed state. The small hydraulic pump slowly withdraws or adds liquid glycol to control the decompressed pressure at a specified low pressure. The low pressure set point will be changed in a

Note: This document is edited for 60kg version from 2 kg operating procedure written by Andrew Sonnenschein, April 9, 2005.

controlled step-wise fashion in the range of 5 psig to 80 psig for physics reasons. The CF3I (at 40 C or 50 C) is in the superheated state at pressures below 90 psig.

Bubble growth in the CF3I is a trigger for the fast recompression. Bubble growth can be sensed visually by camera trigger or by a fast analog pressure rise signal. Upon that trigger (or other assorted interlocks), a fast opening solenoid valve switches the air supply from a vent to the pressurized air tank. Air quickly pressurizes the air cylinder which in turn quickly transmits the force and pressurizes the glycol side.

### **3. Bubble chamber bellows operation**

The CF3I fluid is transferred into the bubble chamber via distillation at a temperature of 1 C. The volume of the 40 kg of CF3I is 36 liters at this temperature. Water is then distilled in to top off the bubble chamber volume. During the filling process, the expansion bellows is controlled at a compressed position, -2.0" (0.0" is the bellows free length). This is done by pressurizing the hydraulic glycol side of the system to 5 psid above the bubble chamber pressure. The bubble chamber volume is sealed after filling. The pressures are maintained at 200 psig. The system is then warmed to the operating temperature of 40 C. The expansion bellows expands from -2.0" to -0.1" as the 36 liters expands to 39.6 liters volume. To operate the system at 40 C, the pressure is released as described in a previous paragraph. The expansion bellows grows from -0.1" to +0.1" when the pressure is decreased from 200 psig to a pressure of 80 psig or less. The volume of the CF3I is approximately 40.0 liters at this state. The CF3I is superheated. When bubble formation is sensed, the fast recompression is triggered and the hydraulic cylinder quickly compresses the CF3I back to 39.6 liters volume and 200 psig. After a brief hold time at pressure, the system is de-compressed to start the cycle anew.