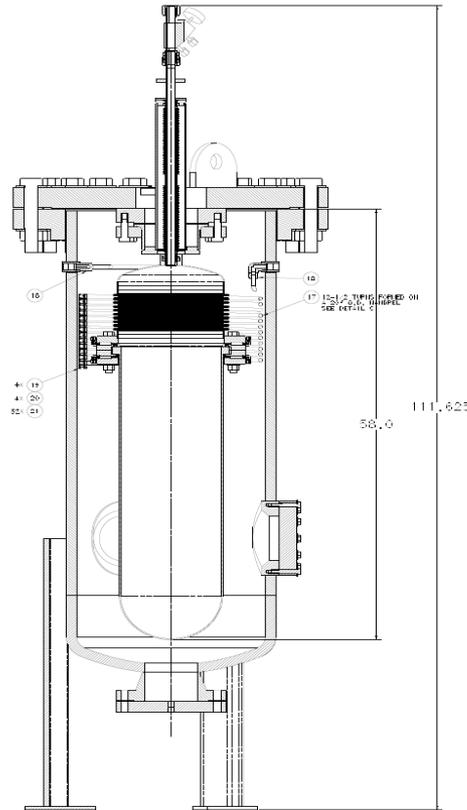


# WBS 1.1 Bubble Chamber

– Status: Mechanical prototype done. HP version fabrication complete. Final cleaning & assembling of HP version left to go



Empty PV with no lid

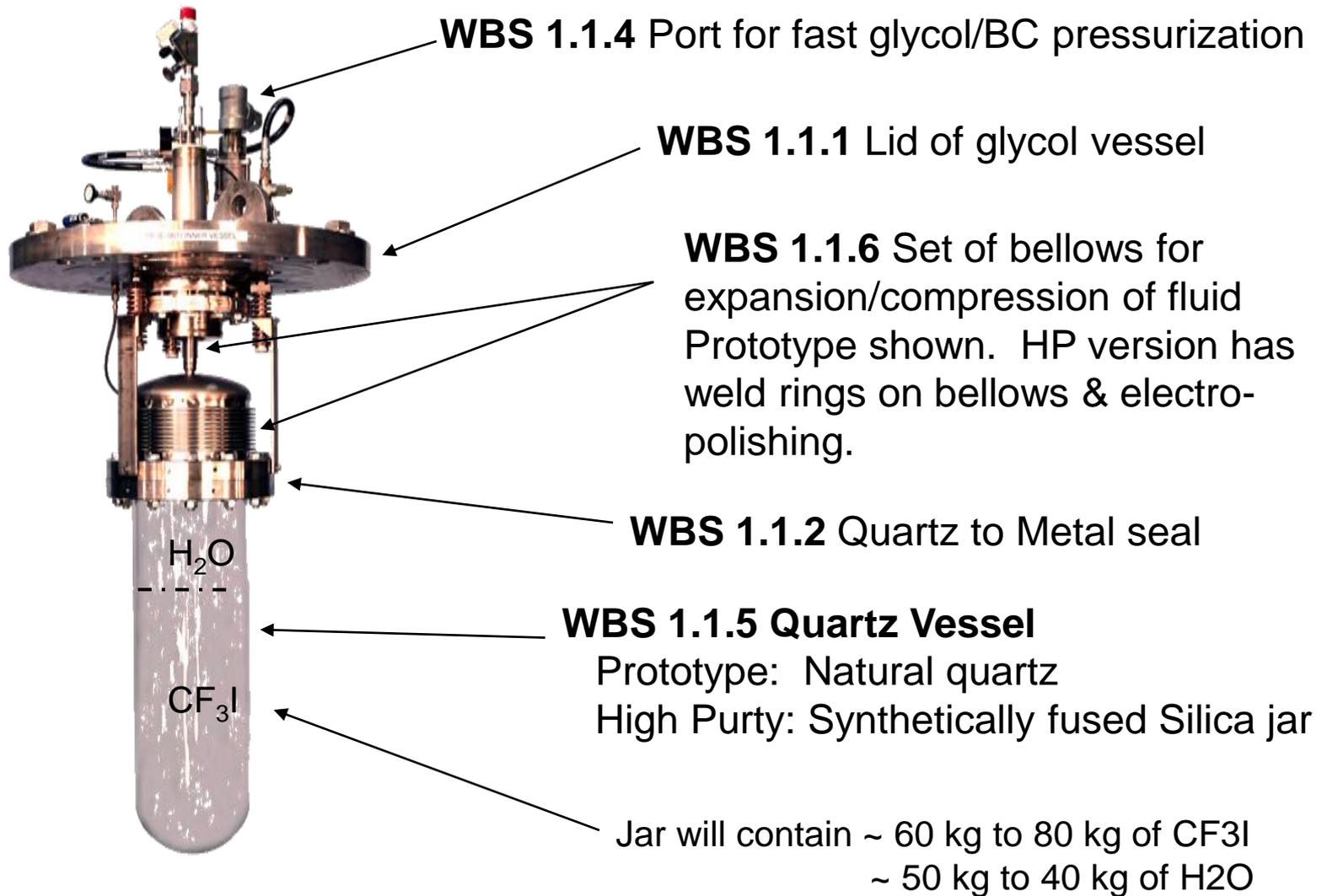


Drawing of BC nested in PV



BC superimposed on PV  
BC Photo Credit: FNAL/VMS, Reidar Hahn

# WBS 1.1 COUPP-60 Bubble Chamber



## WBS 1.1.1 PRESSURE VESSEL

– Used for hydraulic pressure control of the bubble chamber fluid

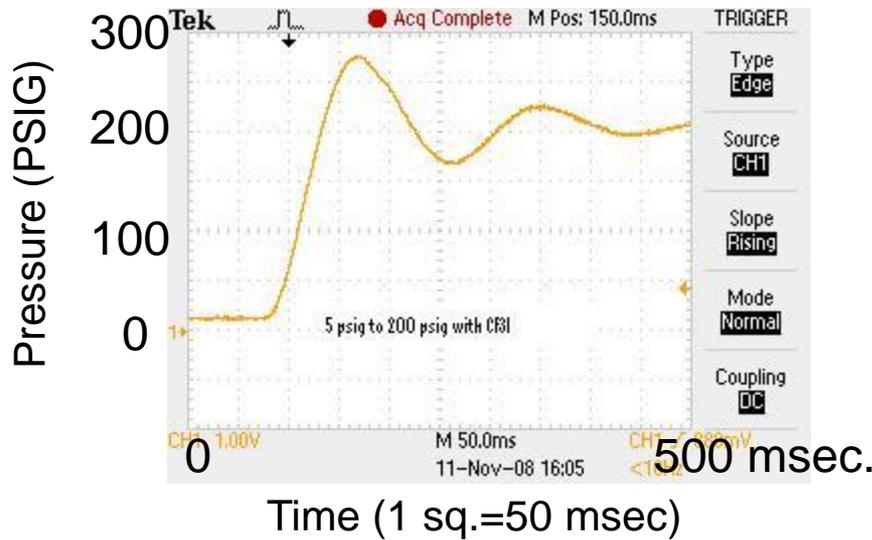


Caption: Mark Ruschman poses next to empty pressure vessel at PAB

- ASME Code stamped vessel built by Val-Fab Inc., Neenah, WI.
- Originally procured in 2006, rated at 600 psig.
  - Shell: 24" sch. 80 pipe (1.22" thick wall)
  - Lid: 30" dia. x 2" thick.
  - 3 – 6" diameter viewports
- We lengthened the shell by 24" and added lid penetrations in 2007 after the design matured.
- Lid penetrations decreased rating to 450 psig. (operating pressures on next slide)

# WBS 1.1.1 PRESSURE VESSEL – Operating Pressure

- Steady state pressure is → 200 psig.
- Operating peak pressure is → 275 psig.
- Small operational relief at → 300 psig.
- Main relief valves are set at → 400 psig.
- Vessel is rated for → 450 psig.



**PRESSURE VESSEL ENGINEERING NOTE**  
**PER CHAPTER 5031**

Prepared by: Russell Rucinski  
Preparation date: December 27, 2007

1. Description and Identification  
Fill in the label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5031		
Vessel Title	<u>COUPP E-961 OUTER VESSEL</u>	
Vessel Number	<u>FPD-10111</u>	←Obtain from Division/Section S
Vessel Drawing Number	<u>FNAL DRG# 9213.400-ME-444753</u>	
Maximum Allowable Working Pressures (MAWP):		
Internal Pressure	<u>450 PSIG</u>	
External Pressure	<u>15 PSI (FULL VACUUM)</u>	
Working Temperature Range <u>-20 °F</u> to <u>120 °F</u>		
Contents <u>PROPYLENE GLYCOL</u>		
Designer/Manufacturer <u>VAL-FAB, Inc., Neenah, WI</u>		
Test Pressure (if tested at Fermi)	Acceptance Date: _____	←Document per Chapter 5034 of the Fermilab ES&H Manual
_____ PSIG, Hydraulic _____ Pneumatic _____		
Accepted as conforming to standard by <u>Greg Beck</u> <u>GREG BECK</u>		
of Division/Section	<u>PPD</u>	Date: <u>3/6/08</u> ←Actual signature required

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by: Mike McGee Date: 3 MAR 08  
Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

Russ Rucinski, Pre-Director's Review, May 11, 2009

## WBS 1.1.2 Quartz to Metal seal development

- Innermost seal – 0.030" Ø Gold wire, impermeable to radon
- Outer seal – Viton o-ring
- 1.9" thick flanges used to limit deflection and possibility of metal to quartz contact.

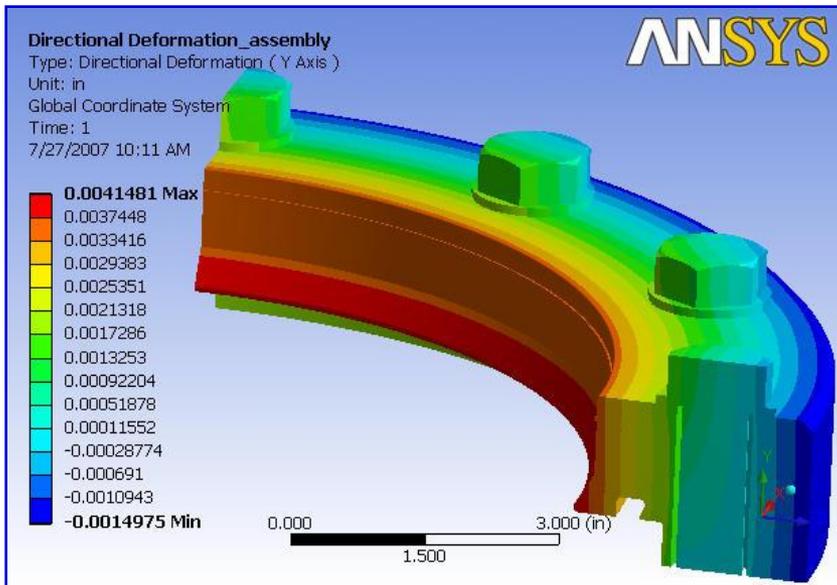
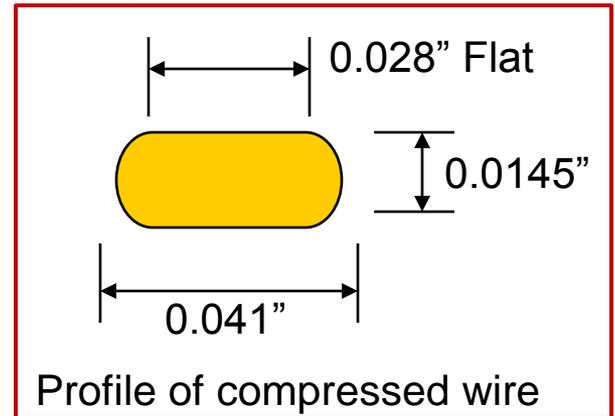
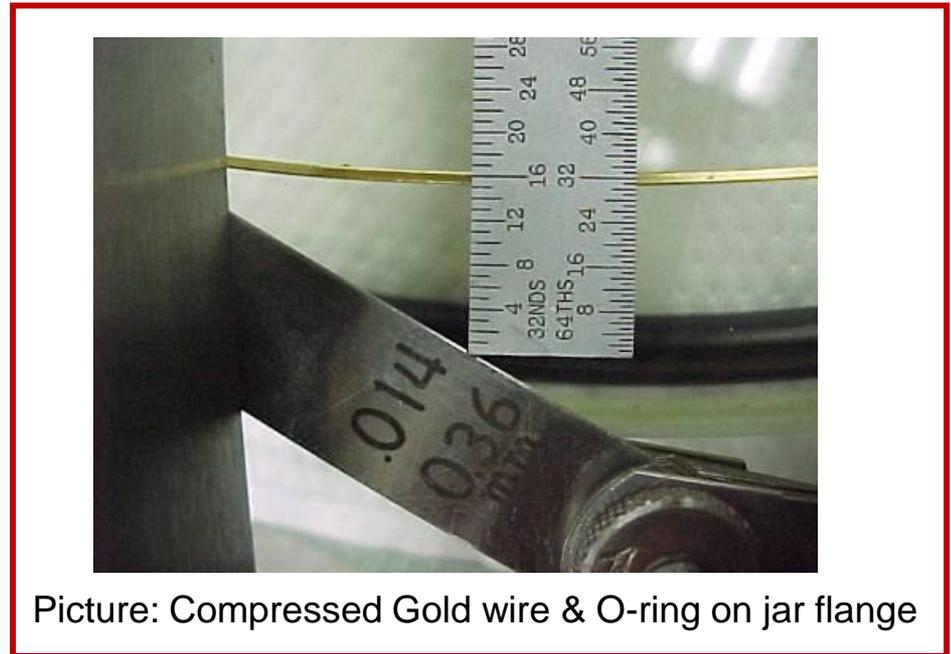
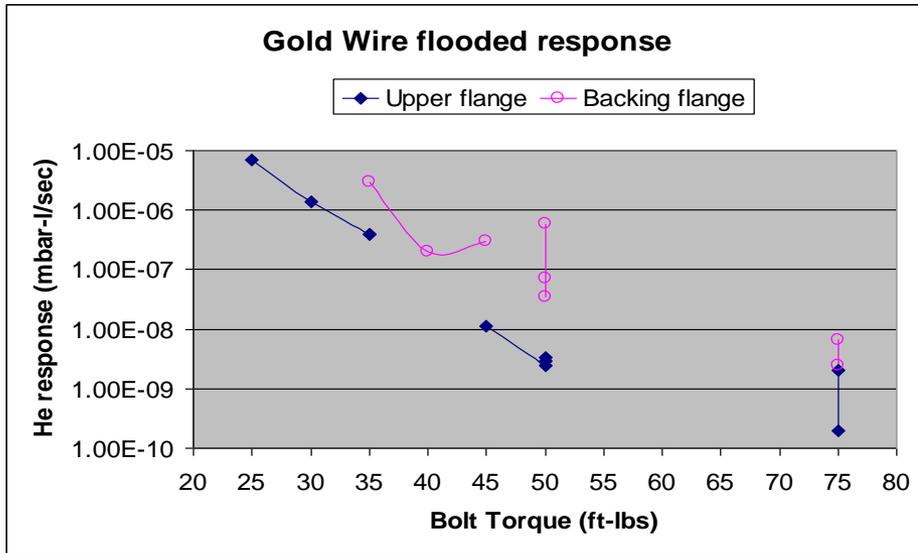
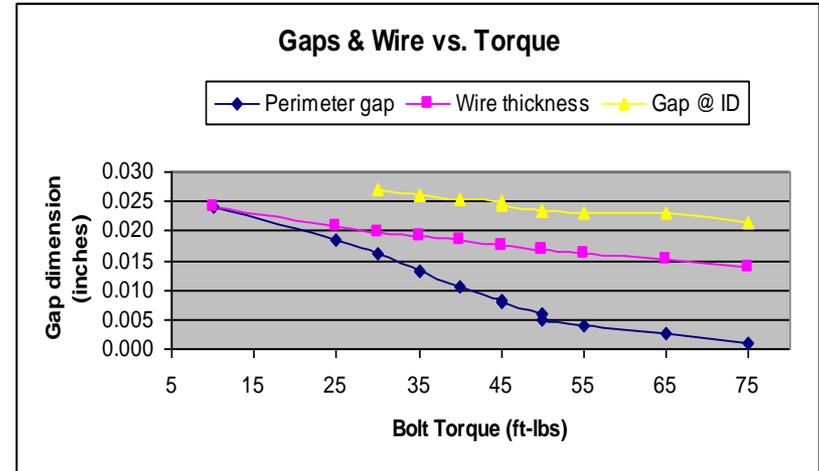
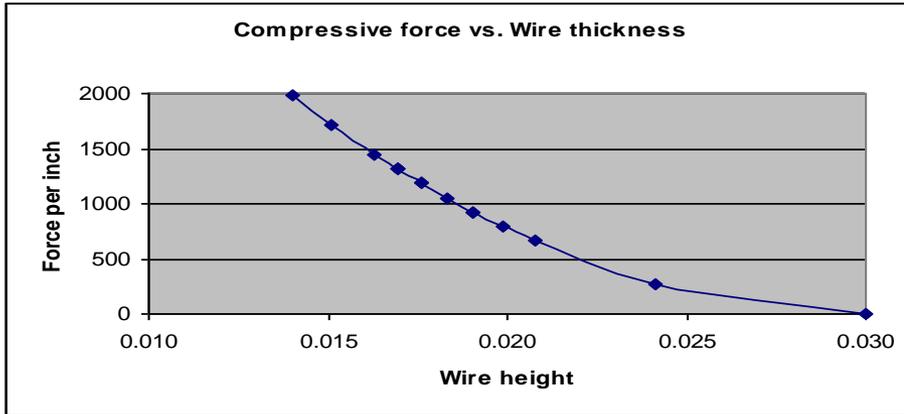


Figure 3. Displacement of the Assembly

FEA by Ingrid Fang, PPD/MD/EA group



# WBS 1.1.2 Quartz to Metal seal – test and validated



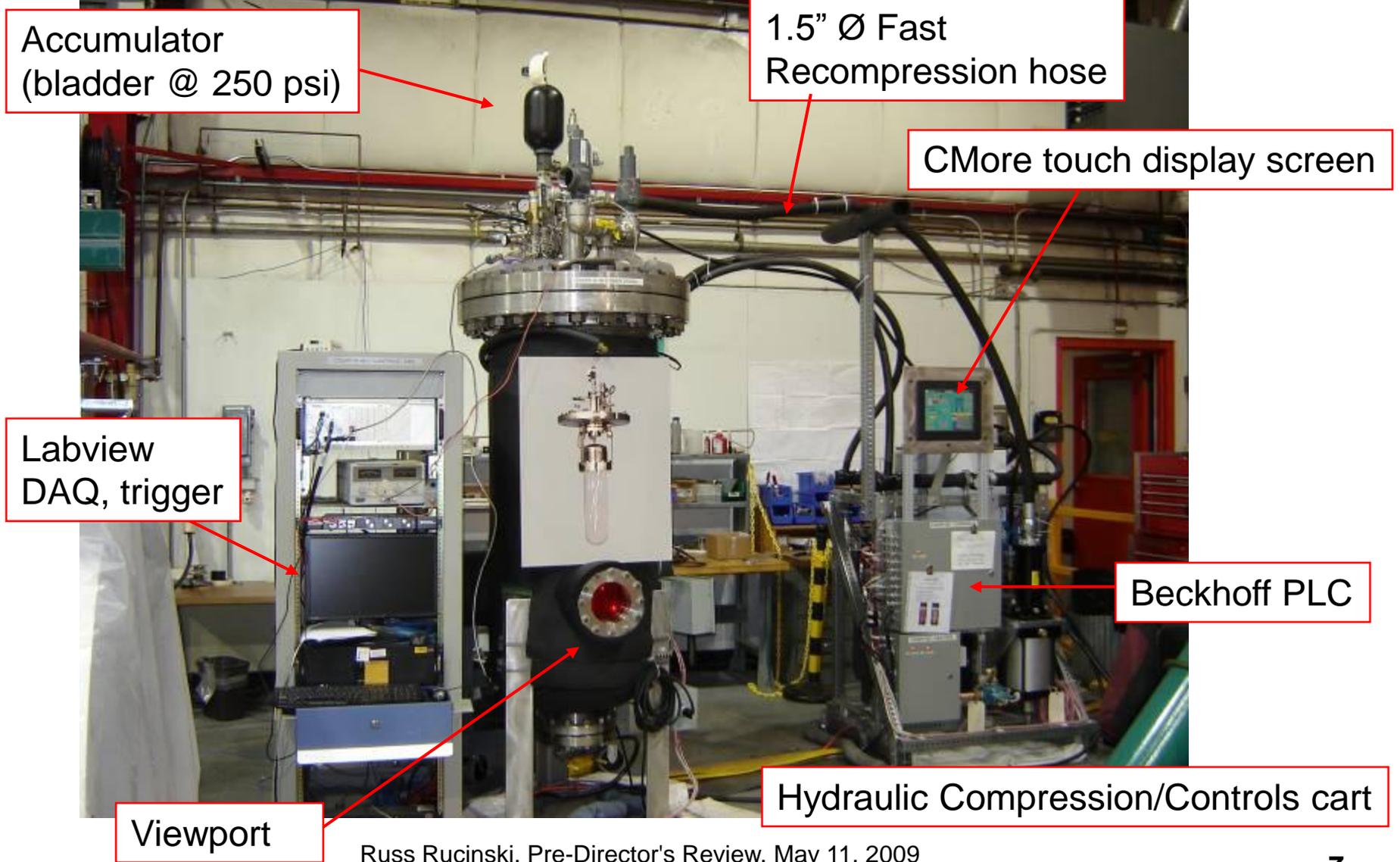
Gold seal leak rate is better than  
**10E-6 mbar-l/s** at 40 ft-lbs.

Viton seal better than **1E-09 mbar-l/s**.

40 ft-lbs chosen as design torque.

# WBS 1.1.3 & 1.1.4 – Controls & Hydraulics (Rich Schmitt)

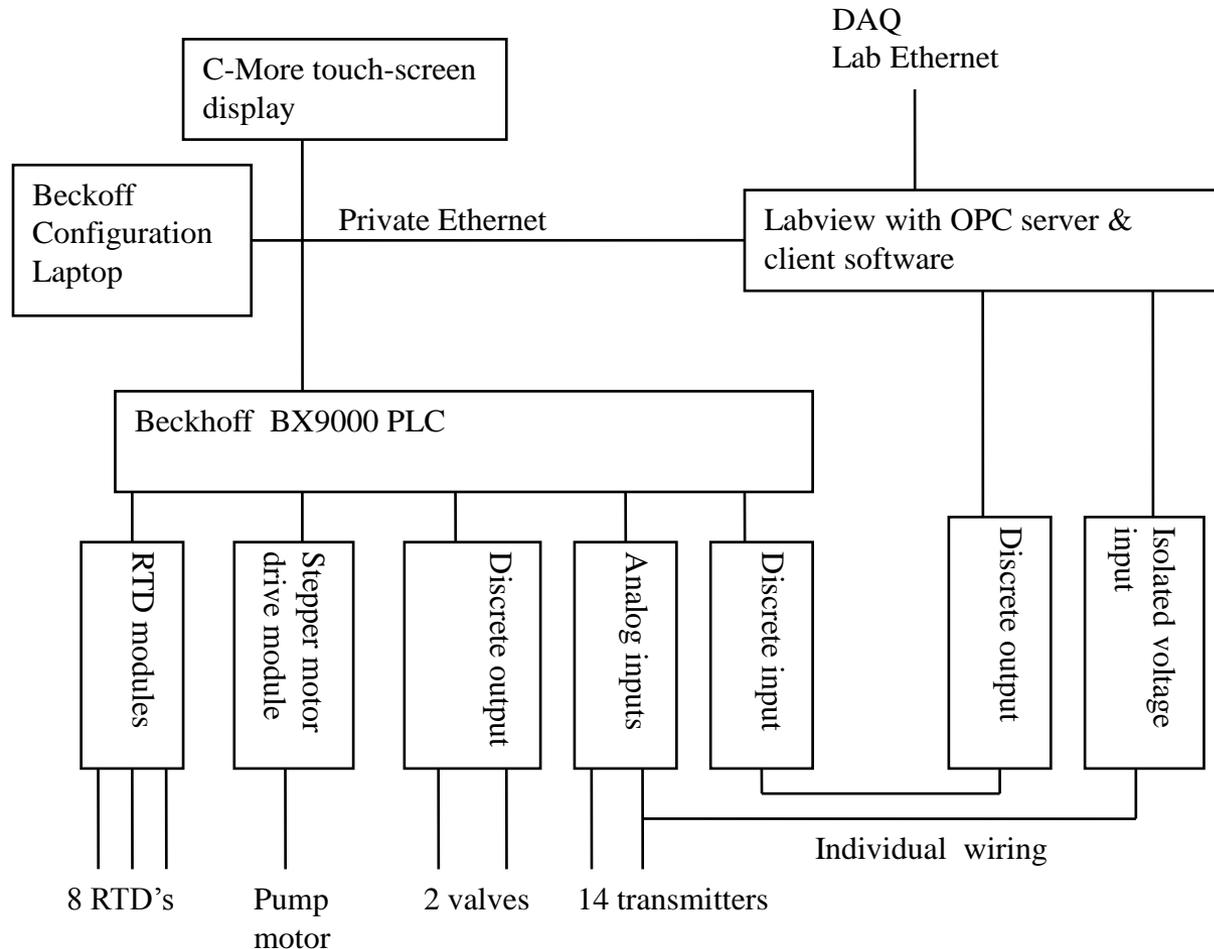
Pictured below Peripheral Equipment for E-961 60 kg Engineering run



# WBS 1.1.3 – Controls (Rich Schmitt)

- Status: Control system was designed and commissioned last year.

## Control Architecture

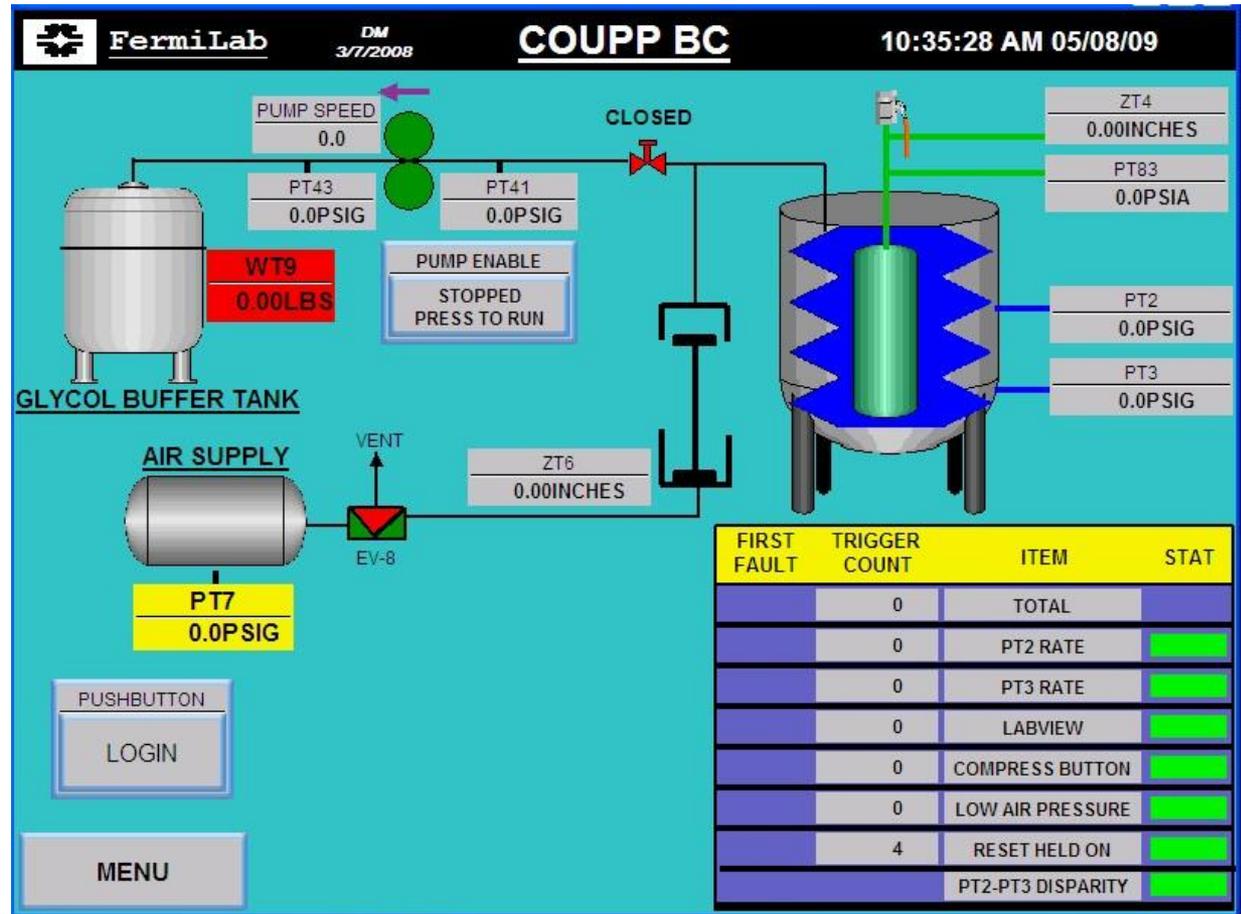


# WBS 1.1.4 – Hydraulics (Rich Schmitt)

- Status: Commissioned last year.

Quench Initiation,  
always active

- Button on touch-screen
- Digital or hard-wired signal from Labview
- Pressure rate-of-rise
- Pressure difference above setpoint
- Low air pressure

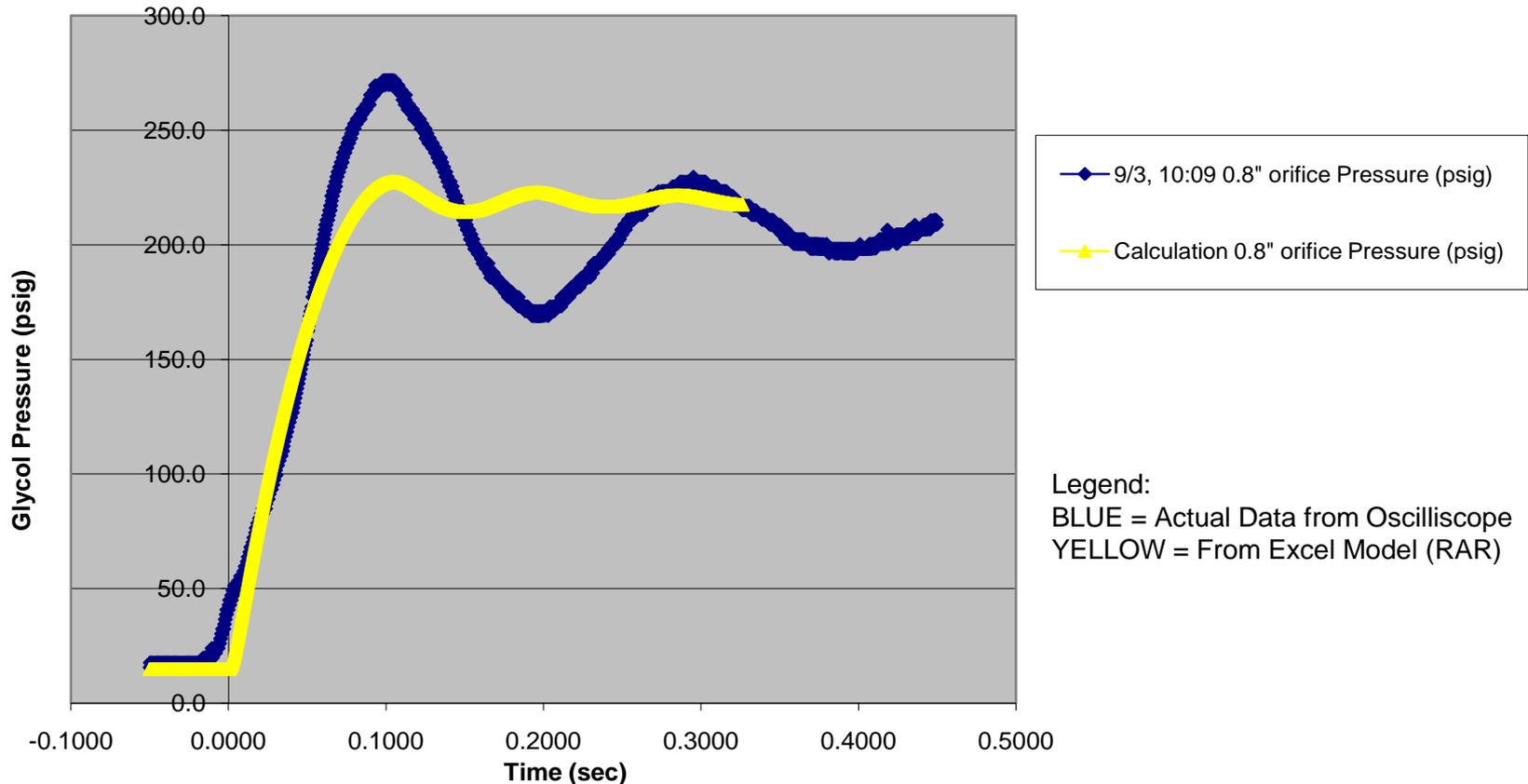


Rich Schmitt, Pre-Director's Review, May 11, 2009

# WBS 1.1.4 – Hydraulics

**Fast:** Bubble quenching <100 msec.

Pressure response 15 psig to 210 psig



# WBS 1.1.5 – QUARTZ Jar

- Three “Cheap” natural fused silica jars obtained.
- One Synthetically fused silica jar was delivered from Covalent Materials Corporation for \$28,000. Synthetic fused silica is required for low background and high radiopurity.



HP version shown below!

# WBS 1.1.6 Expansion chamber

2" travel gives 4 L. volume change

Upper bellows rated for 600 psig  
3 ply Inconel super alloy 625  
(60%Ni-22Cr-9Mo-3.2Cb)

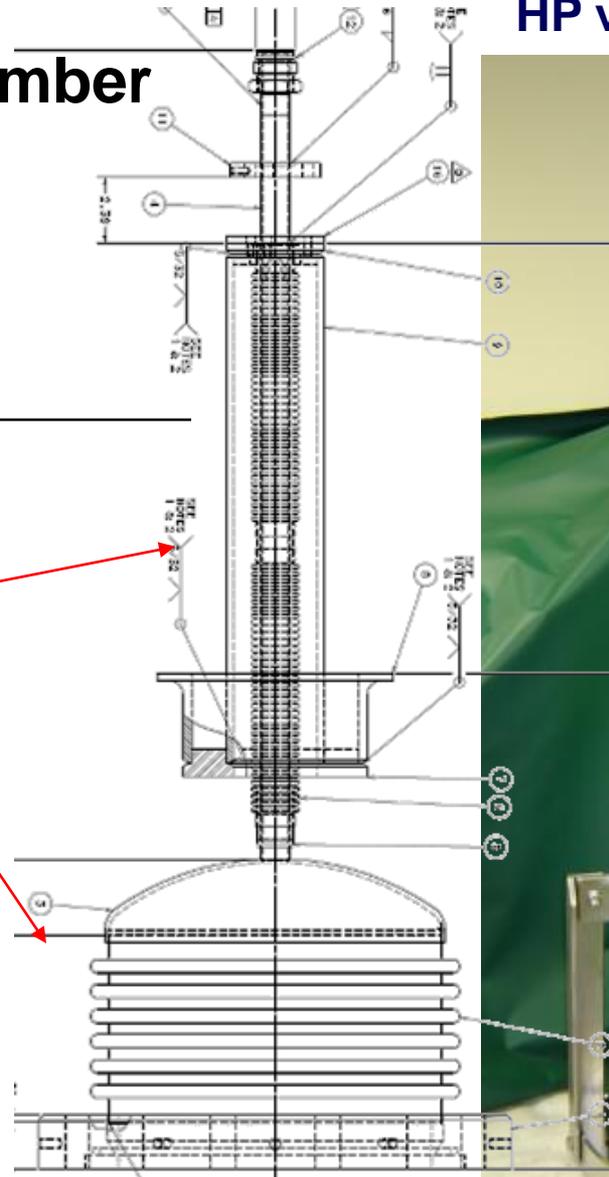
2 sets of Bellows to give volume change

## Lower Bellows

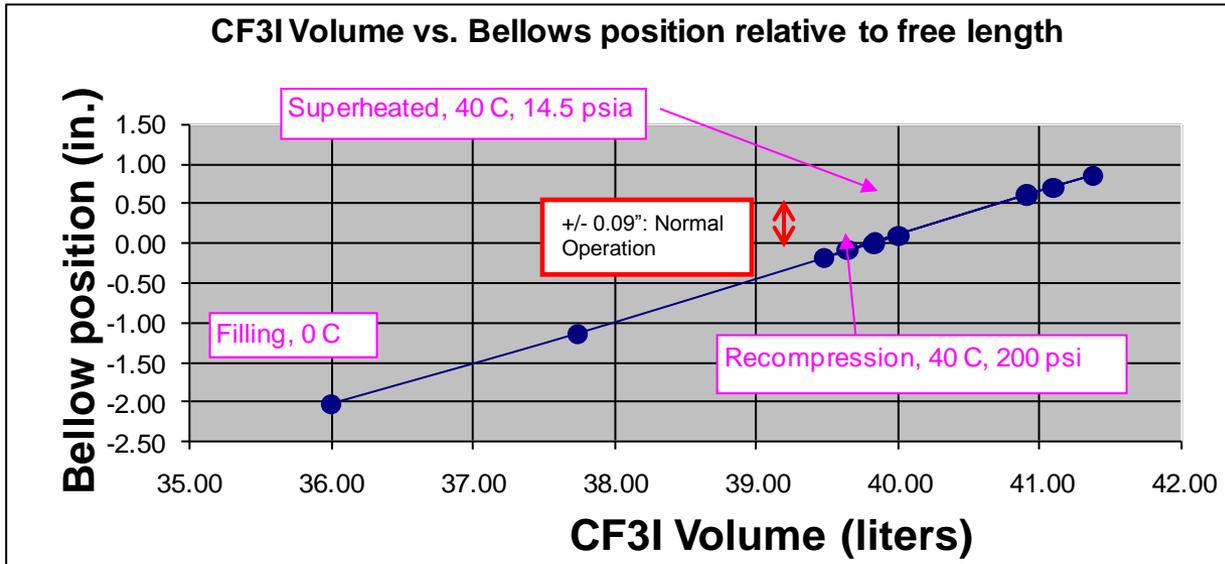
Pressure rating = 33 psid

Maximum expected = 15 psid during evacuation & leak checking

Maximum operating expected = 5 psid



# WBS 1.1.6 Expansion chamber – Operating point analysis



The bubble chamber contains:  
 79 kg CF<sub>3</sub>I  
 43 kg of H<sub>2</sub>O

The total volume changes from 79 to 85 Liters

Operating Condition	Temp (Celcius)	Pressure (Mpa)	CF3I Pressure (psia)	Bellows Position (inches)	Glycol Pressure (psia)	Pressure Differential Outer to inner (psid)
Fill	1	0.4	58.0	-2.03	63.1	5.1
Room temp.	20	0.425	61.6	-1.14	64.9	3.2
Operating Temp. - saturated	40	0.72985	105.9	0.01	107.2	1.3
Operating - cocked	40	0.1	14.5	0.09	14.3	-0.2
Operating - midpoint	40	0.8	116.0	0.00	117.5	1.5
Operating - recompression	40	1.5	217.6	-0.09	220.7	3.2
Aux. operating - saturated	50	0.9324	135.2	0.71	135.4	0.2
Aux. operating - cocked	50	0.1	14.5	0.85	12.6	-1.9
Aux. operating - recompression	50	1.5	217.6	0.61	219.2	1.6
Relieving point of outer vessel	1	2.172	315.0	-0.18	319.8	4.8

# WBS 1.1.6 Expansion chamber – Fatigue analysis

Below is for the Hyspan 7577K bellows  
 12" ID x 5" live length

1000 cycle rated movement (inches)	3.04
Maximum one way movement (inches)	2.38
2000 cycle rated movement (inches)	2.25
5000 cycle Rated movement (inches)	1.85

Estimated life = 120 years

Operating Condition	Movement (inches)	Percent 2K rated movement	Adjusted cycle life for travel used	Cycles required for service	Cycle life Usage Percent
1. Cooldown (movement from -1.1" to -2.05")	-2.05	-91.1%	3500	60	1.7%
2. Stagnant at 20 C, room temperature	-1.12	-60.5%	42000	120	0.3%
3. Operating at 40 C (cycles -0.1" to +0.1")	0.2	10.8%	1.00E+09	1.00E+06	0.1%
4. Operating at 50 C (cycles +.61" to +.85")	0.85	45.9%	1.00E+08	1.00E+06	1.0%
				<b>Total useage</b>	<b>3.1%</b>

Assumes 4 years at 1 event/minute

Estimated life is  
 not based on  
 fatigue since  
 useage < 45%

# WBS 1.1.7 System Level Documentation

Top Level Drawings	FNAL Drawing #	Last Date
COUPP 30L Flow and Instrumentation diagram	9219.000-MD-444682 rev. H	May 2009
COUPP 30L Hydraulic System, Instrument & Control wiring	9213.400-ME-444932	Feb. 2008
COUPP Fluid Handling skid flow and instrumentation diagram	9213.400-ME-466342 rev. A	May 2009
COUPP 30L Pressure Vessel Assembly (Prototype)	9219.400-ME-435803 rev. B	March 2008
COUPP BC Inner vessel Assembly (Prototype)	9213.400-MD-444820	March 2008
COUPP 30 L Pressure Vessel Assembly – High Purity	9213.400-ME-466193	Sept. 2008
COUPP BC Inner Vessel Assembly – High Purity	9213.400-MD-466178	Sept. 2008

Projects-doc-#	Title	Author(s)	Last Updated
<a href="#">541-v1</a>	<a href="#">Short Video movies from COUPP-60 Engineering run</a>	<a href="#">Russell A. Rucinski</a>	08 May 2009
<a href="#">535-v2</a>	<a href="#">Review Slides 1.1 and 1.2 BC and HP Fluid Handling</a>	<a href="#">Russell A. Rucinski</a>	08 May 2009
<a href="#">513-v1</a>	<a href="#">Welding procedure for 60 kg high purity expansion chamber</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">512-v1</a>	<a href="#">Flange seal to quartz jar: FEA and Test results</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">511-v1</a>	<a href="#">Transient Pressure Control calculations for 60 kg hydraulic recompression</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">510-v1</a>	<a href="#">Weights and Sizes of components for 60 kg Bubble chamber system</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">506-v1</a>	<a href="#">Safety Review Documents for 60 kg Engineering Run 2008 first part</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">509-v1</a>	<a href="#">Safety Review Documents for 60 kg Engineering Run 2008 fourth part</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">508-v1</a>	<a href="#">Safety Review Documents for 60 kg Engineering Run 2008 third part</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">507-v1</a>	<a href="#">Safety Review Documents for 60 kg Engineering Run 2008 second part</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">505-v1</a>	<a href="#">pORC Safety signoffs for water tank operation at DAB</a>	<a href="#">Russell A. Rucinski</a>	20 Apr 2009
<a href="#">349-v1</a>	<a href="#">COUPP 60kg Glycol temperature measurements at 40C</a>	<a href="#">Russell A. Rucinski</a>	25 Aug 2008
<a href="#">319-v1</a>	<a href="#">E961 COUPP 60 kg Bubble Chamber General Description</a>	<a href="#">Russell A. Rucinski</a>	25 Jun 2008
<a href="#">314-v1</a>	<a href="#">COUPP 60kg 3D solid model pictures</a>	<a href="#">Russell A. Rucinski</a>	09 Jun 2008
<a href="#">305-v1</a>	<a href="#">COUPP 60kg BC Quartz jar vendor and QC info for mechanical prototype</a>	<a href="#">Russell A. Rucinski</a>	08 May 2008
<a href="#">304-v1</a>	<a href="#">COUPP 60 kg BC: Fluid Operating states and bellows position</a>	<a href="#">Russell A. Rucinski</a>	08 May 2008
<a href="#">500-v1</a>	<a href="#">COUPP R&amp;D Mini-Review Dec. 2009</a>	-----	06 May 2009