COUPP – 60: E-961:

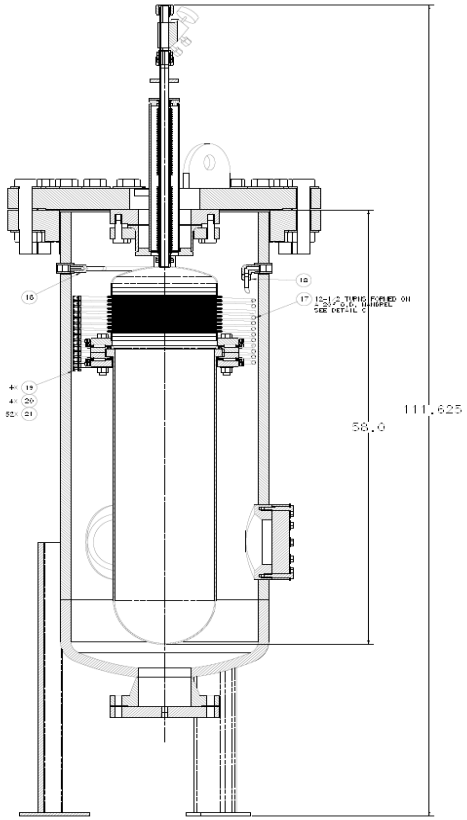
WBS 1.1 - Bubble Chamber
WBS 1.2 - HP Fluid Handling

May 11, 2009

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

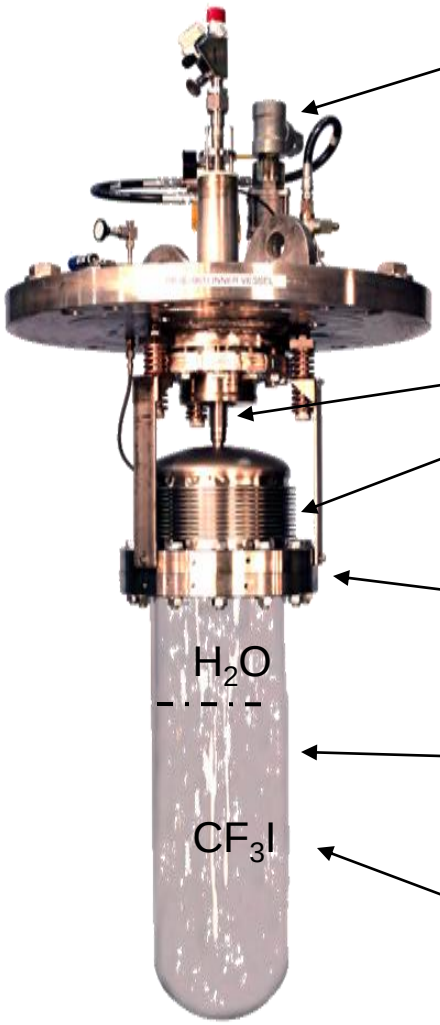


Drawing of BC nested in PV

BC superimposed on PV

BC Photo Credit: FNAL/VMS, Reidar Hahn

WBS 1.1 COUPP-60 Bubble Chamber



WBS 1.1.4 Port for fast glycol/BC pressurization

WBS 1.1.1 Lid of glycol vessel

WBS 1.1.6 Set of bellows for expansion/compression of fluid Prototype shown. HP version has weld rings on bellows & electro-polishing.

WBS 1.1.2 Quartz to Metal seal

WBS 1.1.5 Quartz Vessel
Prototype: Natural quartz
High Purty: Synthetically fused Silica jar

Jar will contain ~ 60 kg to 80 kg of CF3I
~ 50 kg to 40 kg of H2O

Photo Credit: FNAL/VMS, Reidar Hahn

WBS 1.1.1 PRESSURE VESSEL

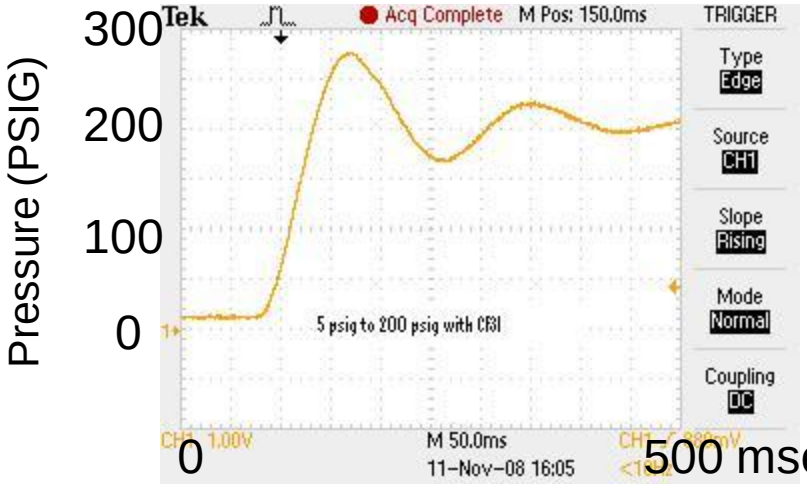
– Used for hydraulic pressure control of the bubble chamber fluid

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 COUPP E-961 OUTER VESSEL

Vessel Number PPD-10111 ←Obtain from Division/Section S.

Vessel Drawing Number FNAL DRG# 9213.400-ME-444753

Maximum Allowable Working Pressures (MAWP):
Internal Pressure 450 PSIG
External Pressure 15 PSI (FULL VACUUM)

Working Temperature Range -20 °F 120 °F

Contents PROPYLENE GLYCOL

Designer/Manufacturer VAL-FAB, Inc., Neenah, WI

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 GREG BOCK

of Division/Section PPD Date: 3/6/08 ←Actual signature required

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

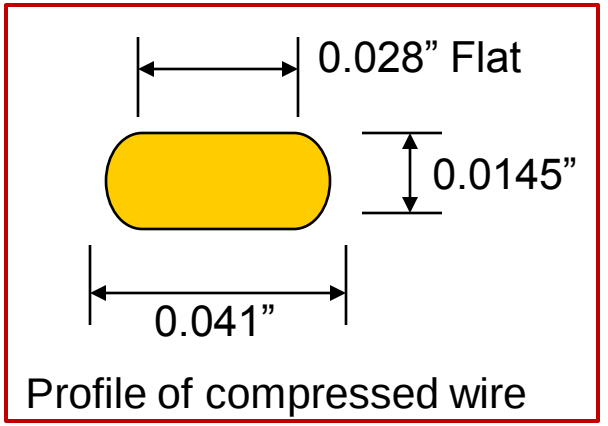
Reviewed by: MIKE McGEE (AD/MD) Date: 3 Mar 08

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.



Profile of compressed wire

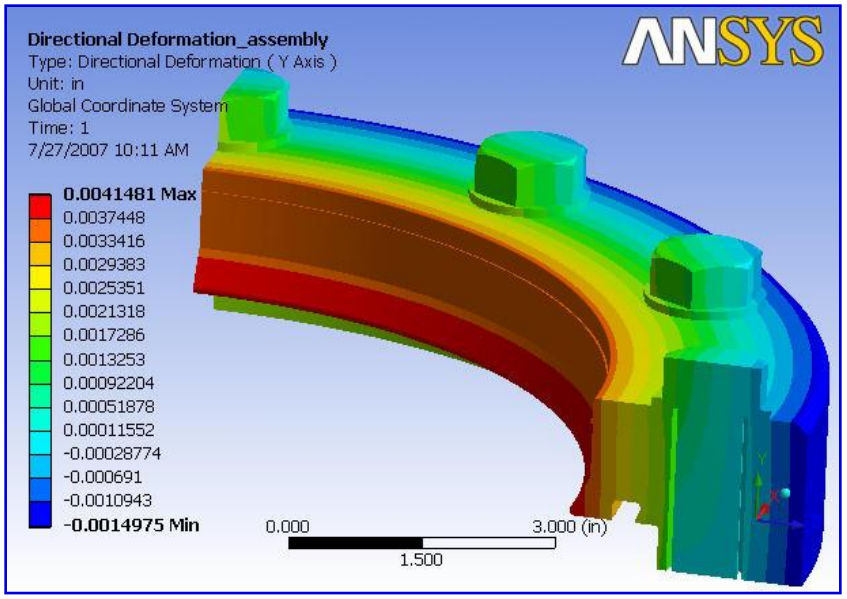
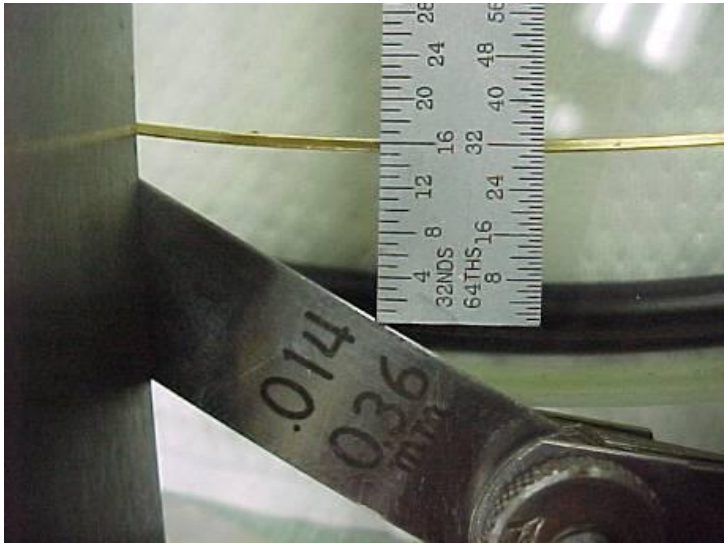


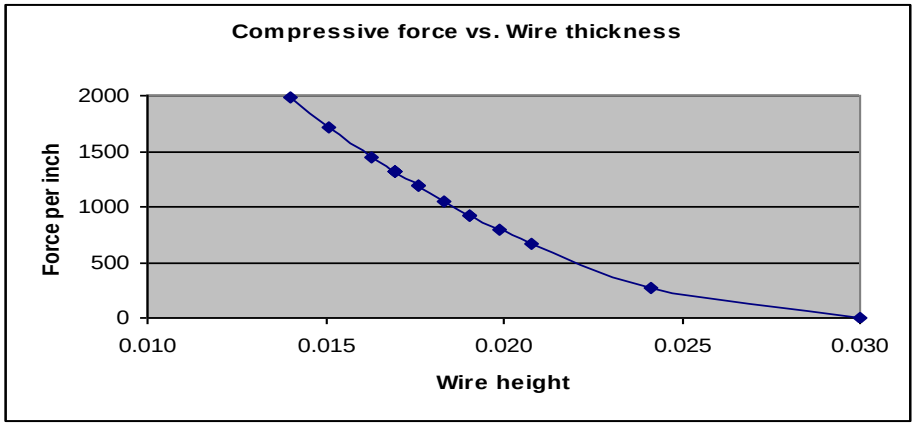
Figure 3. Displacement of the Assembly

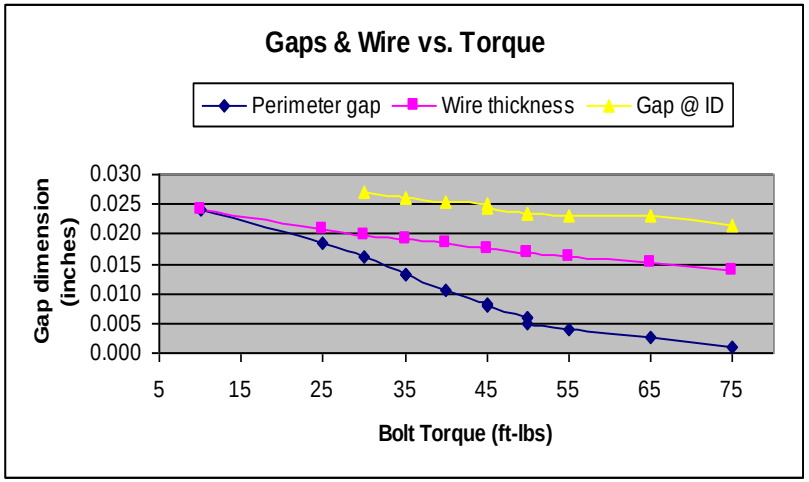
FEA by Ingrid Fang, PPD/MD/EA group

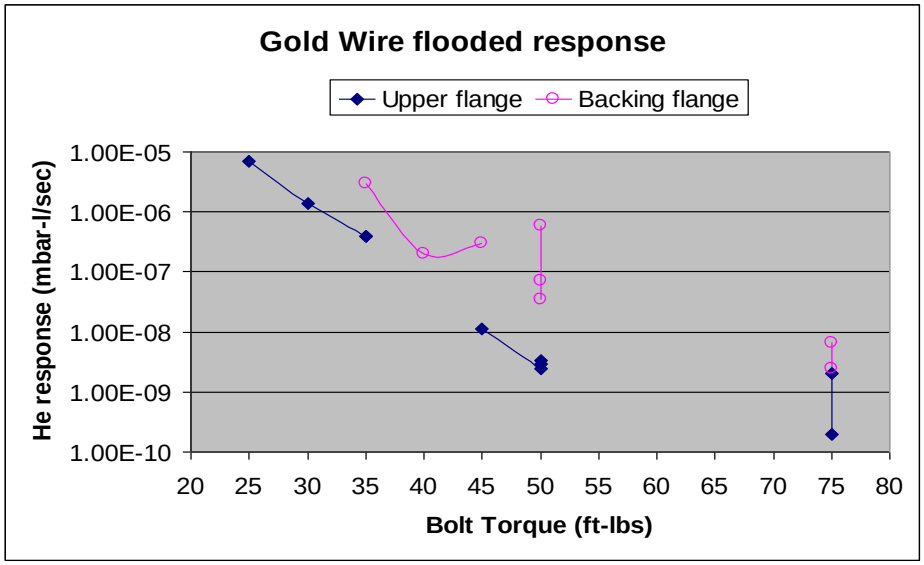


Picture: Compressed Gold wire & O-ring on jar flange

WBS 1.1.2 Quartz to Metal seal – test and validated







Gold seal leak rate is better than

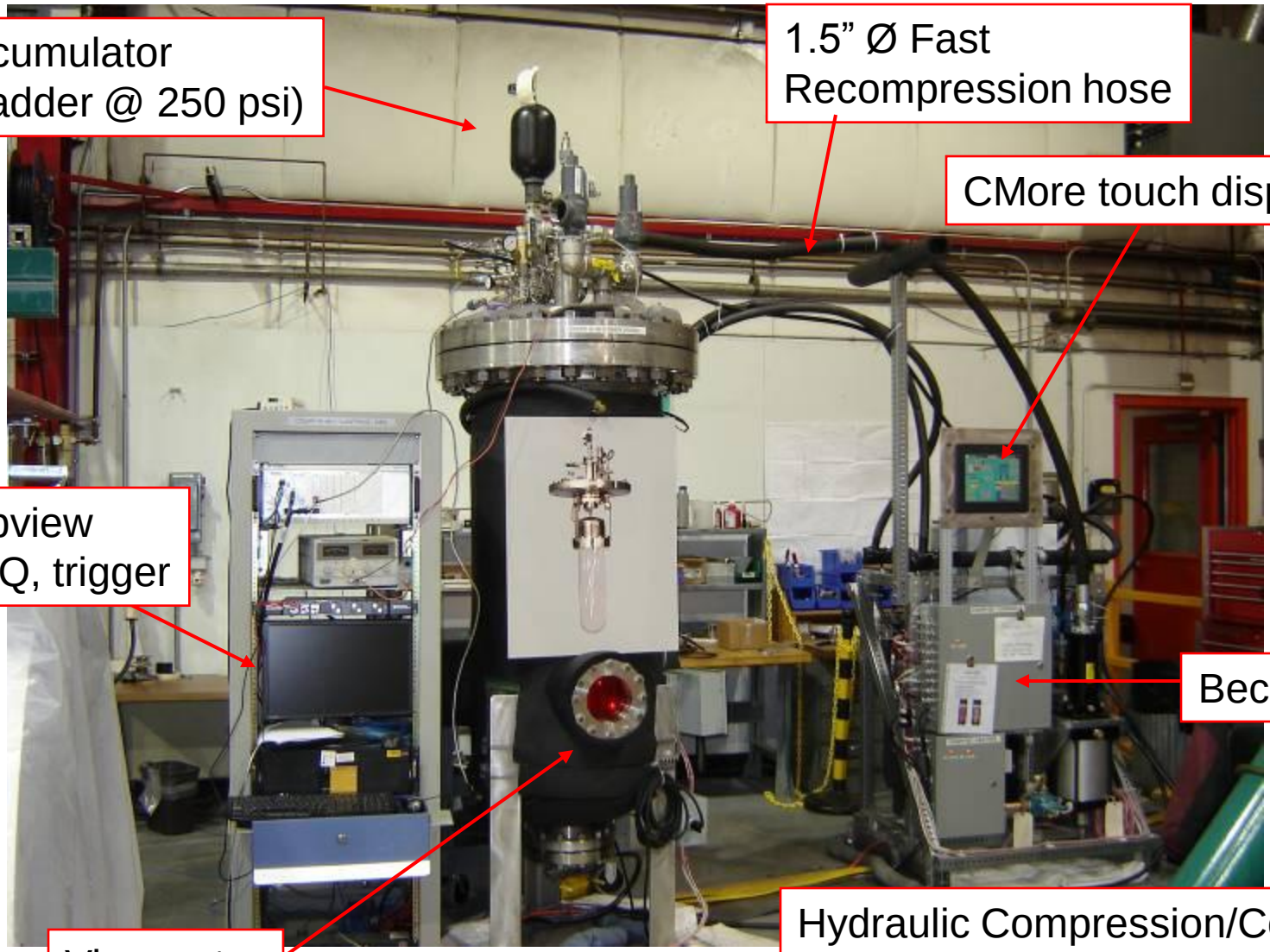
10E-6 mbar-l/s at 40 ft-lbs.

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)

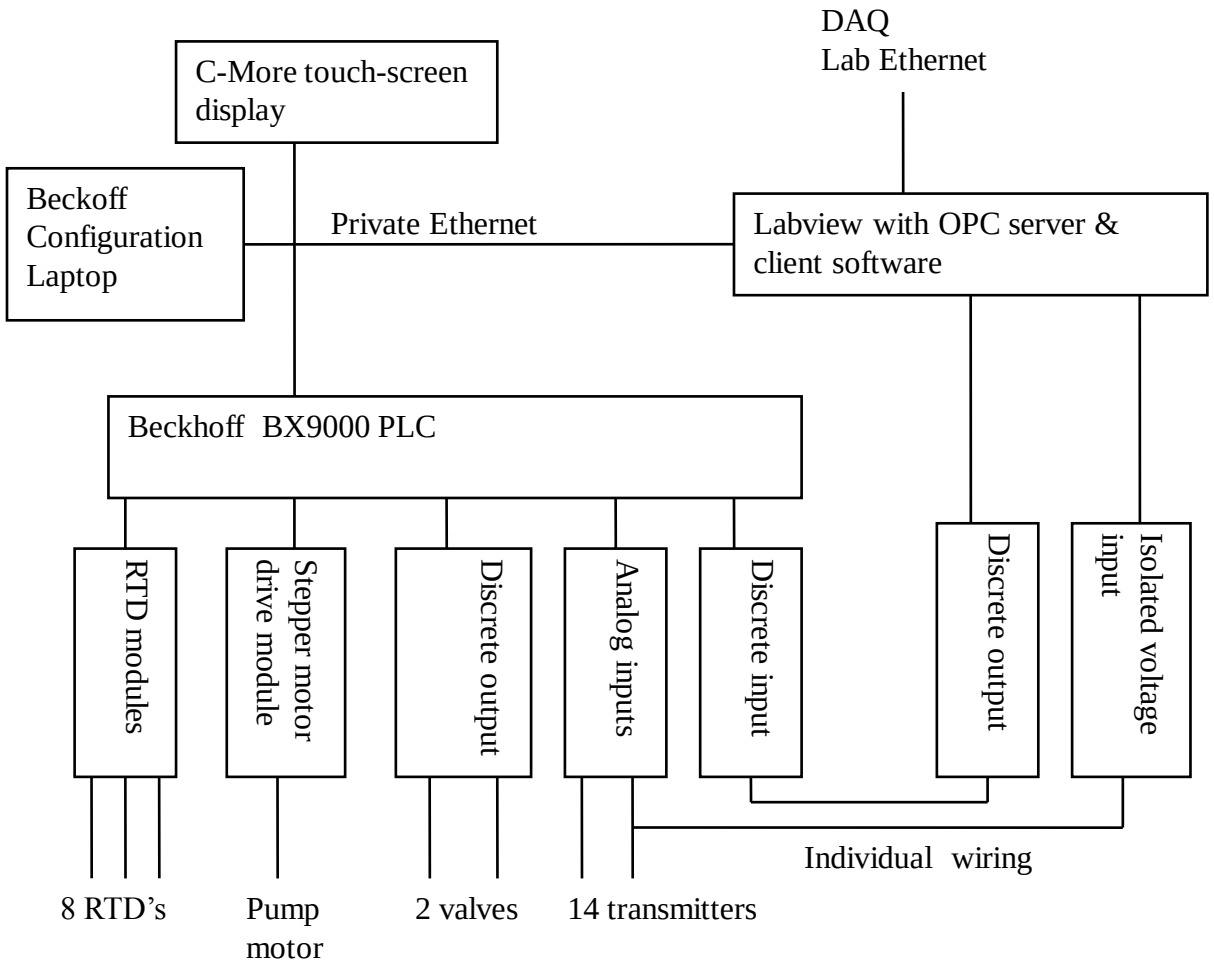
Pictured below Peripheral Equipment for E-961 60 kg Engineering run



WBS 1.1.3 – Controls (Rich Schmitt)

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

Control Architecture



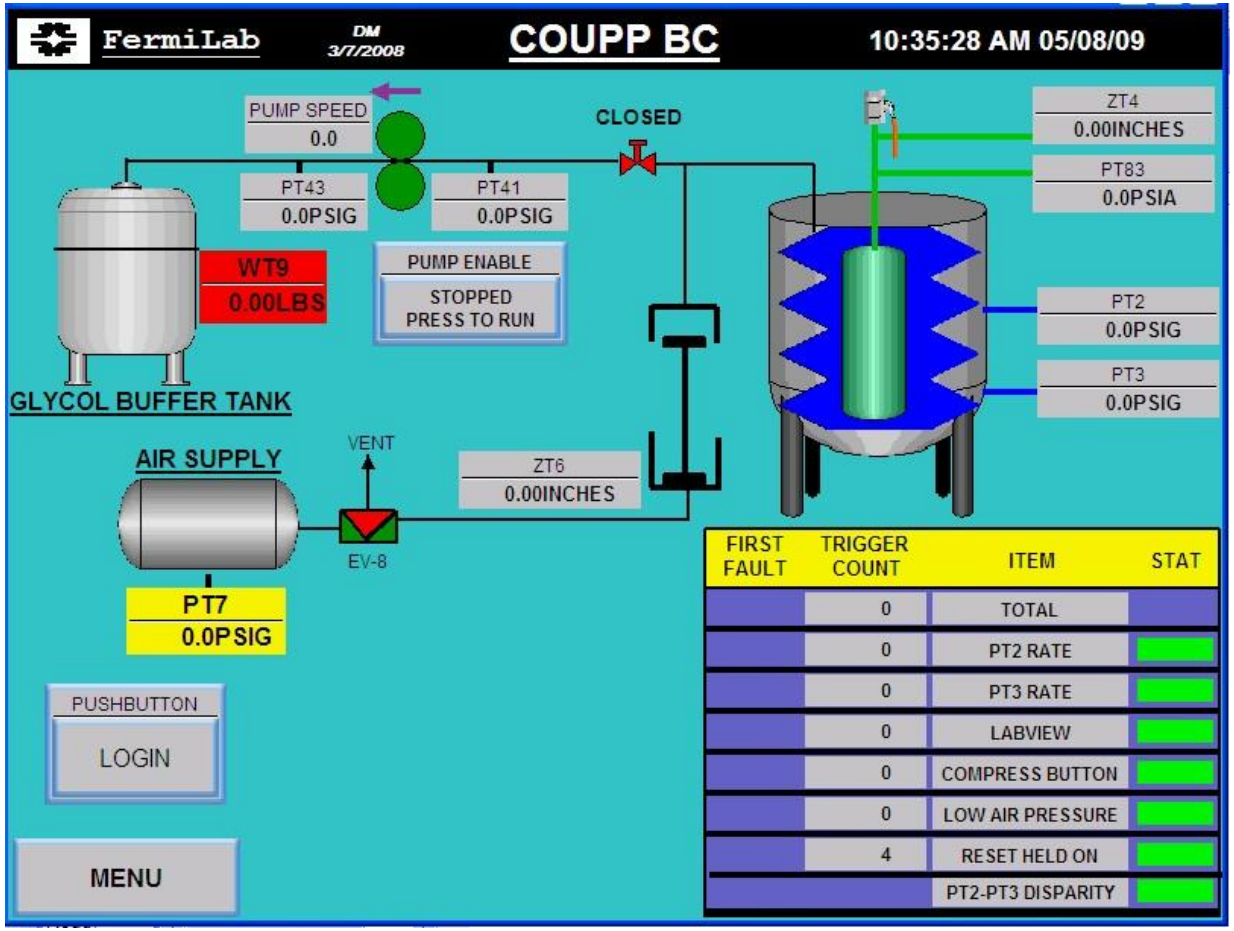
Rich Schmitt, Presented Jan. 2008

WBS 1.1.4 – Hydraulics (Rich Schmitt)

- Status: Commissioned last year.

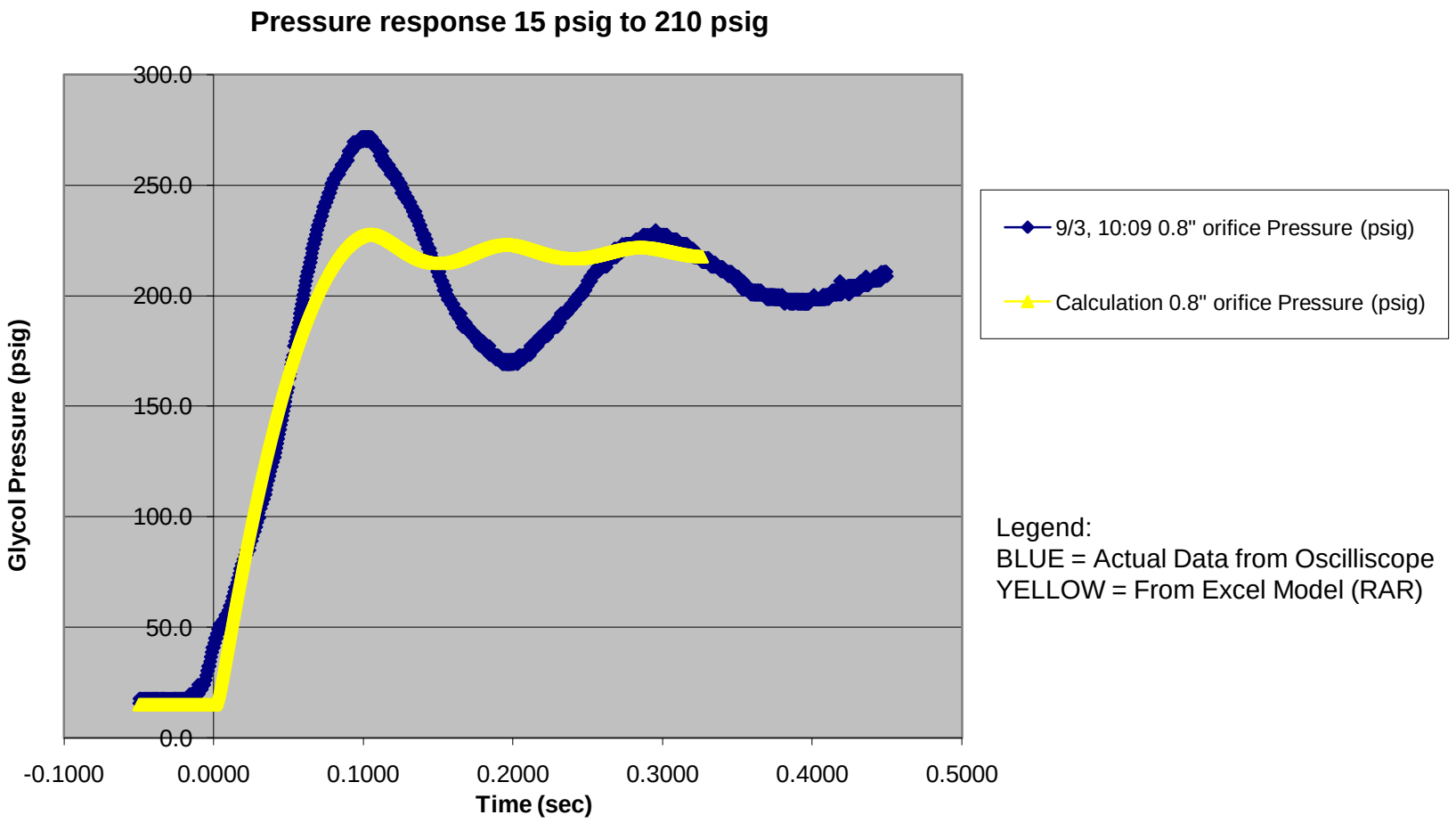
Quench Initiation, always active

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



WBS 1.1.4 – Hydraulics

Fast: Bubble quenching <100 msec.



Legend:
BLUE = Actual Data from Oscilliscope
YELLOW = From Excel Model (RAR)

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.

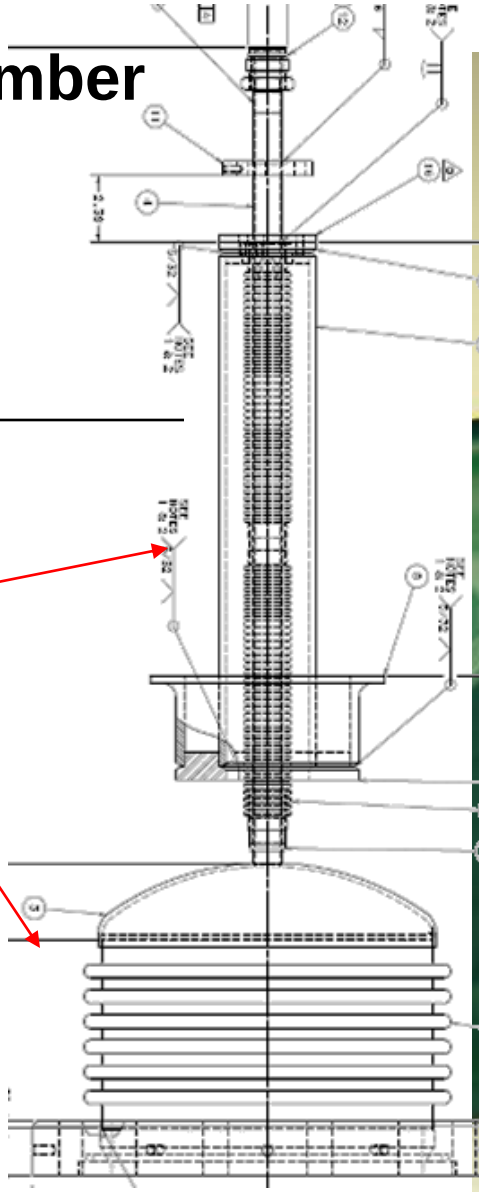
WBS 1.1.6 Expansion chamber

HP version shown below!

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

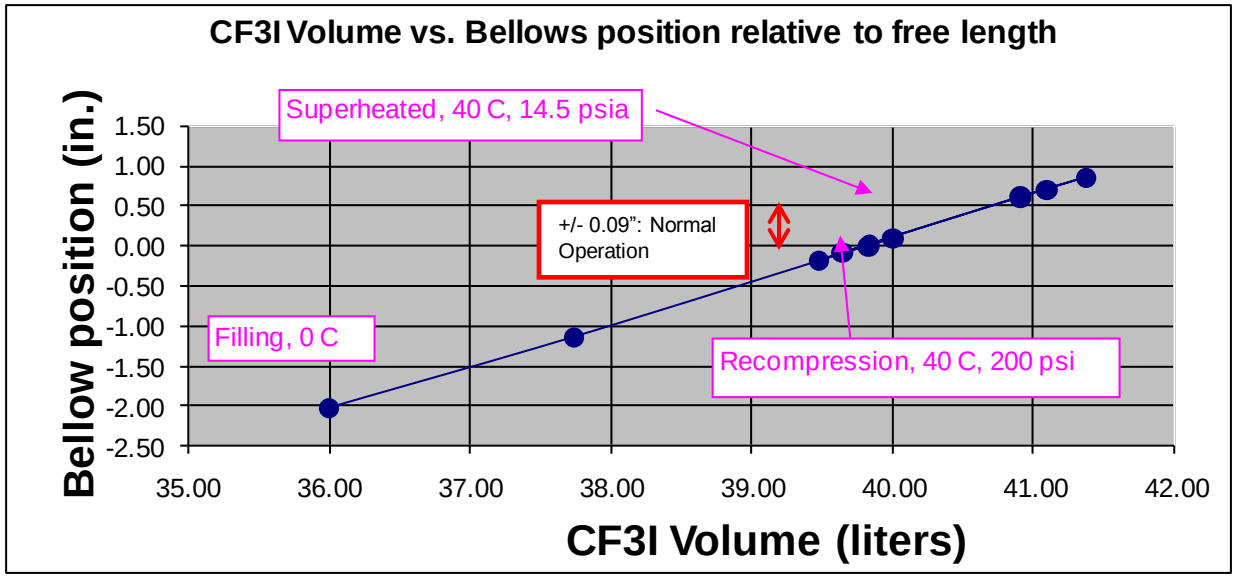


<u>Lower Bellows</u>
Pressure rating = 33 psid

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_3I
43 kg of H_2O

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 Useage 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%
				Total useage	3.1%

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

WBS 1. 2 High Purity Fluid Handling

Status: System is designed. 95% parts procured, 65% on-site, 15% assembled.

It starts with pressurized, filtered DI water at Lab 3…

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

…then Millipore conditioning

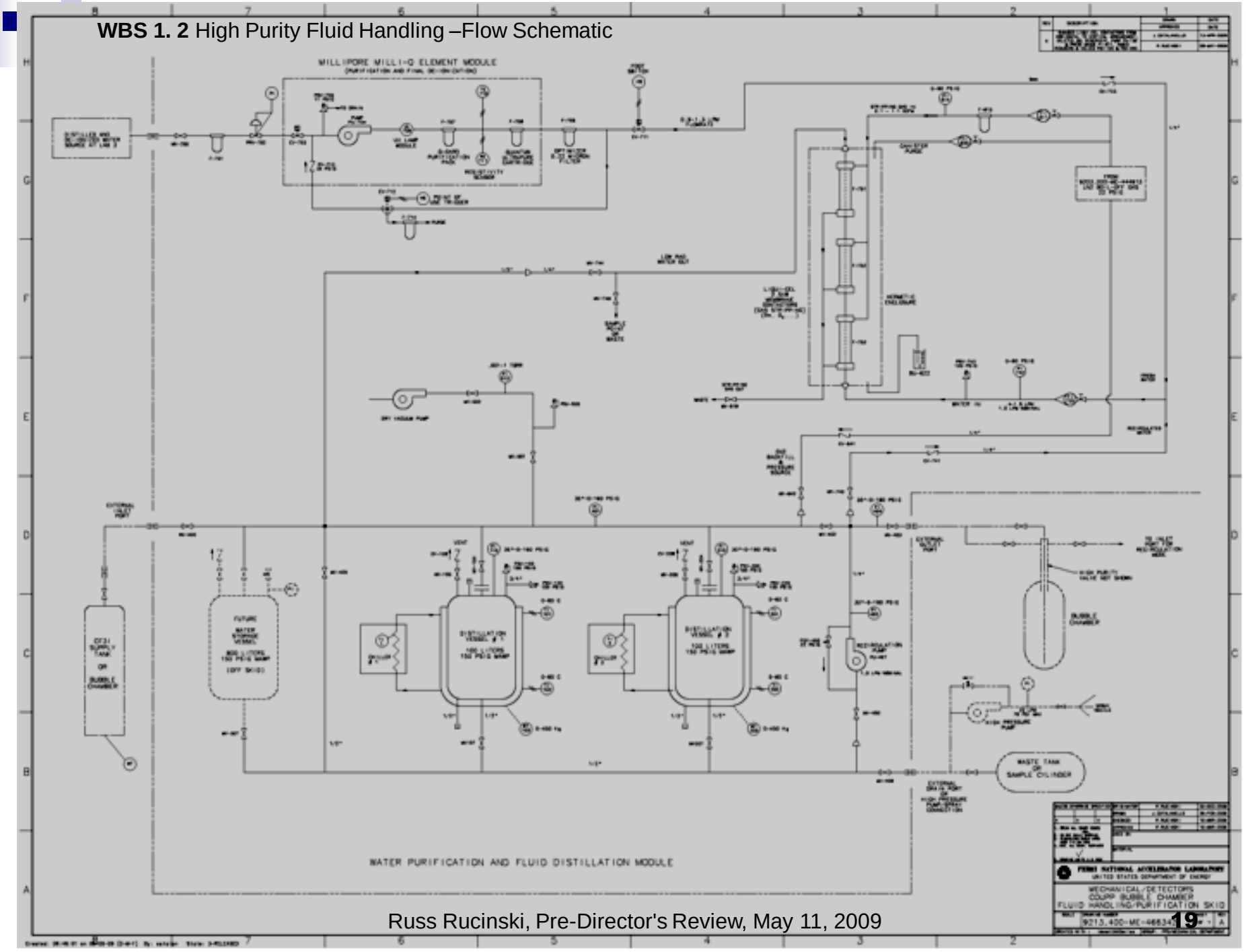
Note boxes of procured parts

WBS 1. 2 High Purity Fluid Handling

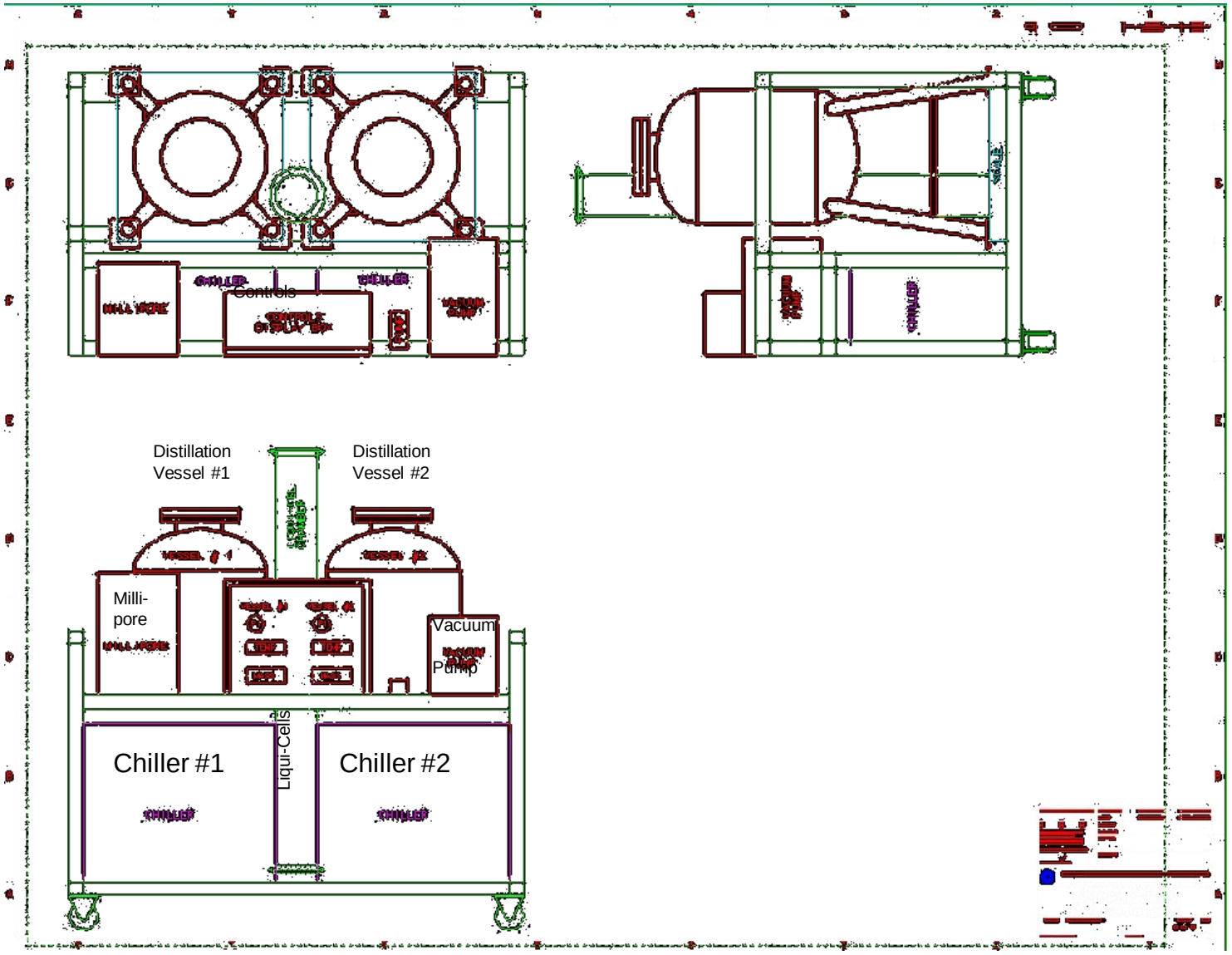
..then gas stripping with Liqui-Cell membrane contactors…

…then into distillation vessel(s).

WBS 1. 2 High Purity Fluid Handling –Flow Schematic



WBS 1. 2 High Purity Fluid Handling module



SUMMARY: Where we stand, what's left to do

(excluding most other WBS categories)

- **WBS 1.1 BC:**
  - The prototype bubble chamber with natural quartz jar is operational and was useful in the testing and evaluation of the design features. It works.
  - The high purity final bubble chamber exists as an unassembled expansion assembly and synthetically fused silica jar. It needs to be cleaned and assembled.

- **WBS 1.2 HP Fluid Handling:**
  - Up until now we have been using a non-dedicated filling system.
  - The design for a high purity fluid handling system is completed. We are starting to build it. It needs to be commissioned and validated. It will be used for filling the high purity bubble chamber.

- **WBS 1.7: Commissioning:**
  - We've completed an "engineering run" at PAB last year. We are getting ready for an "integration run" with the prototype at the DZero Assembly building. Piping modifications need to be finished and safety paperwork/reviews are needed to start the "integration run".