PRESSURE VESSEL ENGINERING NOTE - 096
PER CHAPTER 5031

Prepared by: **Herman Cease**
Preparation date: **6/21/04**

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

This vessel conforms to Fermilab ES&H Manual Chapter 5031	
Vessel Title **BTeV Rich Condensation Tank**	
Vessel Number **PPD-10091**	←Obtain from Division/Section Safety Officer
Vessel Drawing Number **N/A**	
Maximum Allowable Working Pressures (MAWP): Internal Pressure **200 psig** External Pressure **29.9 inch Hg** Working Temperature Range **-20°F +450°F** Contents **C4F8O gas and liquid** Designer/Manufacturer **Manchester Tank** **Vendor - McMaster-Carr**	
Test Pressure (if tested at Fermi) Acceptance Date:_____ _____PSIG, Hydraulic_____ Pneumatic _____ Accepted as conforming to standard by _____ of Division/Section PPD Date: 6/22/04	←Document per Chapter 5034 of the Fermilab ES&H Manual ←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: TERRY TOPE Date: 6/21/04

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

_____ Date: _____

Amendment No.:	Reviewed by:	Date:

Lab Property Number(s): _____
Lab Location Code: **408 Meson Detector Building** (obtain from safety officer)
Purpose of Vessel(s): Condensation tank for BTeV RICH Testbeam gas system

Vessel Capacity/Size: **7 gallons** Diameter: **12 inch** Length: **17 inch**
Normal Operating Pressure (OP) **35 psig**
MAWP-OP = **165 PSI**

List the numbers of all pertinent drawings and the location of the originals.

Drawing #	Location of Original
8918.130-ME-407269 Gas Process Diagram	**PPD/MECH DEPT**

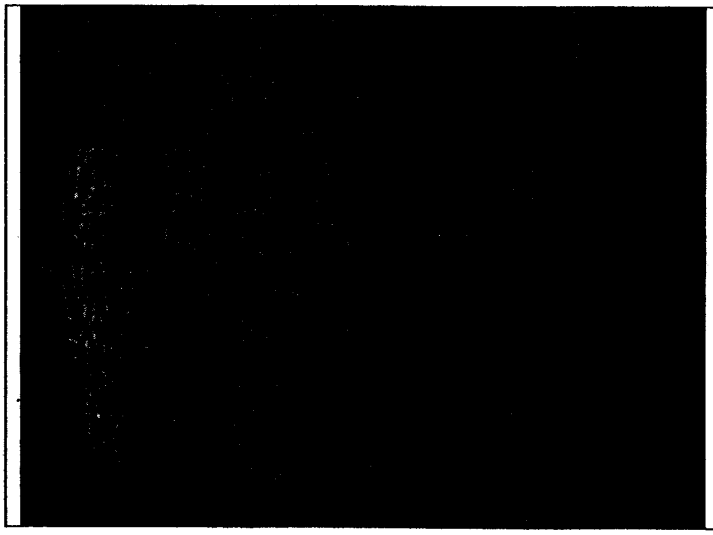
2. Design Verification

Is this vessel designed and built to meet the Code or "In-House Built" requirements?
Yes **X** No_____.

If "No" state the standard that was used _____.
Demonstrate that design calculations of that standard have been made and that other requirements of that standard have been satisfied.
Skip to part 3 "system venting verification."

Does the vessel(s) have a U stamp? Yes **X** No_____. If "Yes", complete section 2A; if "No", complete section 2B.

A. Staple photo of U stamp plate below.



Copy "U" label details here:
Manchester Tank
MAWP 200 PSI 650F

OAT#304935 YR 2003
ORNF114.10
SH .094 GAL 7
HD .094 21SE

Provide ASME design calculations in an appendix. On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. (Only for non-coded vessels)

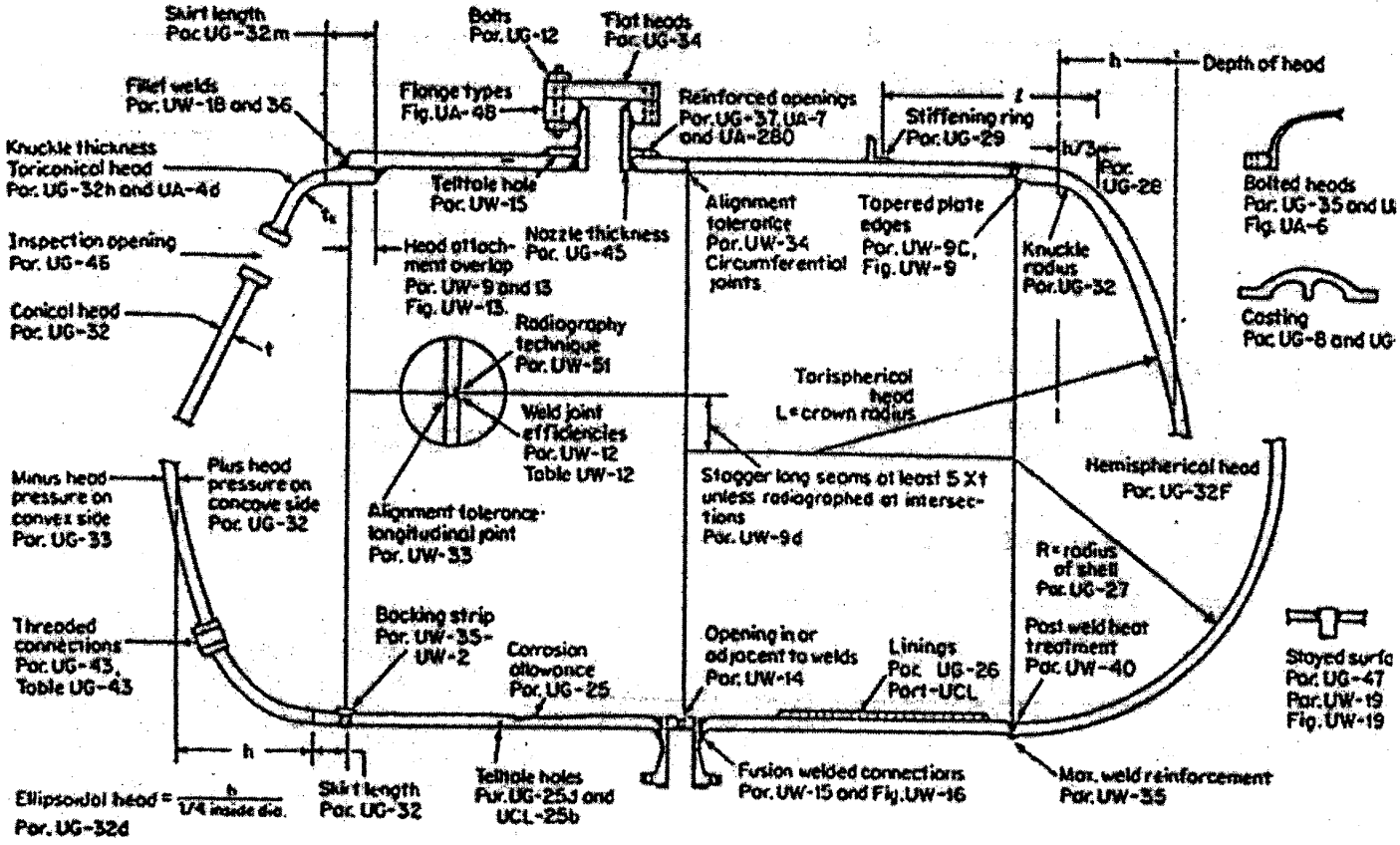


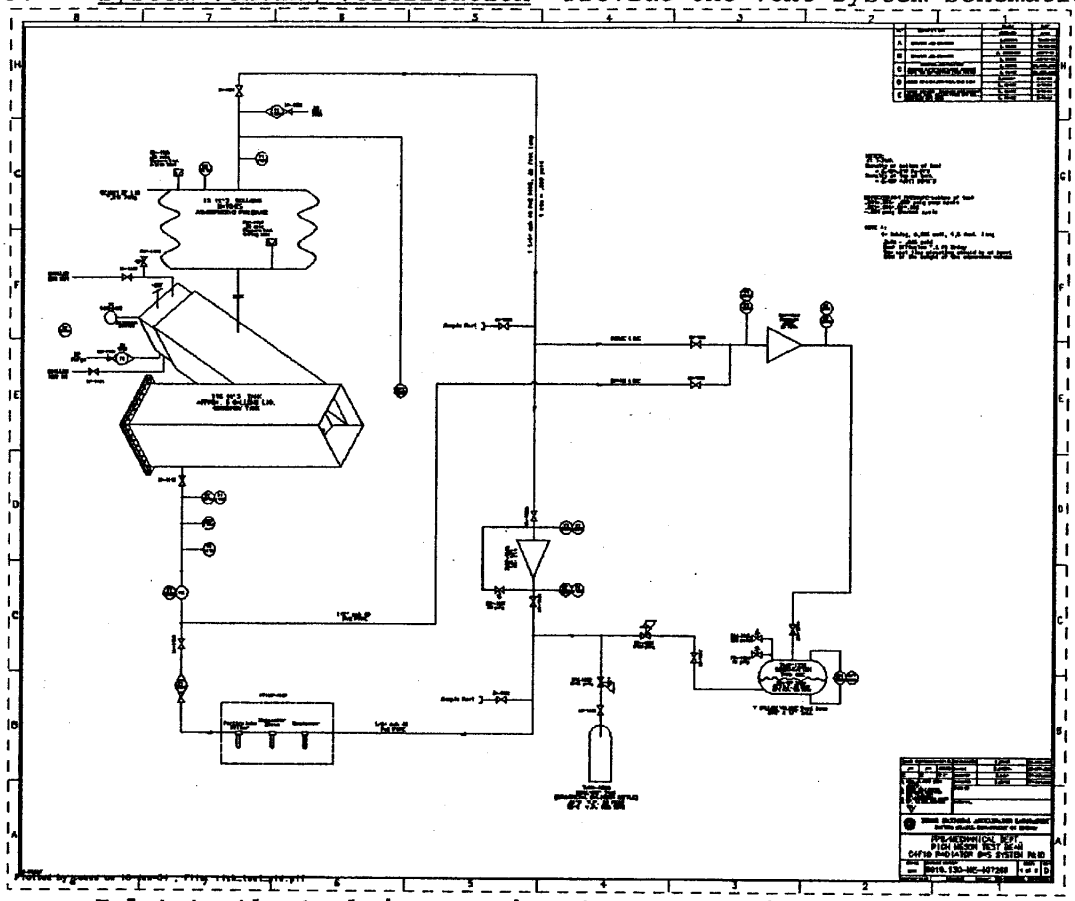
Figure 1. ASME Code: Applicable Sections

2B.

Summary of ASME Code

Item	Reference ASME Code Section	CALCULATION RESULT (Required thickness or stress level vs. actual thickness calculated stress level)
		vs
		vs
		vs
		vs
		vs

3. System Venting Verification Provide the vent system schematic.



Inlet to the tank is restricted to a 3/16 inch Orifice.

Does the venting system follow the Code UG-125 through UG-137?
Yes__X__ No___

Does the venting system also follow the Compressed Gas Association Standards S-1.1 and S-1.3?
Yes __X___ No_____

Fire conditions API code used, See attached.

A "no" response to both of the two proceeding questions requires a justification and statement regarding what standards were applied to verify system venting is adequate.

List of reliefs and settings:

Manufacturer	Model #	Set Pressure	Flow Rate	Size
CIRCLE SEAL	**M5159N-2M(L)-200**		**158 SCFM air**	
CIRCLE SEAL	**D559N-2M-35**	**35 PSIG**	**19 SCFM air**	
			equiv diam = 0.197 inch	
Inlet to the tank is restricted to a 0.188 inch diam. Orifice				

4. Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?
Yes_____ No__X__ (If "Yes", it must be appended)

5. Welding Information

Has the vessel been fabricated in a non-code shop? Yes_____ No__X__
If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.

6. Existing, Used and Unmanned Area Vessels

Is this vessel or any part thereof in the above categories?
Yes_____ No__X__

If "Yes", follow the requirements for an Extended Engineering Note for Existing, Used and Unmanned Area Vessels.

7. Exceptional Vessels

Is this vessel or any part thereof in the above category?
Yes_____ No__X__

If "Yes", follow the requirements for an Extended Engineering Note for Exceptional Vessels.

Appendix A. Relief/Check Valve Calculation For the Condensation Tank

Confirming the inlet restriction is smaller than the outlet diameter of the Relief valve used in operations.

BTEV RICH TESTBEAM CONDENSATION TANK
RESTRICTION INTO THE TANK SIZING

Density of air gas at 300 Kelvin, 27Celsius
1.177 Kg/M^3 Density of Air

inches internal diameter of 1/4 pipe that valve mounts to
0.0110998 Meter 0.437 Inches

air flow rate out of the valve
8.97E-03 M^3/sec 19.000 Scfm

internal diameter of the valve orifice (calculated)
0.005021366 Meter , 0.197692 inches

Throat Velocity		
4*Q/PI*Dt^2	452.8075526	m/sec
B ratio - Dt/Dnom	0.452383435	Ratio of pipe diameter to orifice diameter
K-loss coef.	2	table 7.31 page 530 , fluid mechanics
pressure drop across orifice=		density*K*Velocity_t^2/2
2.41E+05 N/m^s	35.00012 PSI	

CALCULATED ORIFICE INTO THE TANK MUST BE LESS THAN 0.197 INCH DURING OPERATIONAL VENTING
SIZED ORIFICE AT TANK INLET IS 0.188 INCH

Appendix B. Relief Valve Calculation For the Condensation Tank Fire Condition API Code

According to API code, the heat absorbed by a vessel exposed to an open fire is evaluated by:

$Q=21{,}000\ F\ A^{.82}$ (Section 5, formula #9)

Q = Total heat absorption to the wetted surface BTU/hr
F = Environmental factor = 1 for a bare vessel with no insulation
A = Total wetted surface in square feet

Assuming the tank is full of liquid during normal operations. The tank size is 12 inches diameter and 17 inches tall. The wetted surface area is 6 ft^2.

The heat absorbed into the air separator tank, Q;
Q = 92,000 BTU/hr
= 96,000 kJ/hr

The Latent Heat of Vaporization for C4F10, H is 23KJ/mole. This is assumed to be similar to C4-F8-O.

Dividing the heat absorbed by the Latent Heat of Vaporization of C4F10,
Rate of Vaporization = Q/H= 4200 moles/hr = 70 moles/min.
Molecular weight = 0.216 Kg/Mole C4-F8-O
Rate of Vaporization= 70 moles/min x 0.216 kg/mole = 15.1 Kg/min

The density of C4-F8-O is 9.64 Kg/m^3 at atmospheric pressure. The max allowable relieving pressure is 120% MAWP of the tank or 120% 200 psig = 240psig

Calculate required flow rate through the valve:
Flow rate = 15.1 Kg/min / 9.64 Kg/m^3 = 1.566 M^3/min
= 1566 liters/min = 55.3 scfm C4F8-O
Equivalent airflow is 3 times greater (flow thru an orifice is proportional to the square of the gas density)
= 165.9 scfm air at a relieving pressure of 240 psig

The relief valve selected is rated at 158 scfm air at 200 psig. Using the ideal gas law, the flow rate is equivalent to 187 scfm air at 240 psig. **The relief valve has a higher capacity than required for the fire condition.**

A second Relief valve used in operating the system is rated for 19 scfm air at 35 psig and is mounted in the same location as the fire condition relief valve.

Appendix C. Can liquid can ever flow thru the valve?

a) There is not enough gas to overfill the condensation tank. The capacity of the tank is 7 gallons. The gas volume is 116 + 20 = 136 cubic feet (=3.8 m^3)at atm pressure. Absolute density of the gas is 9.6 kg/m^3 = which yields a total of 36.6 kg of gas, liquid density is about 1.52 gm/ml =1.52kg/l so the amount of condensed liquid is 36.6/1.52kg/l= 24.1 liters = 6.4 gallons. It is unlikely that all of the gas will be drained and condensed.

b) Under fire conditions it is assumed that the vapor rises to the top of the tank and is vented out the relief valve.

c) If the tank is full of liquid and somehow the tank is pressurized with nitrogen, the nitrogen will bubble to the top of the tank and vent out the relief as a gas. Both the inlet to the tank and the relief valve are at the top of the tank.

d) If the pump keeps compressing additional c4f8o gas, then it will back up into the pump and not be vented. -The valve set pressure at 35 psig is higher than the vapor pressure 29.5 psia at room temp. The tank cannot be filled faster than it can be vented since the inlet to the tank is restricted more than the relief valve. Also overfilling the tank is prevented by the limited gas volume of the system and also with software warnings on the monitoring system.

Liquid will not be vented out the relief valve.

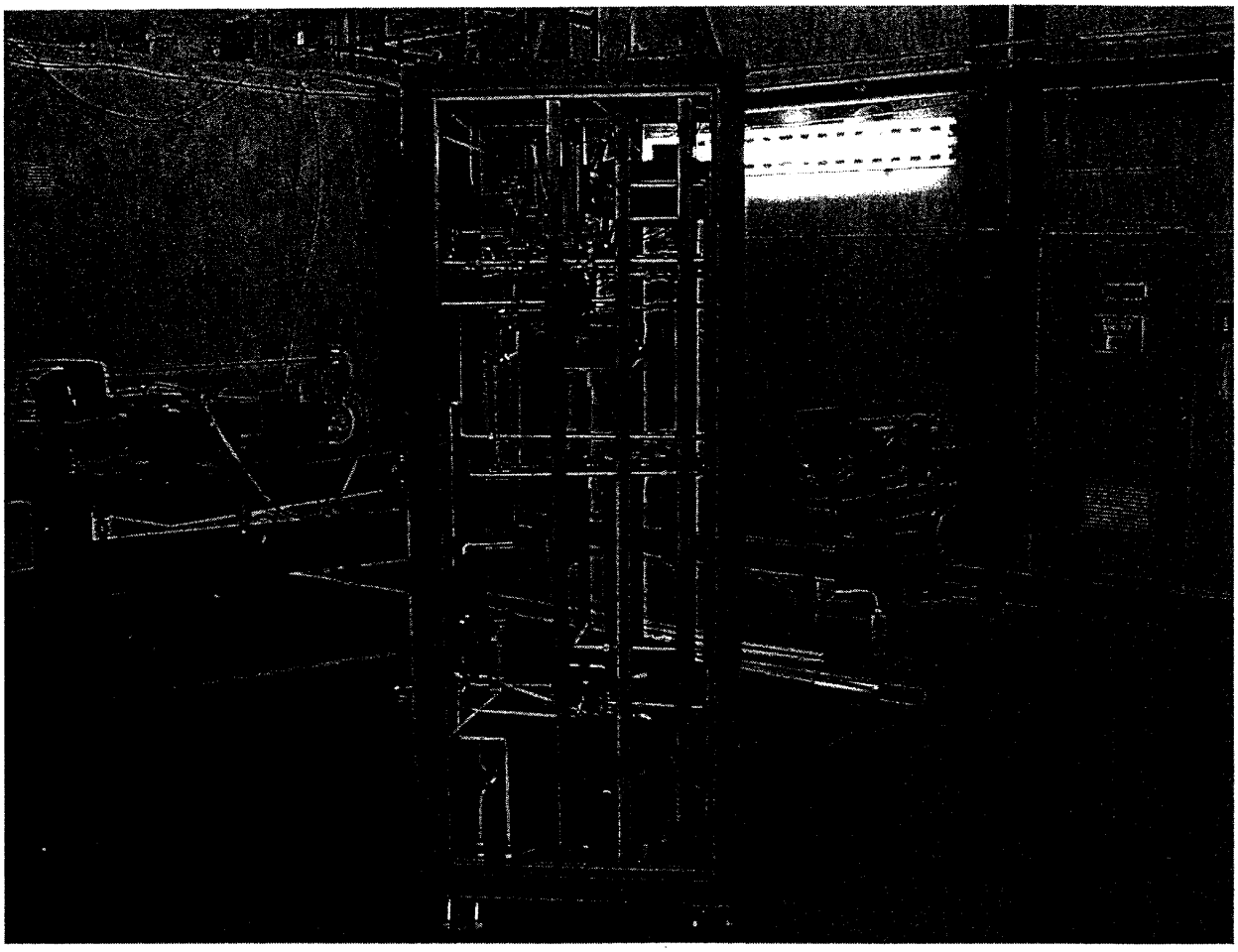


Photo of tank (Black) inside gas process platform.

TEST DOCUMENTATION
CODE STAMPED RELIEF VALVES

This form should be used for relief valves returned from a vendor to check the accuracy and quality of the vendor's work. It should also be used to check code stamped valves for the 6 year test. Valves that pass this test can be put in service if the original seal from a vendor is still in place and not broken.

All valves should be bubble tight at 90% of set pressure while increasing pressure, lift within the code requirement, and reset bubble tight. Reset pressure as a percent of set pressure would vary, depending on the blowdown setting.

The valve should be connected to the appropriate test chamber with adapters as required being careful not to choke the valve with fittings smaller than the valve inlet.

Date - 6/21/04

Vessel number (from silver sticker) - NA

Physical location and valve number - NA

Manufacturer - Circle Seal

Model number - M5159N-2M(L)

Serial number - NA

Valve size - 1/4" mpt

Seal intact - Yes

Set pressure - 200 psi

Bubble tight at 90% set pressure (90% = 180 psi) OK

Valve lift within +/- 2 psig for settings 70 psig and below or within 3% for higher settings? Tolerances defined by ASME UG-134(d)(1) (±6 psi 194-206 psi)

Test 1 - 204 psi Test 2 - 204 psi Test 3 - 204 psi

Bubble tight at reset - 180 psi

If valve passed test, attach a brass tag to valve with "TEST ONLY", date, and tester's initials.

Signed James E. Tweed

Date 6/21/04

PAB Calibration Shop
August, 2003