LTCC Single Sector Jan-Mar 2018 - Gas System

Pressure System Analysis – DHK 1/3/18 DHK 1/3/2018

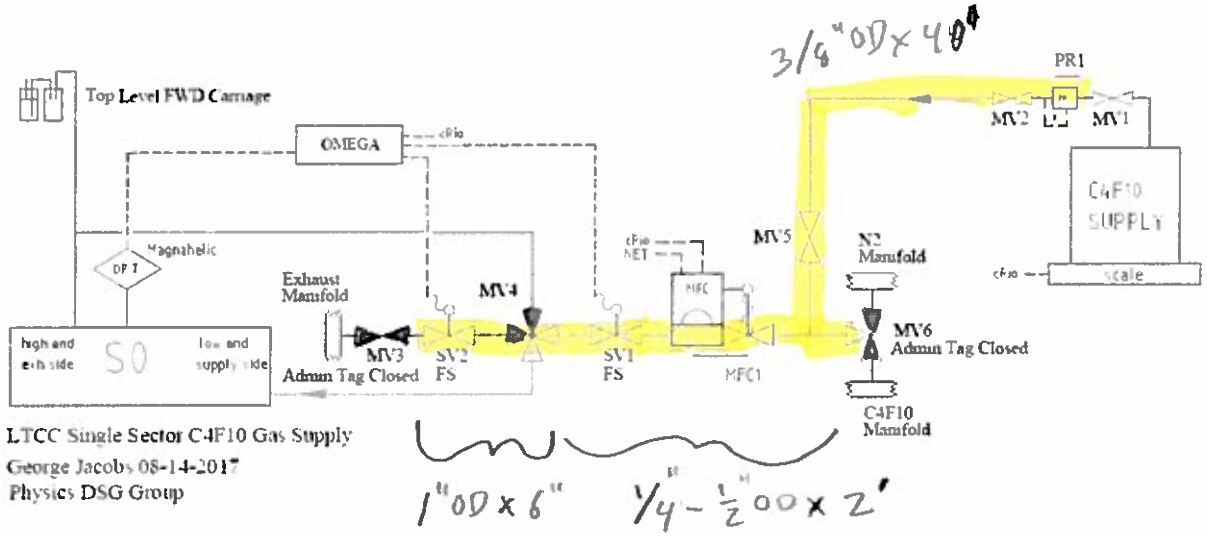
Conclusion:

This is an "excepted" system and does not need to be documented per the Pressure System Requirements. (see below for more information)

Details:

The system is used to fill and continuously top off Sector 5 of the LTCC in Hall B for CLAS12 operations during the winter/spring run 2018. The source gas will come from a storage tank that will be located in Hall B. The gas is C4F10 also known as Refrigerant R610. This is a non-toxic, non-flammable gas. The storage tank has a capacity of 500kg but only has 150kg which should be enough for the entire run. In the tank the C4F10 is a saturated liquid. Hall B is kept below 24C (75degrees F) during typical beam operations. It is usually closer to 70F. The vapor pressure of C4F10 at 24C is 24.2psig, (see attached plot) thus with the exclusion of a fire there is no way to get the system pressure above 24.2psig. The storage tank has a blowout plug in case of fire. The JLAB Pressure system allows use of DOT and other industry standard storage tanks as provided from vendors and does not require further analysis or protection systems for those vessels.

The system is shown on the P&ID below. All components are rated well above the maximum pressure of 24.2psig (see attachment). The portion of the system that can be pressurized to this pressure is from PR1 to MV3 or MV4 depending on the position of MV4, and is highlighted in yellow.



The tubing is the only volume of the system and is very small. It is called out on the P&ID and is such that the stored energy is less than 1000ft-lb. The analysis below shows the max stored energy in the system is 123ft-lb and thus this system is an "excepted" system and does not need full JLab Pressure system documentation.

LTCC single sector Gas System Stored Energy Calculation					
Section		Tubing from regulator to MV5	Other HP tubing	Other Tubing	
Gas		C4F10	C4F10	C4F10	
length	ft	40	0.5	2	
OD	in	0.375	1	0.5	
wall thickness	in	0.035	0.065	0.035	
ID	in	0.305	0.87	0.43	
Volume	cc	-	-		
Volume	in^3	35.05182	3.564999	3.483516	
ratio of specific heats	-	1.056	1.056	1.056	http://webbook.nist.gov/cgi/fluid.cgi?Action=Load&ID=C355259&Type=IsoTherm&Digits=5&PLow=1&PHigh=1&PInc=1&T=20&RefState=DEF&TUnit=C&PUnit=atm&DUnit=g%2Fml&HUnit=kJ%2Fkg&WUnit=m%2Fs&VisUnit=uPa*s&STUnit=N%2Fm
System pressure	psig	24.2	24.2	24.2	
Absolute system pressure	psia	38.9	38.9	38.9	
Energy	in-lb	1.22E+03	1.25E+02	1.22E+02	
	ft-lb	102.1	10.4	10.1	
	kJ	1.38E-01	1.41E-02	1.38E-02	
	lb TNT	6.86E-05	6.97E-06	6.81E-06	
Total System Energy	**ft-lb**	**123**			
Is this portion of the system above 1000Ft-lb		**NO- Not a Pressure System**			
	kJ	1.66E-01			
	lb TNT	8.23E-05			

1.4.1 Baker Equation

The stored mechanical energy of a gas may be calculated using the following expression

$$E = \frac{P_{test}V}{k-1}\left[1-\left(\frac{P_{atm}}{P_{test}}\right)^{(k-1)/k}\right]$$

Where

E = stored energy of test

V = test volume

P_{atm} = absolute atmospheric pressure of test (14.7 psia in US cust. units)

P_{test} = absolute pressure of test

k = ratio of specific heats

Note: any system of units may be used (e.g. ASME PCC-2 Article 5.1) provided that they are consistent.

1.4.2 Equivalent mass in TNT

The stored mechanical energy may be converted to an equivalent mass of TNT. The following equation may be used to convert the stored energy of a system to pounds of TNT

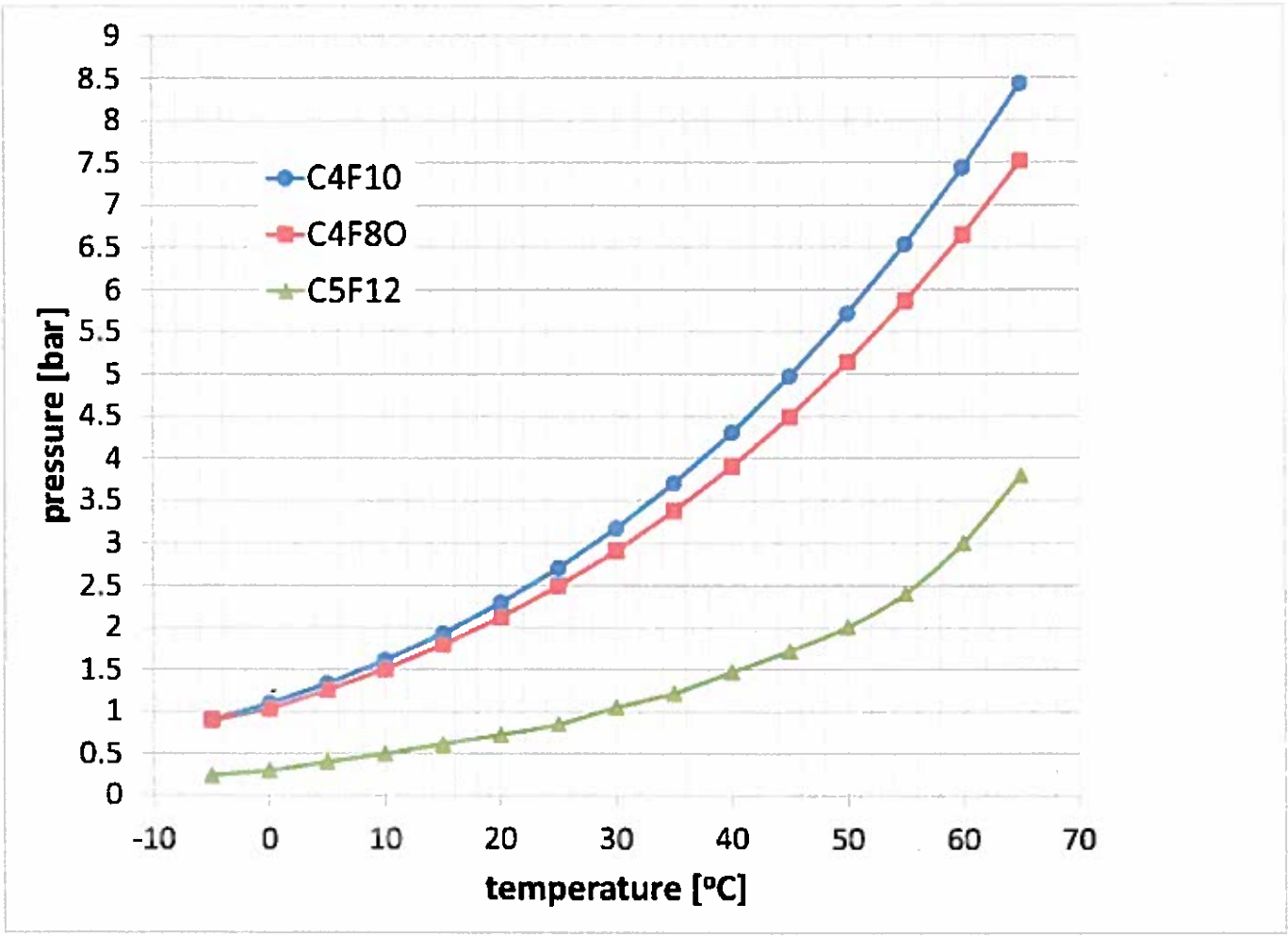
$$TNT = \frac{E}{1488617}$$

Where

E = stored energy of test (ft-lbf)

TNT = equivalent amount of TNT (lb)

Note: alternate units may be used (e.g. ASME PCC-2 Article 5.1) provided that they are consistent.


C4F10
C4F8O
C5F12
pressure [bar]
temperature [°C]
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-10
0
10
20
30
40
50
60
70

	A	B	C	D	E	F
1	Label	Component	Detail	Pressure Rating		
2	MV1	Supply Tank Valve	n/a	n/a		
3	MV2	pressure regulator outlet	Matheson LMT 4374	3500 psi		
4	MV3	exhaust valve	Whitey B-65TS16	1500 psi		
5	MV4	flow reversal valve	Swagelock B-45YF8	1500 psi		
6	MV5	C4F10 supply	Whitey ss-1rs4	1500 psi		
7	MV6	3 way valve	Whitey SS-45XS8	1500 psi		
8						
9	PR1	Matheson 3816-660	0-140 out	3500 psi		
10						
11	MFC1	MKS 0-50 slm N2 -> 0-5 slm C4F10	MKS model GE50 MFC	1500 psi		
12						
13	SV1	solenoid valve	Asco Red Hat 2HTY1	150 psi		
14	SV2	solenoid valve	Asco Red Hat 2HTX7	150 psi		
15						
16	Tubing				Length	Part #
17	3/8" nylon	supply line	newage 2341472	450 psi		
18	1" nylon	exhaust line	newage 2342732	230 psi		
19						
20						
21	Gas	Contents	Pressure			
22	C4F10 (R610)	150 kg	< 120 psi saturated gas, see Press vTemp chart			
23			Tank has blow out plug in case of fire heating			