MONROE BROTHERS LTD

Customer	Sigmaphi		
Project	Jlab Q2-Q3 Pressure Relief	Project Number	SF / 13603
Description	Vessel Vent Path — Vessel to the Burst Disc	Design Note 239	Issue 1
msg_corner			Version at 1 May 2016

Fluid	Helium	
Mass flow rate	19780.0	kg / hr
	5494.4	g / s
Pressure	5.487	bar G
	6.500	bar A
Vent temperature	7.01	K
Superheat	0.00	K
Gas temperature	7.01	K

Pressure drop			
Burst disc	39	mbar	13.2%
Diverter valve	78	mbar	26.1%
Total	298	mbar	100.0%

Convergence error - Absolute 0.00%

Succesful Convergence

Column insertion		Valid	Valid	Valid			Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid			Valid		
Start Position		010	020	030	040	050	060	070	080	090	100	110	120	130	140	140	150	160	170	180
Finish Position		020	030	040	050	060	070	080	090	100	110	120	130	140	140	150	160	170	180	
Description	Entry Loss	010 to 020	020 to 030	030 to 040	NRV	050 to 060	060 to 070	070 to 080	080 to 090	090 to 100	100 to 110	110 to 120	120 to 130	130 to 140	140 to 140	Burst Disc	150 to 160	160 to 170	170 to 180	Vent
Type																FIKE AXIUS Low Press				
Divertor Valve Kv					250															
Divertor Valve Cf					0.6															
Burst disc Sizing parameter																Resistance Coeff Kr 0.45				
Resistance Coeff Kr																				
Pressure	6.500	6.500	6.500	6.500	6.500	6.422	6.422	6.421	6.419	6.353	6.352	6.329	6.329	6.311	6.310	6.310	6.271	6.271	6.271	6.202 bar A
Temperature	7.010	7.010	7.015	7.015	7.015	7.004	7.027	7.040	7.061	7.075	7.083	7.107	7.116	7.131	7.148	7.148	7.139	7.139	7.139	7.123 K
Vapour density	83.675	83.675	83.494	83.494	83.494	82.684	81.870	81.401	80.609	79.113	78.822	77.676	77.392	76.616	76.057	76.057	75.754	75.754	75.754	kg / m³
Vapour viscosity	2.81E-06	2.81E-06	2.81E-06	2.81E-06	2.81E-06	2.80E-06	2.79E-06	2.78E-06	2.77E-06	2.75E-06	2.75E-06	2.74E-06	2.73E-06	2.72E-06	2.72E-06	2.72E-06	2.71E-06	2.71E-06	2.71E-06	kg / m.s
Speed of sound	162.3	162.3	162.2	162.2	162.2	161.2	160.9	160.8	160.6	159.7	159.6	159.2	159.2	159.0	158.9	158.9	158.5	158.5	158.5	
																7.39				in²
	4.000 n.b.,	4.000 n.b.,	4.000 n.b.,	4.000 n.b.,		4.000 n.b.,	3.000 n.b.,	3.000 n.b.,	3.000 n.b.,	3.000 n.b.,	3.000 n.b.,	3.000 n.b.,	3.000 n.b.,	3.000 n.b.,				3.000 n.b.,	3.000 n.b.,	
Pipe nominal bore	sched 10S	sched 10S	sched 10S	sched 10S		sched 10S	sched 10S	sched 10S	sched 10S	sched 10S	sched 10S	sched 10S	sched 10S	sched 10S				sched 10S	sched 10S	
Outside diameter	114.30	114.30	114.30	114.30	180.00	114.30	88.90	88.90	88.90	88.90	88.90	88.90	88.90	88.90	114.30	250.00	114.30	88.90	88.90	mm
Wall	3.05	3.05	3.05	3.05		3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05				3.05	3.05	mm
Inside diameter	108.20	108.20	108.20	108.20	108.20	108.20	82.80	82.80	82.80	82.80	82.80	82.80	82.80	82.80	82.80	82.80	82.80	82.80	82.80	mm
Length	0.0	127.0	0.0	0.0	100.0	576.0	79.4	720.7	172.0	50.8	172.0	50.8	114.3	101.6	0.0	0.0	0.0	0.0	0.0	mm
Flow area	9195.5	9195.5	9195.5	9195.5	9194.8	9195.5	5385.1	5385.1	5385.1	5385.1	5385.1	5385.1	5385.1	5385.1	5385.1	4767.7	5385.1	5385.1	5385.1	mm²
Mass flow	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	5494.4	g / s
Mass velocity	598	598	598	598	598	598	1020	1020	1020	1020	1020	1020	1020	1020	1020	1152	1020	1020	1020	kg / m².s
Velocity	7.14	7.14	7.16	7.16	7.16	7.23	12.46	12.53	12.66	12.90	12.94	13.14	13.18	13.32	13.42	15.15	13.47	13.47	13.47	
Mach number	0.044	0.044	0.044	0.044	0.04	0.045	0.077	0.078	0.079	0.081	0.081	0.082	0.083	0.084	0.084	0.095	0.085	0.085	0.085	
Pipe Contraction Geometry	Sudden						Sudden													
(Node Inlet) Upstream diameter (Large)	Large						108.20													
Node Diameter	108.20						82.80													
Length																				
Angle																				
Diameter ratio	0.000						0.77													
Resistance coefficient	0.464						0.12													
Pressure loss	9.9						7.85													mbar
Pipe Friction Loss Reynolds number		2.30E+07	2.30E+07	2.30E+07		2.31E+07	3.03E+07	3.04E+07	3.05E+07	3.07E+07	3.07E+07	3.09E+07	3.09E+07	3.10E+07	3.11E+07		3.12E+07	3.12E+07	3.12E+07	
Friction coefficient		0.00456	0.00456	0.00456		0.00456	0.00426	0.00426	0.00425	0.00425	0.00424	0.00424	0.00424	0.00423	0.00423		0.00423	0.00423	0.00423	
Pressure drop per unit length		0.90	0.90	0.90		0.91	3.27	3.29	3.32	3.37	3.38	3.43	3.44	3.47	3.50		3.51	3.51	3.51	
Pressure drop		0.11	0.00	0.00		0.52	0.26	2.37	0.57	0.17	0.58	0.17	0.39	0.35	0.00		0.00	0.00	0.00	mbar per m
Pipe Enlargement																			Sudden	
(Node Outlet) Node Diameter																			82.80	mm
Downstream diameter (Large)																			Large	mm
Length																				mm
Angle																				
Coefficient																				
Pressure loss																			68.7	mbar
Pipe Fitting Fitting								Tee - As elbow		Tee - Thru flow		Elbow 90° LR								
(Node Outlet) Velcoity head loss index								8		7		4								
Velocity head loss								1.02		0.34		0.27								
Pressure loss								65.86		22.45		18.16								

Enlargement & Fittings are mutually exclusive)

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Divertor Valve	Kv				250																
Reference 01-033.tif	Cf				0.6																
	Estimated Pressure drop				0.0779																bar
	Gf				10.4838																
	Pressure drop at choked conditions				1.982																bar
Maximum mass flow rate at choked conditions					18665																g / s
	Factor y				0.2974																
	Pressure drop factor				0.2935																
	Mass flow rate				5494.44																g / s
	Error in mass flow				0.000%																
	New estimate in pressure drop				0.078																bar
	Calculated pressure drop				78																mbar
	Damping (100% no convergence)				-200%																
	Next iteration				0.0779																bar
Burst Disc	Resistance coefficient Kr																0.45				
	Loss factor Cd																1.491				
	Estimated pressure drop																0.039				bar
	Isentropic coefficient																3.044				
	Critical pressure ratio																0.350				
	Actual pressure ratio																0.994				
	Used pressure ratio																0.994				
	Mass velocity																1152				kg / s per m²
	Mass flow rate																5495				g / s
	Error in mass flow																0.002%				
	Next estimate in pressure drop																0.039				bar
																	39.4				mbar
	Pressure loss - Incompressible flow																0.039				bar
																					convergnc_r
Heating	External Surface area	0	45604	0	0	56549	206832	22175	201283	48037	14188	48037	14188	31923	28376	0	0	0	0	0	mm³
	Heat Flux + contingency	7000	7000	7000	7000	7000	7000	38000	7000	38000	38000	38000	38000	38000	38000	38000	38000	38000	38000	38000	W / m²
	Heat Load	0.00	319.23	0.00	0.00	395.84	1447.83	842.67	1408.98	1825.42	539.14	1825.42	539.14	1213.06	1078.27	0.00	0.00	0.00	0.00	0.00	W
	Node outlet pressure	6.500	6.500	6.500	6.500	6.422	6.422	6.421	6.419	6.353	6.352	6.329	6.329	6.311	6.310	6.310	6.271	6.271	6.271	6.202	
	Inlet specific enthalpy	19.952	19.952	20.010	20.010	20.010	20.082	20.346	20.499	20.756	21.088	21.186	21.518	21.616	21.837	22.033	22.033	22.033	22.033	22.033	kJ / kg
	Specific enthalpy increment	0.000	0.058	0.000	0.000	0.072	0.264	0.153	0.256	0.332	0.098	0.332	0.098	0.221	0.196	0.000	0.000	0.000	0.000	0.000	kJ / kg
	Outlet specific enthalpy	19.952	20.010	20.010	20.010	20.082	20.346	20.499	20.756	21.088	21.186	21.518	21.616	21.837	22.033	22.033	22.033	22.033	22.033	22.033	kJ / kg
	Outlet temperature	7.010	7.015	7.015	7.015	7.004	7.027	7.040	7.061	7.075	7.083	7.107	7.116	7.131	7.148	7.148	7.139	7.139	7.139	7.123	K
	Temperature rise	0.000	0.005	0.000	0.000	-0.010	0.022	0.013	0.021	0.014	0.008	0.024	0.009	0.015	0.017	0.000	-0.009	0.000	0.000	-0.016	K
Pressure Drop Summary	Inlet contraction	9.91						7.85													mbar
	Pipe friction		0.11				0.52	0.26	2.37	0.57	0.17	0.58	0.17	0.39	0.35						mbar
	Outlet enlarger																			68.71	mbar
	Pipe Fitting									65.86		22.45		18.16							mbar
	Diverter valve					77.91															mbar
	Burst disc																39.41				mbar
	TOTAL	0.00	0.11	0.00	0.00	77.91	0.52	0.26	2.37	66.43	0.17	23.03	0.17	18.55	0.35	0.00	39.41	0.00	0.00	68.71	mbar
	Node outlet pressure	6.50	6.50	6.50	6.50	6.42	6.42	6.42	6.42	6.35	6.35	6.33	6.33	6.31	6.31	6.31	6.27	6.27	6.27	6.20	bar A
	Node outlet temperature	7.01	7.01	7.01	7.01	7.00	7.03	7.04	7.06	7.07	7.08	7.11	7.12	7.13	7.15	7.15	7.14	7.14	7.14	7.12	K