Relief Valve Test Panel: Relief Valve Sizing

T. Schaus, 6/22/92

Five relief valves exist on the RD/Cryo Relief Valve Test Panel. (Please refer to drawing #MD-194470 and 'Piping, Valve, and Instrument List' for information.) To be effective, these relief valves must be able to handle the maximum flow rates supplied by all feasible sources, and will be shown to do so below. Four relief valves are Circle Seal 5100 series valves and one is an Anderson Greenwood valve. More information on them may be found in their catalogs.

Relief Valve MV-121 (set at 450 psig) protects a 0-500 psig gauge (PI-116) and must be able to handle the maximum flow through regulator RV-126 or regulator RV-127, depending on the positions of ball valves MV-104, 105, and 106. If valves MV-104 and 105 are closed and regulator RV-126 is set at 750 psig, a maximum flow rate of 62 SCFM air must be expelled (this number was supplied by a Grove engineer, assuming a 2000 psig input). If MV-104, 105, & 106 are open, regulator RV-127 may supply air. A formula obtained from a Fairchild catalog may be used here with reasonable accuracy. If the maximum inlet pressure is again 2000 psig:

Max. Flow = (.13)(inlet pressure)
= (.13)(2000 psig) = <u>260 SCFM air</u>

The flow capacity of relief valve SV-121 is approximately <u>450 SCFM</u> of air at 10% overpressure (from Circle Seal catalog, 5100 series specifications), and therefore is capable of protecting PI-116 from either source.

Relief valves SV-122 and SV-124 (Anderson / Greenwood) control the pressure in the 0-100 psig and 0-500/0-2000 psig volume chambers, respectively. They are sized using the accepted Compressed Gas Association formula for an un-insulated container holding a non-liquefied gas (CGA S-1.3-1980, p8):

SV-124: Q = .029W, Q = minimum flow rate required
W = weight of water which could fill the chamber

Q = 0.029(.2292 cubic feet)(62.45 lbm per cu. foot)
= <u>0.4150 SCFM air</u>

From Anderson / Greenwood capacity charts, we find that SV-124 can handle approximately <u>1580 SCFM</u> of air at 110% of its 1950 psig cracking pressure, many times more than enough.

SV-122: Q = 0.029(.7292 cubic feet)(62.45 lbm per cu. foot)
= <u>1.321 SCFM air</u>

SV-122 cracks at 103 psig and has a capacity of <u>100 SCFM</u> at 10% overpressure, also more than enough.

Next, relief valve SV-123 must limit the pressure of the manifold at 110 psig. Again, the maximum flow rate through the Grove regulator (RV-125) is <u>62 SCFM</u> of air, as model number 15LG differs from model 15L only in the hand wheel. For SV-123, the Circle Seal catalog gives a maximum flow capacity of <u>100 SCFM</u> of air at 10% overpressure, a satisfactory rate.

Finally, SV-128 must restrict the flex hose pressure to 2300 psig. The highest bottle pressure connected to the panel in the last eight years was 2600 psig, but most fall near the normal 2000 psig pressure. As the bottle's manual valve is opened, the flex line pressurizes to the bottle pressure. If this pressure rises to 2300 psi, SV-128 must start releasing air at the rate it enters. Assuming a flow rate of 400 SCFM air leaving through the valve (SV-128 releases air at approximately 400 SCFM at only 10% overpressure - Circle Seal catalog), we can get a good idea of the time it takes to lower the pressure from 2600 psi to 2300 psi:

Mass at 2600 psig:

$$pV = mRT$$

with: $p = 2600$ psig

$V = \text{vol in ft}^3 = 1.55 \text{ ft}^3$

$m = $ mass in lbm

$$R = \frac{\overline{R}}{M} = \frac{1545}{28.97} = 53.33 \frac{\text{ft lbf}}{\text{lbm °R}}$$

$T = $ temperature in °R

$$m_1 = \frac{pV}{RT} = \frac{(2300 \text{ lbf})(1.55 \text{ ft}^3)(\text{lbm °R})(144 \text{ in}^2)}{(\text{in}^2)(53.33 \text{ ft lbf})(530 \text{ °R})(\text{ft}^2)} = 20.53 \text{ lbm}$$

Mass at 2300 psig:

$$m_2 = \frac{2300}{2600} m_1 = 18.16 \text{ lbm}$$

Change in mass:

$$\Delta m = 20.53 - 18.16 = 2.37 \text{ lbm}$$

At standard temperature and pressure:

$$V = \frac{mRT}{p} = \frac{(2.37 \text{ lbm})(53.33 \text{ ft lbf})(530 \text{ °R})(\text{in}^2)(\text{ft}^2)}{(\text{lbm °R})(14.4 \text{ lbf})(144 \text{ in}^2)} = 32.29 \text{ ft}^3$$

Using a flow capacity of 400 SCFM air:

$$\text{time} = t = \frac{32.29 \text{ ft}^3 \text{ min}}{400 \text{ ft}^3} = 0.0807 \text{ min.} = 4.8 \text{ seconds}$$

With a time on the order of a few seconds, there should be no problem with the valve keeping up with the incoming flow, especially since the operator takes a few seconds to open the bottle valve manually.