Skidmore Air Vent: Understanding Vent Properties to Propose Redesign Solutions

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Abstract

Skidmore Pump is a company that manufactures air vents for the purpose of automatically relieving air from steam main lines. Recently, Skidmore was notified of a significant price increase and tooling cost that would affect parts of the latter two vent models of their Main Vent production line: #35, #75, and #77. Skidmore has proposed a low cost option of reconfiguring the design of Main Vent #35, where slight design modifications will be done to alter performance characteristics. Thus, Main Vent #75 and Main Vent #77 will have their corresponding performance characteristics met within the body of Main Vent #35.

Background

Steam vents are a vital part of any steam distribution system, as they are able to vent out unwanted air amidst a steady flow of steam. The air vents analyzed in this project comprise a metal hollow main body, a thermostatic element, and a ledge on which the thermostatic element rests. A CAD drawing of a vent can be seen below in Figure 1. The main cylindrical body, threaded at the bottom with a smaller orifice on top, houses the thermostatic element—a closed cylindrical body of thin metal. This element closes the vent under steam exposure by heating the water in itself, increasing vapor pressure, and popping the element upward. Additionally, the vent can achieve closure when the internal air or steam system pressure surpasses the vent's maximum operating pressure. Changes in Main Vent #35 explored were the thermostatic element's vertical range of motion, its weight, and top orifice diameter. As the performance characteristics of the vents for airflow vs. pressure were not known by Skidmore, the development of a suitable test fixture to measure these characteristics was imperative.

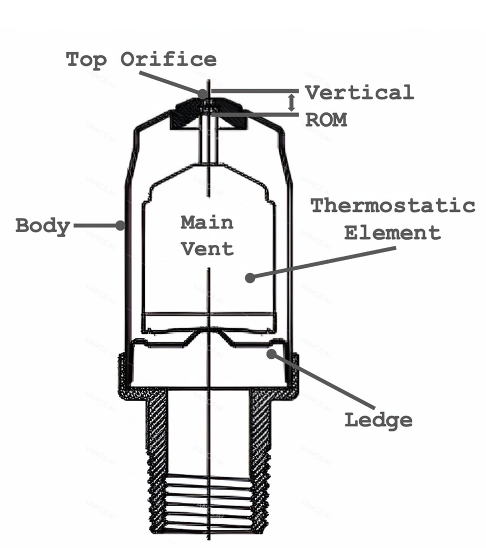

Figure 1: A labeling of Skidmore's Main Vent production line vents.

Methodology

The created test fixture for vent characterization utilizes a pressure gauge rated at 0-10 PSI and flow meter rated at 2-20 SCFH. Once the vent sample is mounted on the top threaded opening, pressurized air is sourced into the bottom of the flow meter. This fixture be seen below in Figure 2. The following steps were then taken to characterize the vents and hypothesize design alterations:

- All readings were manually recorded from the flow meter and pressure gauge at increments of 0.2 PSI. Trials were repeated for 10 samples of each vent model. A systematic block diagram of this process is shown below in Figure 3.
- A theoretical baseline performance model was created and verified with all existing vents using the analysis software Matlab.
- Parameters were changed on the Main Vent #35 model and compared with the corresponding #75 and #77 models.
- Plots of modified #35 vent models were overlaid in Matlab with their ideal baseline performance and verified.

Figure 2: Assembly of vent test fixture created in the computer-aided design software SolidWorks.

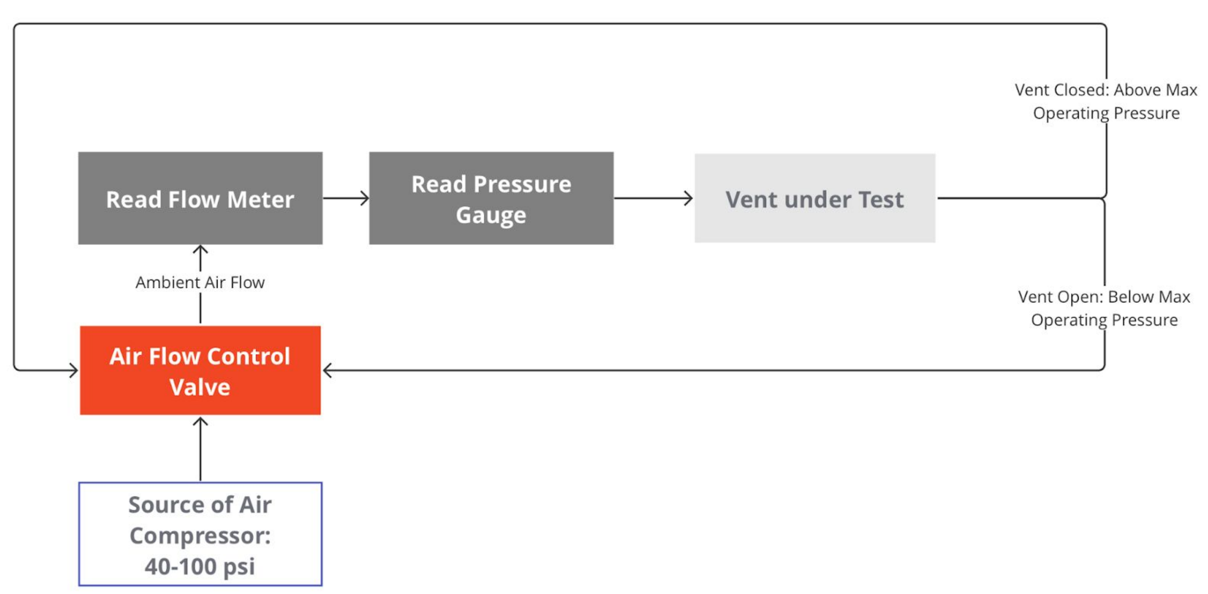

Figure 3: Block diagram outlining the general approach that will be used to obtain air flow and pressure readings.

Results

Using 10 samples per vent model, the data for Main Vent #35, #75, and #77 was compiled and plotted in matlab, as can be seen in Figure 4, Figure 5, and Figure 6 respectively. A wide performance range within each model was observed, spanning substantially for air flow. Deviation from specified max operating pressure for each vent was minimal in comparison.

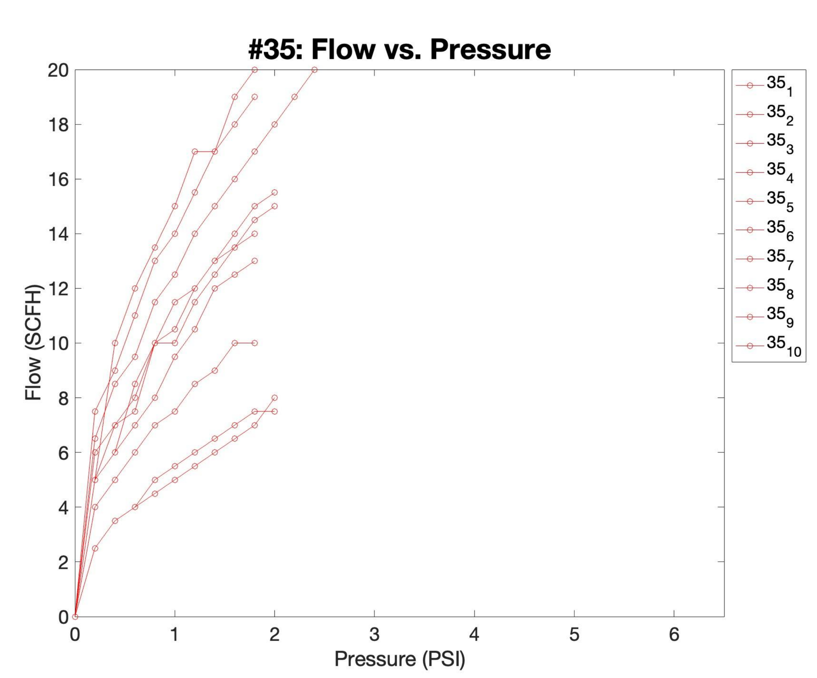

Figure 4: Pressure and air flow data for 10 samples of Main Vent #35 recorded at 0.2 PSI increments.

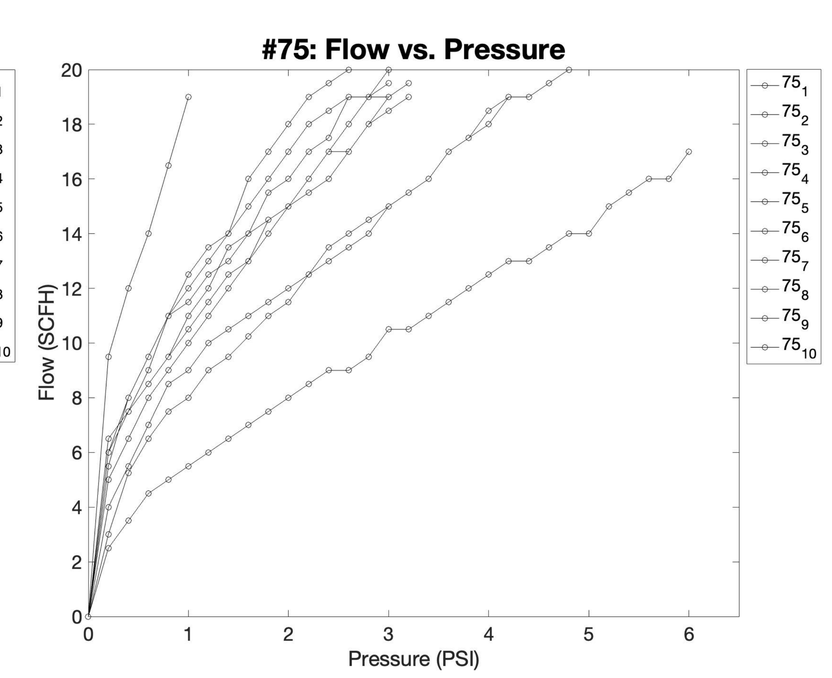

Figure 5: Pressure and air flow data for 10 samples of Main Vent #75 recorded at 0.2 PSI increments.

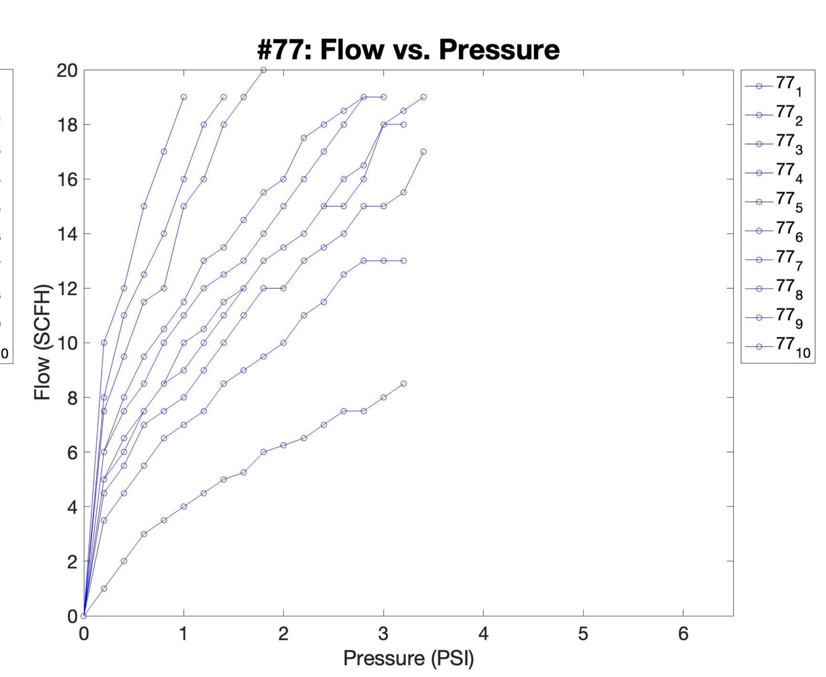

Figure 6: Pressure and air flow data for 10 samples of Main Vent #77 recorded at 0.2 PSI increments.

Conclusions

Successful and accurate models were created for each vent, with the parameters of orifice size and thermostatic element vertical range of motion observed to alter flow rate at a specific pressure. Altering the weight of the thermostatic element was observed to only affect max operating pressure in a linear relationship. The created theoretical baseline models can be seen below in Figure 7. The existing model sets the thermostatic element range of motion of Main Vent #35 at 0.029 inches and orifice size at 0.09375 inches. To match the performance of Main Vent #75 and #77, the altered ranges of motion were 0.029 in. and 0.041 in. respectively. At the same orifice size of 0.09375, the calculated weights of the thermostatic element were 22.0 grams and 16.0 grams respectively. The performance of the altered #35 vents and their corresponding curves can be seen below in Figure 8.

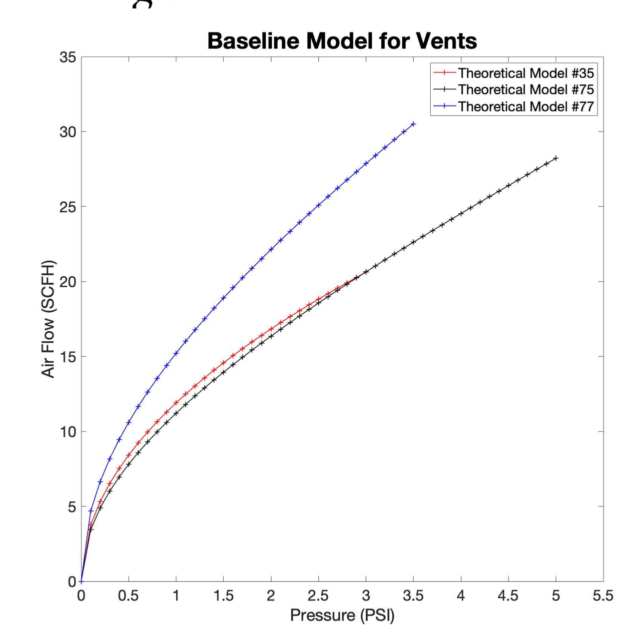

Figure 7: Theoretical Models of Skidmore's Main Vent production line.

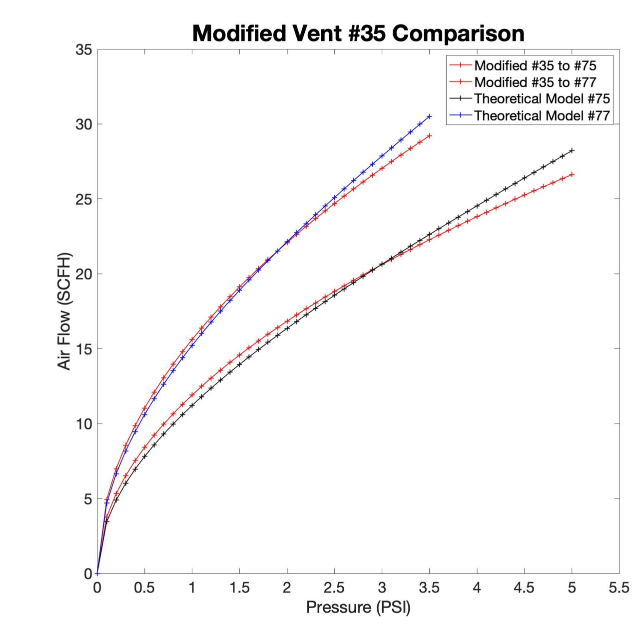

Figure 8: Air flow characteristics of modified Vent #35 overlaid with their corresponding ideal baseline values.

Bibliography

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- Hibbeler, R. C., & Yap, K. B. (2020). *Fluid Mechanics* (2nd ed.). Pearson Education.
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