Program sizes compressible flow for discharge piping

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More accurate prediction of pressure drop, friction factor, and mach number for compressible flow in a network of connecting pipes from a pressure relief valve or valves can be determined by a personal computer program written in Fortran 77.

The program incorporates added features for determining the compressibility factor of a natural hydrocarbon gas, and the TWO-K method for determining the resistance of pipe fittings and of entrance and exit losses.

The design of discharge piping or headers from relief valves for gases generally relates closely to isothermal conditions. Lapple[1] presented equations for compressible flow for both isothermal and adiabatic conditions.

An important guideline for sizing discharge lines and headers from a relief valve using compressible fluids is to prevent the back pressure at relief valve outlets from reducing the fluid-relieving capacity of the valve and header system. Sometimes designs that do that can also cause vibration in the discharge lines and unacceptable noise.

Conversely, if the back pressure is excessive, the relief valve may fail to lift at its set pressure. Conventional relief valves tolerate back pressures up to 10% of their set pressures, while balance-bellows types can tolerate up to 30-50% of set pressure. The capacity of the valves is reduced above these tolerances.

The design of relief valves is governed by well-established guides such as API RP-520 which employs a kinetic energy correction factor,[2] and API RP-521 which relies on the Lapple chart.[3] The limitation in successfully employing these methods is that they are based upon the unknown back pressure or header inlet pressure when the valve is discharging.

Therefore, these methods often require a tedious trial-and-error solution. Fig. 1 illustrates a typical discharge line (or tail pipe) from a safety relief valve.

The program. Various programs have been developed for sizing discharge lines from relief valves. The earliest by Kandell[4] used a Texas Instruments TI-59 calculator program.

Kumar and Mason[5] adopted an explicit form of the friction factor equation given by Chen[6] in a Basic computer program that solves the isothermal gas flow equation. Tsai[7] further incorporated Hooper's TWO-K method into a program to determine the head losses for the various fittings, also using Basic.

For the program described in this article, an interactive Fortran 77 language is used to solve a broad range of pipe sizing problems. The program calculates the pressure drop for compressible fluid flow.

A subprogram is incorporated which calculates the compressibility factor of a natural hydrocarbon gas. An added feature in the program involves determining the excess head loss for fittings using the TWO-K method, which is more