Table 1

Example 1 results

Gas flowrate = 0.2000000E+05 lb/hr
Pipe internal diameter = 0.6065000E+01 in.
Gas compressibility factor = 0.1000000E+01
Pipe inlet pressure = 0.2113698E+02 psia
Pipe outlet pressure = 0.1470000E+02 psia
Actual length of pipe = 0.1200000E+02 ft
Pressure drop of the pipe = 0.6436985E+01 psia
Mach number at the pipe inlet = 0.0414778E+01
Mach number at the pipe outlet = 0.0596405E+01
Total equivalent length = 0.6255641E+02 ft
Total length of pipe = 0.7455641E+02 ft
Reynolds number = 0.1445815E+07
Darcy friction factor = 0.0154212E+00
The upflow gas density = 0.0455015E+00 lb/cu ft
The upstream gas velocity = 0.6082197E+03 fps
The sonic velocity = 0.1465606E+04 fps
Do you want to terminate the program? yes/no

Table 2

Results of Example 2

Gas flowrate = 0.8000000E+04 lb/hr
Pipe internal diameter = .0614000E+01 in.
Gas compressibility factor = 0.0820637E+01
Pipe inlet pressure = 0.1124700E+04 psia
Pipe outlet pressure = 0.6562853E+03 psia
Actual length of pipe = 0.2300000E+02 ft
Pressure drop of the pipe = 0.4684146E+03 psia
Mach number at the pipe inlet = 0.0227294E+01
Mach number at the pipe outlet = 0.0389522E+01
Total equivalent length = 0.0000000E+00 ft
Total length of pipe = 0.2300000E+02 ft
Reynolds number = 0.8226159E+07
Darcy friction factor = 0.0260021E+00
The upflow gas density = 0.4337668E+01 lb/cu ft
The upstream gas velocity = 0.2490088E+03 fps
The sonic velocity = 0.1094962+04 fps
Do you want to terminate the program? yes/no

Table 3

Calculated results for vent lines to the flare stack

Line	Stack	AB	BD	Pipe sections DE	DF	BC	CH	CG
Nominal size, in.	30	18	12	8	8	12	10	6
Schedule	10	20	40	40	40	40	40	40
W, lb/hr	350,000	350,000	180,000	60,000	120,000	170,000	100,000	70,000
Z, (1.0)								
T, °F.	186.6	186.6	233.3	340	180	137.6	150	120
Mw	56	56	69.5	55.0	80	46.4	40	60
μ, cp ft (0.00015)	0.0108	0.0108	0.0118	0.0130	0.0110	0.0099	0.0100	0.00979
P_2, psia	14.7	15.1346	34.1452	37.8689	37.8689	34.1452	36.6166	36.6166
d, in.	29.376	17.376	11.958	7.9812	7.9812	11.958	10.02	6.0645
L, ft	250	1,000	200	180	100	115	300	150
f, friction factor (0.01)								
R, P_1/P_2 (1.0)								
MAPB, psia	-	-	-	45.9	45.7	-	44.7	58.7
Calculated values								
M_1	0.2226	0.2826	0.2570	0.2104	0.3043	0.2848	0.2238	0.2959
M_2	0.2297	0.6375	0.2852	0.2324	0.3447	0.3061	0.2602	0.3959
N_{Re}	6,965,109	11,775,270	8,053,935	3,651,033	8,629,714	9,066,327	6,300,983	7,443,829
ΔP, psia	0.4647	19.0067	3.7429	3.9623	5.0239	2.5549	5.9543	12.3623
P_1, psia	15.1647	34.1413	37.8881	41.8312	42.8928	36.7001	42.5709	48.9789
f	0.01132	0.01221	0.01327	0.01433	0.01418	0.01311	0.01362	0.01501
V_a,fps	168.5035	213.9187	180.8433	178.7124	191.7185	227.6518	194.6861	204.9693
V_s, fps	756.5369	756.369	703.1929	849.1217	639.7255	799.0107	869.4432	692.2208

These values are converted to equivalent lengths of straight pipe and added to the actual straight pipe length to obtain the total equivalent pipe length. From this total equivalent length and the calculated friction factor, the pressure ratio is then calculated.

Discharge line sizing. The following steps are used to size flare manifolds and relief valve blowdown systems:

1. The design starts at the flare tip where the outlet pressure is atmospheric. The calculation is worked back toward each relief valve in the system.

2. A size is assumed for each pipe section, and the maximum allowable velocity at each section inlet and outlet corresponds to a mach number of 0.7. This criterion is applied to avoid pipe vibration and noise generation caused by excess velocity in the lines.

3. Properties in the common headers may be estimated from the relationships given in Equations 19, 20, and 21. In those equations, i is the ith component.

4. The inlet pressure is calculated for each section of the line. At each line change, the inlet pressure for the downstream line, P_1, is taken as the outlet pressure of the upstream line, P_2, and a new upstream pressure, P_1 is calculated. The operation is repeated, working back toward each relief valve.

5. The maximum allowable back pressure, MABP, is taken as 10% of the set pressure for conventional relief valves, and 40% of the set pressure for balanced-bellows relief valves.

6. The calculated back pressure at the relief valve (valves) is then checked against the maximum allowable back pressure (MABP). The calculated back pressure should be less than, but close to the MABP.

7. If there is a great difference between the calculated back pressure and the MABP, the longest header should be decreased in size until the calculated back pressure is close to the MABP.

Vent piping. In general, the discharge piping or tail pipe should be as direct and as vertical as possible. Horizontal runs and elbows should be limited, or at best, avoided.

Vent lines must never have any pockets (traps), and valves should never be installed between the relieving device and the vessel or system it is protecting. Pipe fittings should be kept at a minimum.

If in doubt about pipe size, use a size larger.

Program use. KAFLO is a program for sizing the discharge line or tail pipe of a relief valve or valves for a compressible, isothermal gas flow. The program is interactive with the user and generates report-quality outputs.

The program can be downloaded onto a hard disk of a personal computer, or it can be run from a floppy diskette.

It can be run only on IBM XT/AT and compatible computers that are equipped with graphics adaptors.

The program can be executed directly in the DOS environment. To run the program from a hard disk system, simply type "kaflo.exe or kaflo" after the C> or C:\> prompt if it is loaded into the root directory (after the C prompt for other directories if the program is loaded into its own or another directory other than the root). If running from a floppy disk, type "kaflo" after the a or b prompt.

Examples. Three examples are given to familiarize the reader with the use of the program. The first example is to size the tail pipe for steam flowing through a 6-in., schedule (Sch.) 40 pipe from a pressure relief valve at a set pressure of 110.4 psig, under the following conditions:

W = 20,000 lb/hr, Z = 1.0, T = 320° F., M_w = 18, μ = 0.0144 cp

P_2 = 14.7 psia, d = 6.065 in., L_{st}