SIZING GUIDELINES

General

1. Recommend a 20% or 10 PSIG differential between operating and set pressure, whichever is greater. The set pressure of each pressure relief valve must be in conformance with limits specified in the appropriate ASME code.
2. Relieving Capacity
   a. ASME Section I - The minimum required relieving capacity of the pressure relief valve for all types of boilers shall not be less than the maximum designed steaming capacity as determined by the Manufacturer and shall be based on the capacity of all the fuel burning equipment as limited by other boiler functions. (ASME Section I, PG-67.2.1, 1998)
   b. ASME Section VIII - The minimum required relieving capacity shall be sufficient to carry off the maximum quantity that can be generated or supplied to the attached equipment without permitting a rise in pressure within the vessel with appropriate overpressure condition above the maximum allowable working pressure.
3. Pressure relief valves should not be oversized. Oversizing a pressure relief valve will cause chatter. A multiple valve selection should be used in order to eliminate the possibility of chattering. Use a multiple valve installation when:
   a. The maximum specified capacity requires selection of a pressure relief valve greater than 6 inch pipe size.
   b. When it is more economical to install two smaller valves than one very large one.
   c. If the normal operating capacity of the system is less than approximately 50% of the valve capacity. In this case the volume is not sufficient to keep the valve in its open position and the spring will push the valve closed causing chattering. The first pressure relief valve should be sized on the normal operating capacity and the remaining should be sized on the additional capacity that can be required during the maximum possible capacity of the system.

Single Valve Installation

1. Set pressure of the pressure relief valve shall be set at or below the Maximum Allowable Working Pressure (MAWP) of the weakest item in the system. This includes but is not limited to Steam Boilers, Pressure Vessels and Equipment and Piping Systems.
2. Overpressure
   a. ASME Section I - The pressure cannot rise more than 6% above the maximum allowable working pressure (ASME Section I, PG-67.2, 1998)
   b. ASME Section VIII - The pressure cannot rise more than 10% or 3 psi, whichever is greater, above the MAWP. (ASME Section VIII, UG-125 (c), 1998).

Multiple Valve Installation

1. Overpressure
   a. ASME Section I - The pressure cannot rise more than 6% above the maximum allowable working pressure (ASME Section I, PG-67.2, 1998)
   b. ASME Section VIII - The pressure cannot rise more than 16% or 4 psi, whichever is greater, above the maximum allowable working pressure (ASME Section VIII, UG-125 (c)(1), 1998).
2. Set Pressure
   a. ASME Section I - One or more safety valves shall be set at or below the maximum allowable working pressure. If additional valves are used the highest pressure setting shall not exceed the MAWP by more than 3%. The complete range of pressure settings of all the saturated steam safety valves shall not exceed 10% of the highest set pressure to which any valve is set. (ASME Section I, PG-67.3, 1998)
   b. Section VIII - One valve need to be set at or below the MAWP and the other valves can be set at a higher pressure not to exceed 105% of the MAWP of the weakest item in the system. (ASME Section VIII, UG-134, 1998)

Pressure Relief Valves In Pressure Reducing Stations

There has been much debate in regards to the sizing of Pressure Relief Valves in Pressure Reducing Stations. The sizing guidelines presented below are the recommendations of Spence Engineering. These recommendations are conservative and based on the worst case scenarios. The guidelines are in agreement with the ASME Section VIII code, the National Board Inspection Code and the Power Piping Code ASME B31.1. It is important to understand that each local jurisdiction may have its own set of approved practices and those practices should be followed.

All sizing is based on maximum capacity from the source and piping is in accordance with handling the maximum pressure from the source. Determination of capacity through a given pipe size is complicated. Spence recommends the computation of such values should be through published fluid dynamics reference materials. If the capacity through the pipe is unknown, Spence suggests that when sizing for the limiting value, use the maximum capacity of the first pressure reducing valve and by-pass in the system or maximum capacity from the source, whichever is less.

A. Single Stage Reducing Stations

1. Where pressure reducing valves are used, one or more pressure relief valves shall be provided on the low pressure side of the system. Otherwise, the piping and equipment on the low pressure side of the system shall be designed to withstand the upstream design pressure. The relieving capacity provided shall be such that the design pressure of the low pressure system will not be exceeded if the reducing valve fails open ③ (ASME B31.1 section 122.5.1, 1995)

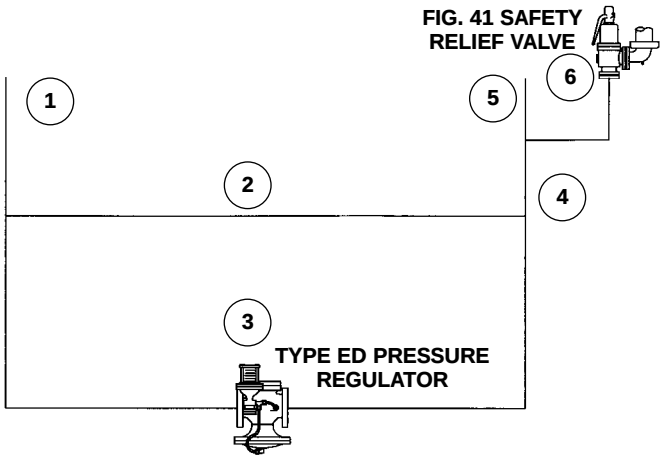

FIGURE A

SIZING GUIDELINES – CONT'D

2. Size SRV for pressure drop across regulator using regulator high side pressure and the safety relief valve set pressure.
3. Hand controlled bypass valves having a capacity no greater than the reducing valve may be installed around pressure reducing valves if the downstream piping is protected by relief valves as required in section ASME B31.1 Section 122.5.1 or if the design pressure of the downstream piping system and equipment is at least as high as the upstream pressure (ASME B31.1 section 122.5.2, 1995)
4. When a pressure reducing valve is installed, there are two possibilities of introducing boiler pressure into the low pressure system. It is necessary to determine the flow under both circumstances and check that the size of the pressure relief valve under either condition will be adequate. The two possibilities are:

   a) the failure of the pressure reducing valve so that it remains at 100% full travel ③

   b) the possibility of the by-pass valve being wide open ②

   (National Board Inspection Code ANSI/NB-23, Appendix G, 1999)

   When taking into consideration the worst possible scenario, Spence Engineering recommends that the pressure relief valve be sized for the maximum flow through both the pressure reducing valve ③ and the by-pass ② or the maximum possible flow through the downstream piping ④ whichever is less. Consideration should be given to the maximum capacity of the source ①.

   For unknown regulator and/or bypass valve capacities, see Section E for approximate sizing formulas
5. When calculating the maximum possible flow through the regulator, in all cases your sizing should be based on the largest orifice size available in the pipe size of the regulator ③. It may be possible that an originally supplied reduced orifice can be changed in the field to a full port orifice without any consideration to the effect on the capacity of the Pressure Relief Valve.
6. In determining the maximum flow through the pressure reducing valve when the valve fails, the failure mode should be considered when the valve plug has reached 100% full travel ③.

B. Parallel Pressure Reducing Stations

1. When sizing a pressure relief valve in a parallel pressure reducing station, the conditions listed above in (A) should all be met.

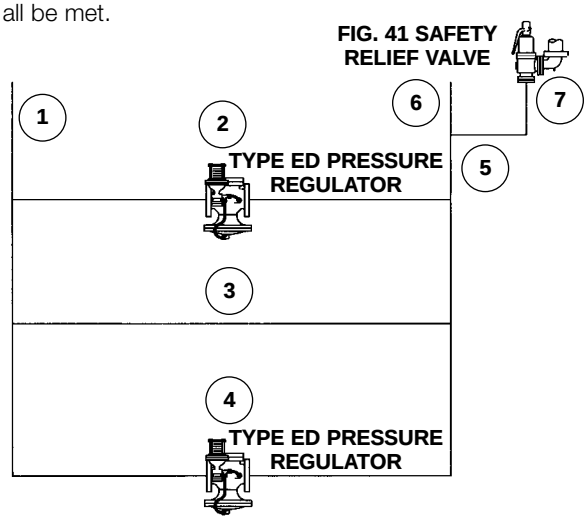

FIGURE B

2. In the case of failure of the pressure reducing valve, the capacity shall be sized on the basis of the possibility that both valves ② & ④ would fail open at the same time plus the by-pass ③ or the maximum possible flow through the downstream piping, whichever is less ⑤. Consideration should be given to the maximum capacity of the source ①.
3. Size SRV for pressure drop across regulator using regulator high side pressure and the safety relief valve set pressure.

C. Two Stage Pressure Reducing Stations

1. When sizing a pressure relief valve in a two stage pressure reducing station, the conditions listed above in (A) should all be met.
2. In the case of failure of the pressure reducing valve, the capacity shall be sized on the basis of the high side pressure regulator (National Board Inspection Code ANSI/NB-23, Appendix G, 1999) having the largest possible orifice size plus the bypass ② or the maximum possible flow through the downstream piping, whichever is less. Consideration should be given to the maximum capacity of the source ①.

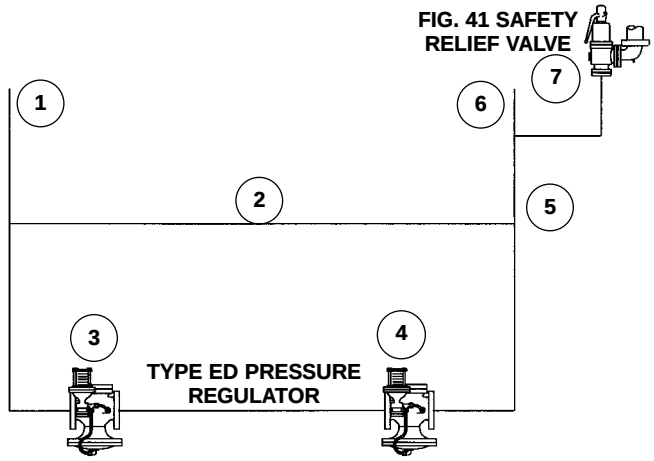

FIGURE C

3. If an intermediate pressure line is taken off between the pressure reducing valves then this line and the final low side shall be protected by pressure relief valves sized on the basis of the high side pressure and the largest possible orifice size of the first pressure reducing valve ③ in the line (National Board Inspection Code ANSI/NB-23, Appendix G, 1999) plus the bypass ② or the maximum possible flow through the downstream pipe ⑦, whichever is less. Consideration should be given to the maximum capacity of the source ①.

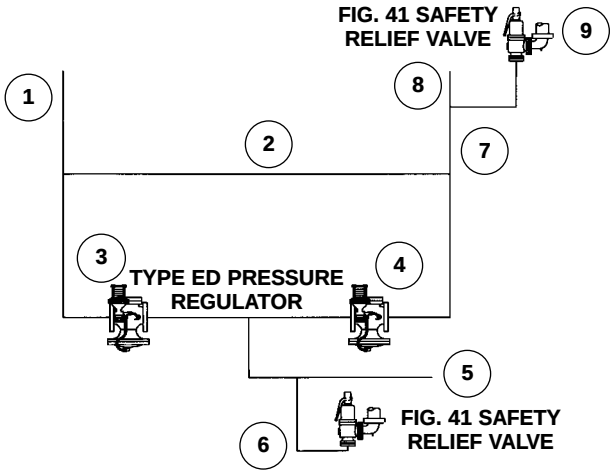

FIGURE D

SIZING GUIDELINES – CONT'D

4. If an intermediate by-pass line is designed in between the pressure reducing valves then the final low side shall be protected by a pressure relief valve sized on the basis of the high side pressure and the largest possible orifice size of the first of the two pressure reducing valves plus the bypass valves ②, ③ and ⑤ or the maximum possible flow through the downstream piping ⑦, whichever is less. Consideration should be given to the maximum capacity of the source ①.
5. Size SRV for pressure drop across regulator using regulator high side pressure and the safety relief valve set pressure.

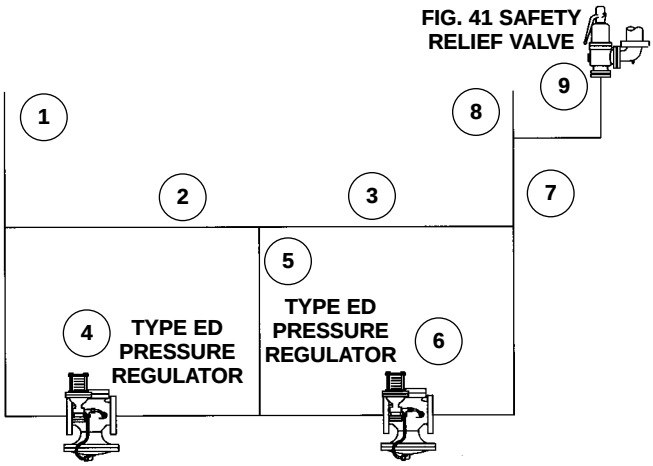

FIGURE E

D. Two Stage Parallel Pressure Reducing Station

1. Sizing is based whenever any condition from (B) and any condition from (C) applies.
2. In addition, all sizing should be based on maximum capacity from sources.

E. When Flow Coefficients Are Not Known

For sizing Spence regulators and/or control valves:

Main Valve Sizing Formula
CV Data

For all other manufacturer's valves where flow coefficients are not known, the following may be approximated.

It is possible that the flow coefficients K and K_1 may not be known and in such instances for approximating the flow, a factor of 1/3 may be substituted for K and 1/2 for K_1.

The formulas in E above then become:

W = 1/3AC for the capacity through the pressure reducing valve and

W = 1/2A$_1$ for the capacity through the by-pass valve

WHERE:

W = steam flow, in lbs/hr through the pressure reducing valve

A = internal area in sq. in. of the inlet pipe size of the pressure reducing valve (See Pipe Data Table)

A$_1$ = internal area in sq. in. of the pipe size of the bypass around the pressure reducing valve (See Pipe Data Table)

C = flow of saturated steam through a 1 sq. in. pipe at various pressure differentials (See Steam Capacity Table)

C$_1$ = flow of saturated steam through a 1 sp. In. pipe at various pressure differentials (See Steam Capacity Table)

Caution should be exercised when substituting these factors for the actual coefficients since this method will provide approximate values only and the capacities so obtained may in fact be lower than actual. It is recommended that the actual flow coefficient be obtained from the pressure reducing valve manufacture and reference books be consulted for the flow coefficient of the by-pass valve (National Board Inspection Code ANSI/NB-23, Appendix G, 1998).

PIPE DATA TABLE

Nominal Pipe Size, Inches	Actual external diameter, inches	Approx. internal diameter, inches	Approx. internal area square inches
3/8	0.675	0.49	0.19
1/2	0.840	0.62	0.3
3/4	1.050	0.82	0.53
1	1.315	1.05	0.86
1 1/4	1.660	1.38	1.5
1 1/2	1.900	1.61	2.04
2	2.375	2.07	3.36
2 1/2	2.875	2.47	4.78
3	3.500	3.07	7.39
3 1/3	4.000	3.55	9.89
4	4.500	4.03	12.73
5	5.563	5.05	19.99
6	6.625	6.07	28.89
8	8.625	8.07	51.15
10	10.750	10.19	81.55
12	12.750	12.09	114.8

Note: In applying these rules, the area of the pipe is always based upon standard weight pipe and the inlet size of the pressure reducing valve.

Adapted from National Board Inspection Code ANSI/NB-23, Appendix G, 1998.