Excessive Inlet Pressure Drop - A pressure relief valve starts to open at its set pressure, but under discharging conditions, the pressure acting on the valve disc is reduced by an amount equal to the pressure drop through the inlet piping and fittings. If this pressure drop is sufficiently large, the valve inlet pressure may fall below reseating pressure, causing it to close, only to reopen immediately since the static pressure is still above the set pressure. Chattering results from the rapid repetition of this cycle. To avoid this mechanism as a cause of chattering, inlet piping to PR valves should be designed for the lowest practical pressure drop (including entrance loss, and piping and isolation valve pressure drop), no more than 3% of set pressure at design relieving rate. This limitation, based on experience, is recommended by the major PR valve manufacturers. Friction pressure drop only is taken into account in this calculation. In unusual cases, such as with large PR valves in low-pressure vapor service, 5% inlet pressure loss may be used. The 3% maximum limitation is particularly important for valves in liquid service.

Excessive Built-up Back Pressure - Built-up back pressure resulting from discharge flow through the outlet system of a conventional PR valve results in a force on the valve disc tending to return it to the closed position. If this returning force is sufficiently large, it may cause the valve to close, only to reopen immediately when the effect of built-up back pressure is removed. Chattering results from the rapid repetition of this cycle.

To prevent chattering from this mechanism, conventional PR valve discharge systems should be designed for a maximum built-up back pressure of 10% of set pressure, when relieving with accumulation of 10%. In cases where pressure relief design is controlled by fire conditions, with 21% overpressure, built-up back pressures up to 21% of set pressure are permissible.

Where outlet pressure losses exceed 10%, bellows valves are often considered. However, substitution of a bellows valve for a conventional valve may not necessarily solve the chatter problem since debits associated with bellows valves reduce the rated capacity of this type valve. Hence, the valve has a tendency to become oversized depending on the amount of back pressure encountered. For this reason, revision of outlet piping to reduce the back pressure within the 10% limit is strongly preferred to the alternative of installing a bellows valve.

Multiple PR Valve Installation

In certain cases it is necessary to install two or more PR valves in parallel for a

single service. These applications are described below, together with appropriate design guidelines.

The magnitudes of some large releases may be greater than the capacity of the largest single PR valve that is commercially available, necessitating the use of two or more valves. Even when a single PR valve is available, the relative cost of multiple valves should be considered. Above a certain size (typically 200 x 250 mm), structural and piping engineering considerations associated with the large piping and valves may result in a lower installed cost for two smaller PR valves. When two or more PR valves are installed for these reasons, they should be specified with staggered set points as described below to secure the additional advantage of minimizing chattering at low release rates.

In PR valve sizing it is always necessary to select the next larger commercially available orifice above the calculated size. Furthermore, a PR valve may lift as a result of various contingencies, any one of which requires a lower relieving rate than the design contingency. Both these factors affect the probability of a vapor PR valve chattering in service, since chattering (as described previously) is more likely to occur when the quantity of fluid being discharged is less than about 25% of its maximum capacity.

Where different contingencies of equal probability require substantially different capacities, it is always best to use two or more PR valves with staggered settings. For example, if one contingency required a capacity of 3 kg/s and another 12 kg/s, two PR valves would be used, with one of 3 kg/s and the other 9 kg/s minimum capacity. The lower capacity valve in this case would be at the lower staggered set pressure. When a fire contingency is the largest contingency and the next contingency is less than 1% of the fire relieving rate, multiple PR valves with staggered settings should always be used. However, when the fire contingency is the smallest load it is generally ignored. This is because fire is a remote contingency and chattering under fire conditions is not a significant concern.

When two or more PR valves are required in cases such as the above, capacities and set points should be specified in accordance with the ASME Code, as follows:

1. The code stipulates that when multiple valves are used, only one of them needs to be set at the maximum allowable working pressure (MAWP). The additional valves can be set at up to 105% of the MAWP. For design purposes the maximum allowable working pressure is assumed to be the same as the design pressure.

2. In addition, 3% tolerance on set pressure is permitted for valves nominally set at design pressure or MAWP. Thus, careful adjustment of the set point in the

field can provide some stagger, but this is not normally considered in the design. The matters of set point, stagger, tolerance, and overpressure are areas where other codes may differ from the ASME Code.

3. Where fire is the governing situation, a supplemental valve set as high as the Code permits is shown in Figure 7. This provides the maximum seat loading possible. This setting leaves only 9.1 percent overpressure available for sizing, although the pressure accumulation in the vessel is 21%.

4. The total relieving rate for some PR systems can be very high. This rate may be economically handled by one PR valve discharging liquid to a closed system and another, set at a higher pressure, discharging vapor to the atmosphere. The configuration should ensure that liquid is preferentially discharged to the valve set at the lower pressure, and that the possibility of entrainment through the vapor valve is minimized by providing a vapor space equal to at least 15 minutes of liquid holdup above the high liquid level alarm.

General Characteristics of the Spring-Loaded PR Valve

The additional features described below, available as means of improving a springloaded PR valve tightness below set pressure, may be justified for some applications. The soft seat design is illustrated in Figure 8. A synthetic "0" ring seal, or soft seat (e.g., of Viton or silicone rubber), may be incorporated into the valve disc seating area on either a conventional or a balanced bellows PR valve. With this device tight shutoff may be achieved closer to set pressure than with typical metal-to-metal seating. It is particularly applicable to difficult services, such as:

1. Operation close to set pressures, e.g., due to pressure fluctuations or pulsations. However, the normal 10% or 100 to 170 kPa between operating and set pressure should still be applied in designs.
2. Light, hard-to-hold fluids, e.g., hydrogen.
3. Presence of solids fines.
4. Vibrating equipment.
5. Corrosive fluids.
6. Nozzle icing under relieving conditions.

The Sta-Tite adapter is a device incorporated by some valve manufacturers into some conventional and balanced bellows valves to reduce leakage (or "simmer") below the set point. It functions by applying an additional auxiliary spring load onto the valve stem through a toggle linkage. The PR valve inlet pressure is applied through small piping to a piston which controls the toggle position such that increasing vessel pressure increases the seating force applied by the auxiliary spring. The linkage is designed such that when set pressure is reached, the toggle moves over-center and trips to a neutral position where no