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OVERPRESSURE PROTECTION METHODS
Class # 6090

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Introduction

Overpressure protective devices are of vital concern to the gas industry. Safety codes and current laws require their installation each time a pressure reducing station is installed that supplies gas from any system to another system with a lower maximum allowable operating pressure.

The purpose of this article is to provide a systematic review of the various methods of providing the overpressure protection. Advantages and disadvantages of each method are evaluated, and engineering guidelines are provided.

Methods of Overpressure Protection

The most commonly used methods of overpressure protection in the gas industry, not necessarily in order of use or importance include

1. Relief
2. Monitoring
3. Series Regulation
4. Shut-Off

There are also variations of these methods. Let's examine them in detail.

Relief

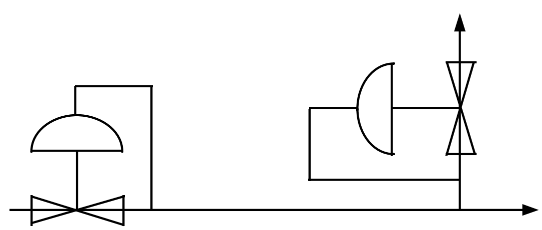

Figure A

Relief incorporates the use of any device to vent the gas to atmosphere in order to maintain the pressure downstream of the regulator to a safe maximum value. Relief is the most common form of overpressure protection used in North America. It is most typically used for protection in city gate applications, farm taps, and at compressor stations.

The basic types of relief valves currently used in the gas industry are

1. Pop type
2. Self-operated relief valves
3. Pilot-operated relief valves
4. Internal relief valves

(Note: These four classifications reflect gas industry usage only and should not be confused with the classifications of "safety valve," "relief valve," and "safety relief valves" as shown in the ASME Boiler and Pressure Vessel Code.)

The pop type relief valve is the simplest form of relief. Pop relief valves tend to go wide open once the pressure has exceeded its setpoint by a small margin. The setpoint can drift over time, and because of its quick opening characteristic, the pop relief can sometimes become unstable when relieving, slamming open and closed. Many have a non-adjustable setpoint that is set and pinned at the factory.

If more accuracy is required from a relief valve, the self-operated relief valve would be the next choice. It can throttle better than a pop relief, and tends to be more stable yet is still relatively simple. Although there is less drift in the setpoint of the self-operated relief valve, a significant amount of buildup is often required to obtain the required capacity.

The pilot-operated relief valves have the most accuracy but are also the most complicated and expensive type of relief. They use a pilot to dump loading pressure, fully stroking the main valve with very little buildup above setpoint. They have a large capacity and are available in larger sizes then other types of relief.

Many times internal relief will provide adequate protection for a downstream system. Internal relief uses a relief valve built into the regulator for protection. If the pressure builds too far above the setpoint of the regulator, the relief valve in the regulator opens up, allowing excess pressure to escape through the regulator vent.

Another type of relief device (not a valve) is the rupture disc, which, as its name implies, blows wide open when pressure reaches its setpoint. Obviously these cannot be tested; however, they offer more capacity than any other type of venting overpressure protection. They also cannot reseat after operation and could blow down a system to dangerously low pressure if not serviced immediately.

Other equipment in limited use for relief applications includes oil and water seals.

Advantages. The relief valve is considered to be the most reliable type of overpressure protection because it is not subject to blockage by foreign objects in the line during normal operations. It also imposes no decrease in the regulator capacity which it is protecting, and it has the added advantage of being its own alarm when it vents.

It is normally reasonable in cost and keeps the customer in service despite the malfunction of the pressure reducing valve.

Disadvantages. When the relief valve blows, it could possibly create a hazard in the surrounding area by venting gas. A venting, noisy relief valve can also create a public relations problem where population densities are such that the public is alarmed by its operation. The relief valve must be sized carefully to relieve the gas that could flow through the pressure reducing valve at its maximum inlet pressure and in the wide open position, assuming no flow to the downstream. Therefore, each application must be sized individually.

The requirement for periodic testing of relief valves also creates an operational and/or public relations problem.

<u>Monitoring Regulators</u>

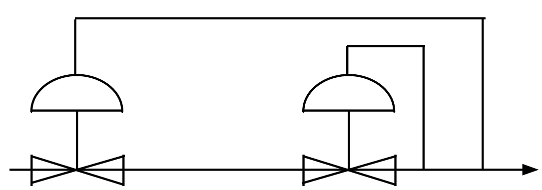

Figure B

Monitoring is overpressure control by containment. When the working pressure reducing valve ceases to control the pressure, a second regulator installed in series, which has been sensing the downstream pressure, goes into operation to maintain the downstream pressure at a slightly higher than normal pressure. The monitoring concept is gaining in popularity, especially in low pressure systems, because very accurate relay pilots permit reasonably close settings of the working and monitoring regulators.

The two types of wide open monitoring are upstream and downstream monitoring. One question often asked is, “Which is better, upstream or downstream monitoring?" Using two identical regulators, there is no difference in overall capacity with either method.

When using monitors to protect a system or customer who may at times have zero load, a small relief valve is sometimes installed downstream of the monitor system with a setpoint just above the monitor. This allows for a token relief in case dust or dirt in the system prevents bubble tight shutoff of the regulators.

Advantages. Because the gas is automatically contained and controlled, no public relations problem is created. Monitoring also keeps the customer on the line and keeps the pressure supplied downstream in an emergency relatively close to the setpoint of the working regulator. Testing is relatively easy and safe. To perform a periodic test on a monitor, increase the outlet set pressure of the working device and watch the pressure to determine if the monitor takes over.

Disadvantages. Compared to relief valves, monitoring generally requires a higher initial investment. Monitoring regulators are subject to blocking, which is why filters or strainers are specified with increasing frequency. Because the monitor is in series, it is an added restriction in the line. This extra restriction can sometimes force one to use a larger, more expensive working regulator.

Another disadvantage related to monitoring installations is that there is no way of knowing for certain that a stand-by wide open monitor will work if required. In many cases, the monitor will be examined more frequently than other forms of overpressure protection.

<u>**Working Monitor**</u>

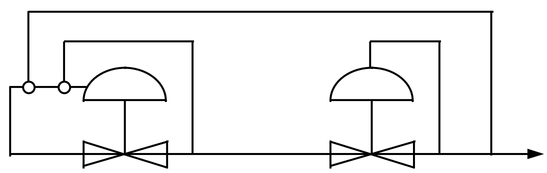

Figure C

A variation of monitoring overpressure protection that overcomes some of the disadvantages of a wide open monitor is the "working monitor" concept wherein a regulator upstream of the working regulator uses two pilots. This additional pilot permits the monitoring regulator to act as a series regulator to control an intermediate pressure during normal operation. In this way both units are always operating and can be easily checked for proper operation. Should the downstream pressure regulator fail to control, however, the monitoring pilot takes over the control at a slightly higher than normal pressure and keeps the customer on the line. This again is pressure control by containment and eliminates public relations problems.

<u>**Series Regulation**</u>

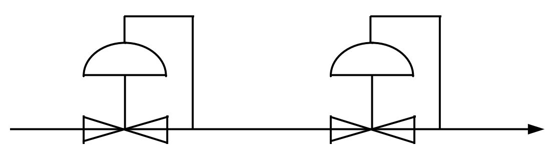

Figure D

Series regulation is also overpressure protection by containment, in that two regulators are set in the same pipeline. The first unit maintains an inlet pressure to the second valve that is within the maximum allowable operating pressure of the downstream system. Under this setup, if either regulator should fail, the resulting downstream pressure maintained by the other regulator would not exceed the safe maximum value.

This type of protection is normally used where the regulator station is reducing gas to a pressure substantially below the maximum allowable operating pressure of the distribution system being supplied. Series regulation is also found frequently in farm taps and in similar situations within the guidelines mentioned above.

Advantages. By containing gas, there is no public relations problem created should one of the units fail, nor is any hazard created by venting gas.

Disadvantages. Because the intermediate pressure must be cut down to a pressure that is safe for the entire downstream, the second stage regulator often has very little pressure differential available to create flow. This can sometimes make it necessary to increase the size of the second regulator significantly. Another drawback occurs when the first stage regulator fails and no change in the final downstream pressure is noticed, because the system operates in what appears to be a "normal" manner without benefit of protection. Also, the first stage regulator and intermediate piping *must* be capable of withstanding and containing maximum upstream pressure.

The second stage regulator must also be capable of handling the full inlet pressure in case the first stage unit fails to operate. If the second stage regulator fails, its actuator will be subjected to the intermediate pressure set by the first stage unit. The second stage actuator pressure ratings should reflect this possibility.

Shut-off

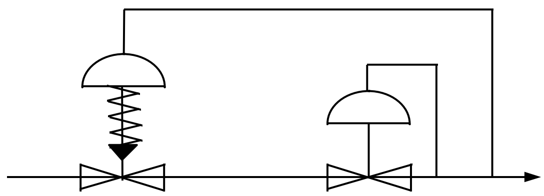

Figure E

The shut-off device also accomplishes overpressure protection by containment. In this case, the customer is shut off completely until the cause of the malfunction is determined and the device is manually reset. Many gas distribution companies use this as an added measure of protection for places of public assembly such as schools, hospitals, churches, and shopping centers. In those cases, the shut-off device is a secondary form of overpressure protection. Shut-off valves are also commonly used by boiler manufacturers in combustion systems.

Advantages. By shutting off the customer completely, the safety of the downstream system is assured. Again there is no public relations problem or hazard from venting gas.

Disadvantages. The customer may be shut off because dust or dirt has temporarily lodged under the seat of the operating regulator, preventing bubble tight shutoff. This type of situation can be taken care of by a small relief valve. When the shut-off trips, the customer or customers and all of their appliances must be re-lit.

On a distribution system with a single supply, using a slamshut can require two trips to each customer--the first to shut off the service valve, and the second visit after the system pressure has been restored to turn the service valve back on and re-light the appliances. In the event a shut-off is employed on a service line supplying a customer with a process such as baking, melting metals, or glass making, the potential economic loss could dictate that the use of an overpressure protection device that would keep the customer on the line would be a better choice.

Another problem associated with shutoffs is encountered when the gas warms up under no load conditions. For instance, a regulator locked up at approximately 7- in. w.c. could experience a pressure rise of approximately 0.8 in. w.c. per degree F rise, which could cause the high pressure shutoff to trip when there is actually no equipment malfunction.

Relief Monitor

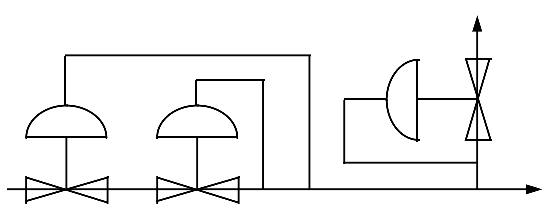

Figure F

Another concept in overpressure protection for small industrial and commercial loads, up to approximately 10,000 cu ft per hr, incorporates both an internal relief valve and a monitor. In this device, the relief capacity is purposely restricted to prevent excess venting of gas in order to bring the monitor into operation more quickly. The net result is that the downstream pressure is protected, in some cases, to less than 1 psig. The amount of gas vented under maximum inlet pressure conditions does not exceed the amount vented by a domestic relief type service regulator.

With this concept, the limitation by regulator manufacturers of inlet pressure by orifice size, as is found in "full relief" devices, is overcome. Downstream protection is maintained even with abnormally high inlet pressure. Public relations problems are kept to a minimum by the small amount of vented gas. Also, the unit does not require manual resetting but can go back into operation automatically.

Dust or dirt can clear itself off the seat, but if the obstruction to the disc closing still exists when the load goes on, the customer would be kept on the line. When the load goes off, the downstream pressure will again be protected. During normal operation, the monitoring portion of the relief monitor is designed to move slightly with minor fluctuations in downstream pressure or flow.

Summary

From the foregoing discussion it becomes obvious that the gas design engineer has many philosophies available and choices of equipment to implement his overpressure protection requirements. He must also assume that the overpressure device will be called upon to operate at some time after it is installed. The overall design must include an analysis of the conditions created when the protection device operates.

The table below shows

1. What happens when the various types of overpressure protection devices operate
2. The type of reaction required by the gas company
3. The effect upon the customer or the public
4. Some technical conditions

These are the general characteristics of the various different types of safety devices.

From the conditions and results shown, it is easier to decide which type of overpressure equipment best meets your needs. Undoubtedly compromises will have to be made between the conditions shown here and any others which may govern your operating parameters.

TYPES OF OVERPRESSURE PROTECTION

	Relief	Working Monitor	Monitor	Series Regulation	Shutoff	Relief Monitor
Keeps customer "on line"?	YES	YES	YES	YES	NO	YES
Public relations problems caused by venting?	YES	NO	NO	NO	NO	MINOR
Manual resetting required after operation?	NO	NO	NO	NO	YES	NO
Reduces capacity of regulator?	NO	YES	YES	YES	NO	NO
Constantly working during normal operation?	NO	YES	NO	YES	NO	YES
Demands "emergency" action by gas company?	YES	NO	NO	NO	YES	MAYBE
Will surveillance of pressure charts indicate	NO	YES	MAYBE	YES	NO	NO

partial loss of performance of overpressure device?						
Will surveillance of pressure charts indicate regulator has failed and safety device is in control?	YES	YES	YES	YES	YES	YES