MULTI-LAYER OVER PRESSURE PROTECTION

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Introduction

Natural gas distribution systems need to manage working pressure(s) to a safe maximum allowable operating pressure (MAOP) which ensures customers and systems are protected. When overpressure protection (OPP) is inadequate or fails, the consequences can vary from compliance issues to widespread structural damage or even public safety emergencies. Using multiple layers of OPP adds redundancy to these systems avoiding single point failure. Recent incidents such as the Merrimack Valley gas explosions underscore the criticality of robust OPP; this along with similar events have driven renewed attention to risk controls and have helped shape the current direction of standards, traceability, and enforcement.

Layers of OPP

OPP can be conceptualized as a sequence of thresholds as depicted in Figure 1. A key insight, not depicted, is the gap between compliance and catastrophic events. While devices and procedures may meet minimum system requirements, system exposures can still allow rare but high-consequence failures if not mitigated by multiple independent protection layers. This is more pronounced in low pressure (LP) networks typically feeding residential applications or customers.

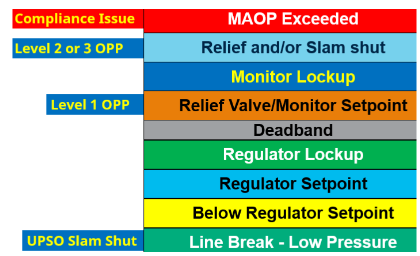

Figure 1: Layers of OPP

Regulatory Response & Direction

Following the Merrimack Valley incident, the National Transportation Safety Board (NTSB) recommended that 49 CFR Part 192 be revised to require OPP for LP distribution systems to avoid single point equipment failure and urged removal of certain exemptions so that licensed professional engineers reviewed and stamped relevant infrastructure projects. It also mandated that operators keep records that are traceable, reliable, and complete. Although the NTSB is a non-regulatory body, it influences congressional action and Pipeline and Hazardous Materials Safety Administration (PHMSA) rule making through investigations and recommendations. The relationship between Congress, NTSB, and PHMSA follows a cyclical nature; approximately every four years PHMSA's pipeline safety program is reauthorized by congress.

PIPES Act of 2020

The PIPES Act of 2020 directed updates across distribution integrity management, emergency response, operations and maintenance manuals, safety management systems, and safety practices. I also emphasized time bound requirements for monitoring district stations, upgrading district regulator stations to eliminate common failure modes, and implementing comprehensive records management. While there are new revisions of the PIPES Act, the 2020 version continues to be the predominant direction guiding OPP requirements.

OPP In Low-Pressure Systems

Typical LP systems deliver pressure at 4 to 11 inches of water column (wc). MAOPs are typically around 14 wc or slightly higher. Many legacy systems rely on tribal knowledge for pressure derivation and many lack service regulators allowing the meter, house pipe, and appliances to see street pressure as seen on Figure 2. In these applications OPP is usually only seen at the district station which leaves the downstream equipment exposed if the intermediate-pressure (IP) system or high-pressure (HP) system fails.

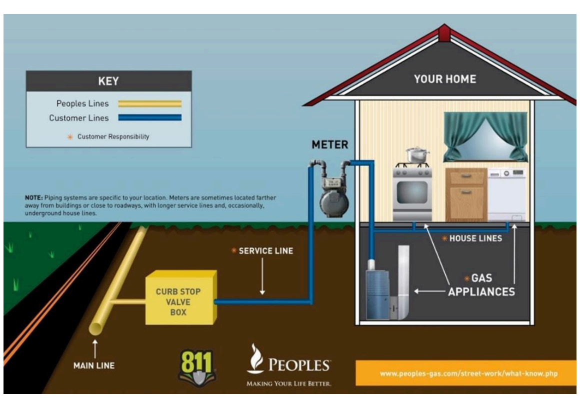

Figure 2: LP system lacking service regulator at the meter[1]

There are different methods to add additional layers of OPP to LP systems. Installing a service regulator as a wide-open downstream monitor adds additional layers; the regulator itself and, if equipped, internal relief valves (IRV) to keep LP systems under 2 psig MAOP in the event of a regulator failure per ANSI B109.4. Other options include integral slam-shut devices for containment (no venting), but these require manual reset after a trip.

The inclusion of a service regulator with IRV allows for three layers of OPP while also allowing the system design to raise the delivery pressure. As a result, the legacy systems can more closely resemble typical IP systems with an added benefit being that most service regulators can handle 'high' inlet pressures (e.g. 125 psig) which enable conversion to IP. That said, commercial service regulators with IRV may not be the best option in high dense areas due to the venting requirements and the lack of a uniform IRV capacity standard across manufacturers. This makes sizing and selection essential as well as traceable documentation.

If integral slam shuts or IRV are not ideal, commercial service regulators may also offer secondary seats (internal monitors), Figure 3, or a built-in wide-open monitor sharing a common body (integral monitor). It is important to note that internal monitors may not be considered OPP depending on the failure mode (e.g. lever disconnect) and which version of ANSI B109 is being considered. Under ANSI B109.4 it *may* be considered OPP while for ANSI B109.5 it cannot be considered OPP.

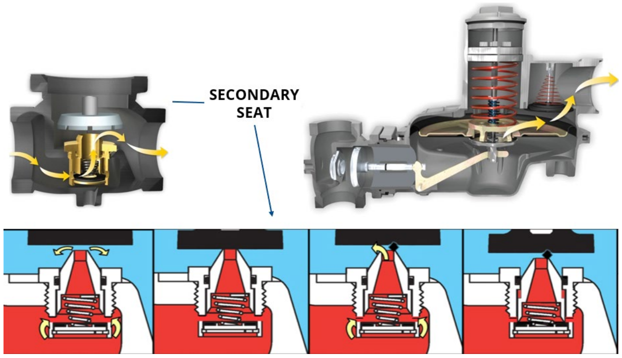

Figure 3: Fisher CS400 with secondary seat

OPP Considerations for Stations

Many existing district stations employ a wide-open monitor system as a single effective OPP layer often accompanied by token relief downstream as seen on Figure 4. To enable regulator maintenance, these stations may employ an unregulated bypass which can create an operational hazard if the bypass valve fails or the operator does not operate it correctly. To help enhance security, many stations use redundant standby runs instead of a manual bypass, but the industry trajectory is to strengthen stations beyond these baselines by layering additional OPP.

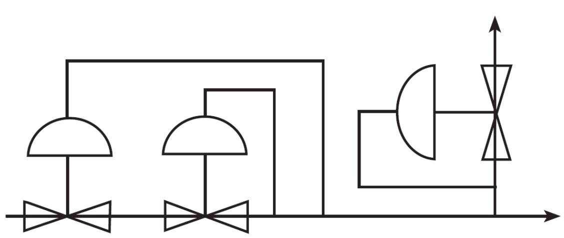

Figure 4: Wide-open monitor with token relief

Future-ready district stations target double-layer OPP by incorporating slam-shuts or full capacity relief valves (Figure 5). Retrofitting wide-open upstream monitors with integral slam-shuts can be relatively simple using existing flanged constructions with common face-to-face dimensions. An additional benefit of leveraging integral designs is a reduced capacity loss vs a standalone slam-shut.

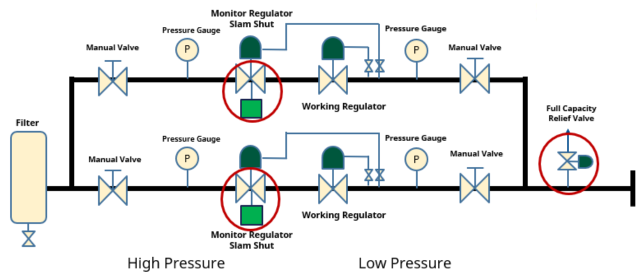

Figure 5: District station with double-layer OPP options

Several other considerations come into play when choosing the station design ideal for the application such as vault installations. Operators must account for device separation, fire/explosion prevention, water intrusion, control line routing/placement, etc. In addition, technology needs to be evaluated for the benefits and the customer/end user downstream needs to be considered to ensure the best selection is made.

If there are preferences for relief valves over slam-shuts or monitor systems, several solutions exist. Section VIII ASME stamped safety relief valves offer certified capacities, defined overpressure requirements, material traceability, hydrostatic testing, tamper-evident seal wiring and serialization. Non-section VIII reliefs can also be used and are popular across the industry, but selection needs to be aligned with station function and flow requirements.

Monitoring, Telemetry, and Control of Stations

As pressure stations become more complex with layered OPP it is important to be aware of the process conditions to pinpoint a root cause in the event of over pressurization. In some cases, the stations are remotely located, which emphasizes the need for remote monitoring. There are different technologies in the industry that serve similar functions but for the most part the process conditions are what are monitored e.g. inlet pressure, intermediate pressure, and downstream pressure. Depending on the device and station layout, all the assets may be able to be monitored; for example, the wide-open monitor, the worker, the relief valve downstream, the slam-shut upstream, filters etc.

The Fisher Armor device also offers travel monitoring on Fisher pressure regulators which enables predictive analytics and flow estimation. By leveraging these analytics and report by exception capabilities, companies can reduce their maintenance and repair (M&R) costs in several ways. For example, reducing truck rolls, defining specific maintenance cycles, maximizing asset service life, and even downsizing pressure regulators thus reducing up-front costs.

In addition to monitoring, technologies exist that enable remote control of pressure regulators. Remote set point adjustment via pilot-operated regulator loading-pressure control (e.g. Figure 6) or remote-operated valves (ROV) are a couple of examples. In some situations, operators may even be able to count an ROV as an additional layer of OPP when it provides a reliable path to cut off flow.

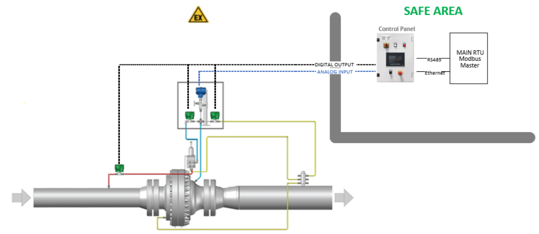

Figure 6: Emerson Remote Automated Flow (RAF) system

Conclusion

The near-term direction for distribution utilities includes broad adoption of two-layer OPP at LP stations and targeted upgrades elsewhere based on risk assessments. Expanded monitoring, and control, will become common. Supported by analytics that quantify events, confirm setpoints, and estimate flows. Cyber-physical security integration and emissions accountability will further shape design choices. A layered OPP strategy from the service riser to the district station reduces the likelihood and impact of overpressure events in gas distribution systems.

The experience of past incidents, coupled with current regulatory momentum, argues for designs that cannot be defeated by a single error or failure and for comprehensive monitoring that transforms raw signals into actionable operational intelligence. With careful technology selection, retrofit planning, and a disciplined approach to records and training, operators can meet regulatory expectations while materially improving system safety and public confidence.

References

1. https://www.facebook.com/peoplesnatgas/photos/did-you-know-that-the-gas-pipes-running-from-the-curb-to-your-meter-and-from-you/2236296596614384/?_rdr

Appendix: Acronyms

HP – high-pressure

IP – intermediate-pressure

IRV – internal relief valve

LP – low pressure

MAOP – maximum allowable operating pressure

M&R – maintenance and repair

NTSB – National Transportation Safety Board

OPP – overpressure protection

PHMSA – Pipeline and Hazardous Materials Safety Administration

ROV – remote-operated valve

wc – water column