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Take the Pressure Off Overpressure Protection

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CONTENTS

Understand Regulations Requiring Pressure Relief Devices

Pay close attention to the laws requiring such devices and how best to stay in compliance

The requirements for refineries, chemical plants and other industries are similar worldwide, with the main difference being the tolerated amounts for each type of pollutant released. The more stringent rules can be generalized with three simple requirements:

1. Provide indication and location where a pressure relief device (PRD) event occurs through electronic monitoring.
2. Measure the time and duration of the PRD event for recording and reporting.
3. Notify the operator of the event so corrective action can occur.

Also, it is expected that the flare operates at all times when emissions may be vented to them, so quick identification of a PRD release is imperative. In general, newer and more stringent rules apply not only to normal operation, but also to startup/shutdown periods, where there has historically been more leniency. These startup/shutdown periods are often when process upsets are most likely to occur, so compliance with new regulations can be very demanding.

Plants must comply with environmental regulations by law. Failing to do so can cause serious damage to the environment and personnel. It can also cause serious damage to plant equipment and explosions. In addition, lack of compliance can result in expensive fines, production disruptions, and bad publicity. But there is another very compelling reason to monitor and curb fugitive emissions: leakages caused by PRD malfunctions can waste large amounts of valuable product, along with the energy required to produce these products.

REGULATION DETAILS

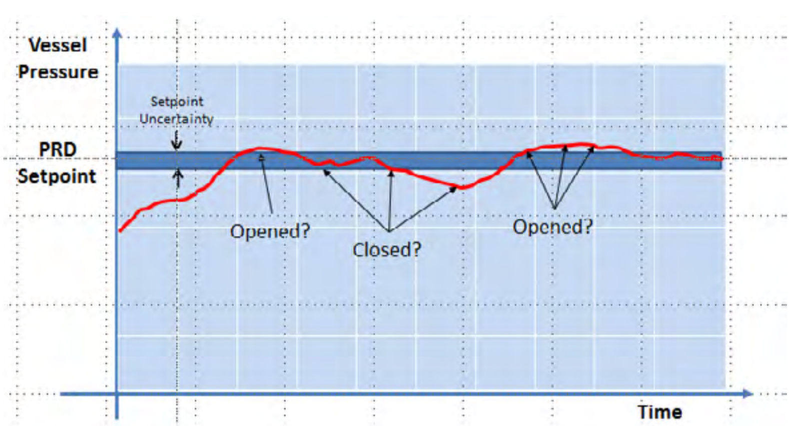
Every national and international government has its own rules to control and monitor emissions of pollutants. In the U.S., the Clean Air Act (CAA) is the key federal law regulating air emissions from stationary and mobile sources. Among other things, this law authorizes the Environmental Protection Agency (EPA) to establish national ambient air quality standards to protect public health and public welfare by regulating emissions of hazardous air pollutants. Many other

Leakages caused by PRD malfunctions can waste large amounts of valuable product, along with the energy required to produce these products.

countries' environmental agencies work together to achieve common goals, including the U.S.'s EPA, Europe's Directorate-General for Environment, China's Ministry of Environmental Protection, Brazil's Ministry of Meio Ambiente, Kuwait's Environmental Public Authority, India, and others to exchange information about best practices worldwide.

These environmental agencies periodically review emission standards for new sources of criteria air pollutants (CAP), volatile organic compounds (VOC) and other pollutants as well as set emission standards for toxic air pollutants from stationary sources reflecting the new maximum achievable control technology (MACT) based on the best performing facilities in an industry. Several industries are subject to tight regulations, going so far as to issue detailed requirements for specific units in a plant, such as:

1. More stringent operating requirements for flare control to ensure good combustion. This is achieved, but not restricted, by:
   - Measuring and monitoring the flow of waste gas going to the flare.
   - Measuring and monitoring the content of the waste gas going to the flare.
   - Measuring and monitoring any air or steam added into the flare.
2. Emission control requirements for storage tanks, flares and delayed coking units at petroleum refineries.
3. Pollutant monitoring around the plant fence line as a development in practices for managing emissions of toxic pollutants from fugitive sources.
4. Elimination of exemptions during periods of startup, shutdown and malfunction.
5. Most importantly, bypasses and discharges through PRDs are considered a violation of these laws in many countries, requiring plants to monitor discharges of individual PRDs.



Inaccurate PRD Monitoring

Figure 1. Plants monitor pressure relief devices (PRDs) by observing process pressure, but when the pressure is close to the operating limit, the peaks and valleys make it difficult to determine when the PRD is actually opened or closed.

MONITORING PRDS

Historically, PRDs have been difficult to monitor because they are simple mechanical devices by design. Monitoring methods typically include manual inspection of telltale signs. For example, on PRDs releasing to the atmosphere, wind socks are often used to monitor releases.

In order to monitor with this method, it is common to use process instrumentation to observe pressure peaks and valleys around the pressure limit, temperature downstream and flow in the discharge header. However, this method cannot be used in enclosed systems. Plants monitor PRDs by observing process pressure, but when the pressure is close to the operating limit, the peaks and valleys make it difficult to determine when the PRD is actually opened or closed (Figure 1).

Unfortunately, these measurements are susceptible to false positives and inaccuracies and provide no insight into the health and status of the individual PRDs.

Measuring flow in the discharge header does not show which PRD or PRDs were activated. Observing changes in the flare flame is also inaccurate and does not show which unit and which PRD caused the release.

A significant part of the difficulty when designing and installing a comprehensive monitoring system is that a typical plant will have several different PRD makes, models, sizes and operating pressures from various vendors. This can make it difficult to design a standardized monitoring system.

Another serious limitation is the introduction of pressure, flow or temperature measurements in an existing plant. Use of intrusive measuring devices disrupts plant operation and the cost of laying new cables can be very high.

As explained before, in addition to the challenges of compliance monitoring, there are other issues to contend with such as PRDs that leak, don't close and reseat after an event, or have their bypass valves in the wrong position due to human error. These issues can all cause a waste of product, and inefficient use of human resources.

In theory, PRD activation should occur only in exceptional circumstances, but in actuality, activation happens quite often. This may be an indication of other problems, such as issues with the PRDs, plant operating practices, or equipment specifications.

Monitoring how many times PRDs activate and how long each was releasing product helps plant personnel understand processes better, and it can also help improve combustion control. □

Effectively Monitor Pressure Relief Devices and Valves

Wireless acoustic transmitters provide effective tracking of PRD activation and leakage.

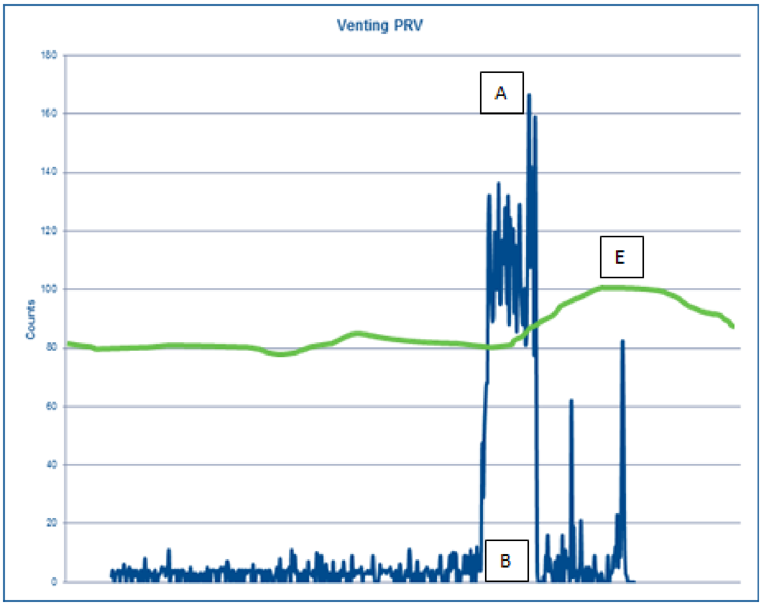
□ A very reliable, effective and economic way to monitor pressure relief valves (PRVs) is to use wireless acoustic transmitters.

Process fluid flowing through valves and orifices generates ultrasonic energy, but some is also in the human audible range as well. Acoustic transmitters are able to detect this ultrasonic frequency in the pipe wall as well as its temperature. These devices are wireless, small, lightweight and non-intrusive, so they do not require any change in plant installation. They can be easily clamped on the exhaust pipe, as shown in Figure 1.

PRV operating condition can be determined by:

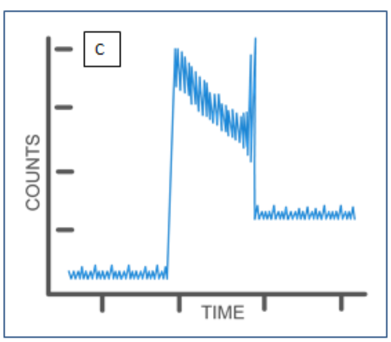
Wireless Acoustic Transmitter

Figure 1. Acoustic transmitters detect ultrasonic energy in the pipe wall and can be easily clamped on to the exhaust pipe.



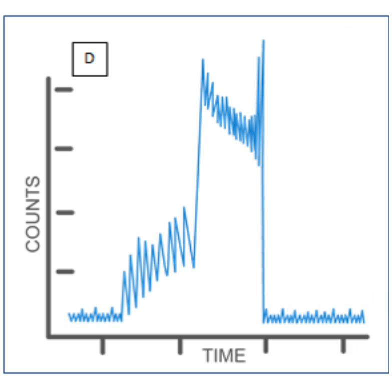
PRV Discharge Followed by Temperature Change

Figure 2. A acoustic level increase indicates the PRV has been activated, while noise level returning to the previous level indicates the PRV is no longer discharging.



PRV Discharge Followed by Leakage

Figure 3. Acoustic level returning to a level above the previous level indicates leakage due to the valve not closing completely.



Continuously Changing Noise Level

Figure 4. Acoustic level changing continuously indicates that the valve may be simmering or chattering.

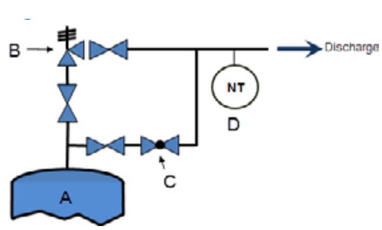
a. Acoustic level increase indicates that the PRV has been activated (Figure 2)

b. Acoustic level returning to the previous level indicates that the PRV is no longer discharging (Figure 2)

c. Acoustic level returning to a level above the previous level indicates leakage due to the valve not closing completely. This may be caused by deposition of particles or scale between the disc and its seat or due to a mechanical misalignment (Figure 3)

d. Acoustic level changing continuously indicates that the valve may be simmering or chattering (Figure 4)

e. Temperature changes may be used as an additional indication to validate a release. Figure 2 illustrates the flow discharge followed by a temperature change.



A. Protected vessel
B. Pressure relief valve
C. Bypass valve
D. Wireless acoustic transmitter

Wireless Acoustic Transmitter Installation

Figure 5. Installing a wireless acoustic transmitter downstream, close to the valve helps monitor not only discharges or leakages of the relief valve, but also monitors flow through the bypass valve.

Wireless acoustic transmitters used for relief valve monitoring should be installed downstream of the relief valve, as close as possible to the valve. Relief valves are usually installed with shutoff and bypass valves for maintenance and special operating conditions. Bypass valves may be inadvertently left open or not close completely, causing unexpected flow to the recovery system. The wireless acoustic transmitter installed as indicated in Figure 5 monitors not only discharges or leakages of the relief valve, but can also catch leaking in the bypass valve.

RUPTURE DISC MONITORING

Some types of rupture discs are equipped with a burst detector that generates a discrete signal indicating disc rupture. There are also devices that can be installed on the rupture disc surface that can detect when the disc ruptures and indicate the event through a discrete signal. The discrete signal is usually wired back to a supervisory system or safety system. The signal can initiate an action to minimize the release effect and cancel the overpressure root cause.

A wireless discrete transmitter can be used to transmit the discrete signal, eliminating costly and troublesome wiring, as indicated in Figure 6. The burst detector wires are connected to the transmitter that sends the signal wirelessly to a host system.

Rupture discs use a relatively thin membrane that may have pinholes created by pitting corrosion. Process fluid leaks through the pinholes. The burst detectors are not activated unless the disc ruptures, so the leakage can go undetected for a long time.

A MORE EFFECTIVE WAY TO MONITOR

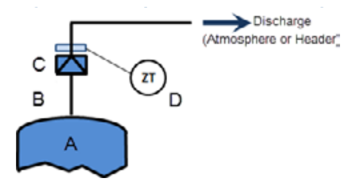
Rupture discs can be better monitored with the use of a wireless acoustic transmitter as indicated in Figure 7. The transmitter can detect when the disc ruptured and the duration of the discharge, as it does for relief valves, but it may also detect even small leaks caused by pinholes.

MONITORING RELIEF VALVES AND RUPTURE DISCS

As discussed before, rupture discs are one-time devices. Once they burst, they cannot close again, so the process fluid will be discharged until there is not enough pressure to make it flow. RPs are a better solution, as they close when the process pressure returns to normal conditions. However, in some applications, they must be isolated from harsh process conditions by using rupture discs. In normal operation, the relief valve is not in contact with corrosive, gumming or hot process fluids. If the vessel pressure reaches unsafe values, the rupture disc bursts, followed by the RP opening. The RP closes when the pressure returns to safe values.

One problem with this type of installation is the possibility of rupture disc leakage caused by pinholes. The volume between the rupture disc and the relief valve can be filled with process fluid and the pressure between the two sides of the rupture disc will be the same, so the disc will not burst. Vent lines and/or excessive flow valves may be installed to release eventual leakage, but to be safe, standards and regulations ask for remote monitoring of the pressure in that space. In the U.S., ASME UG127, section VIII, Division 1 establishes this requirement.

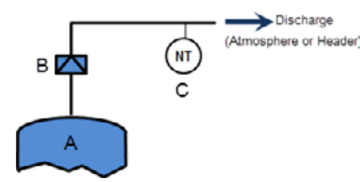
A pressure switch can be used, but these switches do not provide a pressure measurement, which is very important to determine



A. Protected vessel
B. Rupture disc burst detector
C. Rupture disc
D. Wireless acoustic transmitter

Rupture Disc Monitoring with Discrete Transmitter

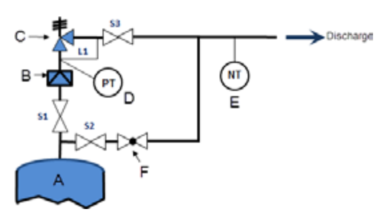
Figure 6. A wireless discrete transmitter can be used to transmit the discrete signal, eliminating costly and troublesome wiring. The burst detector wires are connected to the transmitter that sends the signal wirelessly to a host system.



A. Protected vessel
B. Rupture disc
C. Wireless acoustic transmitter

Improved Rupture Disc Monitoring

Figure 7. A wireless acoustic transmitter can detect when the disc ruptured and the duration of the discharge, and may also detect small leaks caused by pinholes.



A. Protected vessel
B. Rupture disc
C. Relief valve
D. Wireless pressure transmitter
E. Wireless acoustic transmitter
F. Bypass valve

Monitoring a Combination of Relief Valves with Rupture Discs

Figure 8. A wireless acoustic transmitter installed downstream of the relief valve provides dependable information about relief valve releases.

potential dangerous conditions. A wireless pressure transmitter can provide accurate and reliable pressure measurement; however, monitoring the pressure between the RD and an RV is not sufficient to reliably determine when the RV has opened or closed. A wireless acoustic transmitter installed downstream of the RV, as shown in Figure 8, provides dependable information about RV releases.

Rupture discs can also be used downstream from the valve to protect the valve against aggressive fluids, particulates and other damaging conditions that may be present in the discharge header.

Note, the rupture disk does not need to be replaced immediately after bursting, because the wireless acoustic transmitter is still monitoring pressure releases. This allows maintenance personnel to replace or maintain the equipment at the most convenient time, without having to slow or shutdown the process.

WIRELESS TRANSMITTERS

The wireless devices mentioned here utilize *Wireless*HART technology. *Wireless*HART is an open standard that provides secure, reliable and flexible wireless communication. The devices form a self-organizing, self-healing mesh network, with redundant communication paths.

Total cost of implementation(1) 200 × PRDs		
	Traditional method	Pervasive Sensing™ Solution(2)
Total project cost ($K)	$3,520	$464 – $1,088
Total cost per PRD ($K)	$18	$2.3 –$5.4
Savings	N/A	69% – 87%
Field installation	Intrusive	Non-intrusive
Cabling and trenches required	Yes	No
Technology	Wired	Wireless
Total compliance and operational improvements at a fraction at fraction of the cost of traditional methods		

1.Total costs include monitoring of the wireless system, tamper-proof secure data, and engineered services.
2.Cost range dependent on application: PRV only or PRV with rupture disc monitoring.

Total Cost Comparison

Table 1. Wireless acoustic, pressure, and discrete transmitters are a very effective, reliable, and economic way to have a compliant and better performing process.

CONCLUSION

Pressure relief device monitoring is necessary for environmental protection compliance and can avoid expensive fines, and possible process unit or plant shutdowns. Monitoring also prevents waste of costly material and energy, avoids bad publicity and helps improve plant personnel and neighboring communities' health. Wireless acoustic, pressure, and discrete transmitters are a very effective, reliable, and economic way to have a compliant and better performing process as shown on Table 1. ☐

Plants Look Harder for Leaks

More sites are adopting enhanced leak detection and repair strategies

☐ The quest to reduce fugitive emissions has taken on new urgency at many sites. This reflects increased attention to operational issues, such as product purity and losses, as well as demands by the U.S. Environmental Protection Agency (EPA), Washington, D.C., for more stringent leak detection and repair (LDAR) strategies.

One company that has successfully lowered leaks is Air Products & Chemicals, Allentown, Pa. It has achieved significant reductions at its two plants that manufacture nitrogen trifluoride (NF3) — in Hometown, Pa., and Ulsan, South Korea. The chemical, which is classified as a greenhouse gas (GHG), mainly is used for cleaning chemical-vapor-deposition chambers for making liquid crystal displays and thin-film solar cells.

Because of the purity demanded by users, leak tightness figured significantly in the design of the NF3 manufacturing process. It features welded systems, bellows valves, diaphragm compressors and sealess pumps to minimize leaks. However, despite the stringent design standards, leak points still existed — so, the company initiated a project to identify them.

"The initial scope of the project was to identify operator actions, through observation and interviews, in order to understand why and how product was being lost, especially during startup, shutdown and upset conditions. The 'non-optimal' operating conditions were noted, and a program was put in place to document and calculate the amount of product which was released," explains Jim Kourpas, global plant process engineering manager.

Air Products relied on a straightforward approach: track times when the units were operating but not producing product, in other words, stable operations, and calculate the amount of product lost. This led to modifications in the work process, simplifying the operators' actions as well as reducing vent losses through automation and reprocessing. The project halved NF3 leakage to approximately 2% of total production.

However, the company wanted to cut leakage to 0.5% and, thus, initiated a further project. "Ideas were generated, further focusing on vent abatement and reclamation. The entire process was again evaluated from production down to the supporting systems. There was debate as to the location of where this next opportunity occurred, in what parts of the process and utility systems this remaining inefficiency existed. Plant engineers performed detailed sensitivity studies of each plant area to arrive at an estimate of the losses with a high confidence of accuracy," says Kourpas.

AIR MONITORING

Figure 1. Data collected around key hardware helped identify fugitive emissions at a NF3 facility. Source: Air Products & Chemicals.

As part of this detailed evaluation, the engineers looked at every unit operation in the NF3 process, performing an energy and material balance for each. The idea was to close the balance around the entire process from raw material feed to final product. The leak volumes determined via the energy and material balances closely matched those calculated from the amount of product lost during "non-optimal" operating conditions. "This helped us pinpoint product losses through some other previously unexamined leak points like our in-process analytical systems. This also revealed there was a significant margin improvement opportunity by conserving product," he notes.

The overall evaluation also considered fugitive emissions. A research and development team assisted in creating a series of analytical tests around the facility to determine if something was missed in closing the mass balance.

In certain areas of the facility, particularly around rotating equipment such as compressors and near the reactors and loading areas, air monitoring instruments recorded fugitive emissions (Figure 1).

Checking that compressors were leak-tight became a part of routine maintenance, as did monitoring piping around the machinery for vibration, which could result in additional leak points at certain piping-to-equipment connections.

"It is important to note that when you are trying to detect process leaks at these extraordinarily low values, even wind direction can be an important factor. The tests were repeated over a range of different environmental conditions, including time of day and various ventilation conditions," Kourpas adds.

Today, the Hometown plant reviews NF3 emissions monthly to ensure its GHG target is achieved. In addition, periodic fugitive emission testing will occur — perhaps annually at first, with data collected determining the frequency going forward.

The Ulsan facility has started a similar GHG reduction program in the past fiscal year, particularly to help prevent venting losses.

On a broader level, Air Products has implemented LDAR programs at multiple locations in the U.S. to comply with several different regulatory requirements. "In almost all cases, we partner with outside LDAR service contractors who are typically selected locally at the site level. We believe this to be the most successful approach in terms of performing the actual monitoring activities themselves, maintenance of leak inspection records in suitable databases, and preparation of necessary reports," says a spokesman.

ANOTHER CORPORATE INITIATIVE

Meanwhile, Solvay, Brussels, Belgium, has integrated its own emissions control strategies with those inherited from Rhodia following its 2011 takeover of that company.

"Sites located in countries where leak detection is regulated such as the U.S. and Europe and most of the big sites handling volatile compounds already report solid quantitative data regarding their fugitive emissions. The plan is to bring all sites to the same standards is terms of leakage rate assessment," says Solvay environmental expert Laurent Sapet.

The company has identified valve stems, flange and reactor gaskets, relief valves, rupture disks and loading/unloading arms as areas for specific focus.

"The strategy is to promote leak detection and repair on all sites and, in particular, those handling volatile and dangerous product such as substances of very high concern as defined in the European REACH directive. Our industrial department is already providing support to those sites willing to start an initiative in this field. It is planned to build a corporate policy supported by group guidance within the next two years," Sapet notes. The initiative could involve

INFRARED CAMERA

Figure 2. Many plants now use such cameras to pinpoint the source of fugitive emissions. Source: Sage Environmental Consulting.

a global contract with specific suppliers for leak detection and repair, he adds.

REGULATORY DRIVER

Moves by the EPA are prompting other companies to act. Most recently, in a June 27 consent decree, EPA got BASF, Florham Park, N.J., to revise the emissions strategy for its Wyandotte, Mich., plant.

"BASF is working cooperatively with U.S. EPA to continuously reduce the instances of leaking equipment subject to LDAR requirements. This process is commonly referred to as an enhanced LDAR program. These efforts include preventive maintenance practices, ensuring that equipment is properly specified for the expected service and monitoring for leak-free performance," says a spokesman at BASF's global headquarters in Ludwigshafen, Germany. "BASF is currently working with its third-party supplier to implement and manage the program," he adds.

One person who has been taking a keen interest in the evolution of LDARs is Jim Drago, senior manager, market intelligence, Garlock, Palmyra, N.Y. He says EPA's July 31, 2009, settlement with the Lanxess/Ineos facility in Addyston, Ohio, is the first example of the agency demanding an enhanced LDAR.

ORGANIC VAPOR ANALYZER

Figure 3. Since the early 1990s, supplemental environmental monitoring has relied on devices using EPA Method 21. Source: Team Industrial Services, Inc.

"Enhanced LDAR is being imposed when existing LDAR is found not to be working effectively. The most progressive part of an enhanced LDAR program is the demand to use low-leak valves and packings: 100 ppm — as opposed to current 500 ppm — for five years, plus a guarantee and test report from the manufacturer to ensure the target is being met," he notes.

He also has noticed that recent decrees focus particularly on quality programs, repair timing and management of change — although a typical enhanced LDAR program has 14 elements, including: monitoring frequency; leak detection and repair action levels; leak repairs; equipment upgrades, replacement and improvement; training; record keeping; and reporting.

PLANTWEB
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Pressure Relief Valve Monitoring with Pervasive Sensing™ and Plantweb™ Insight from Emerson™

Continuous Monitoring. Remote Visibility.

Your business counts on Pressure Relief Valve (PRV) monitoring to help keep personnel safe as well as determine environmental and production losses. Furthermore, in most cases, environmental regulations require monitoring of PRVs. Commissioning requirements and limited visibility, however, make most monitoring solutions too expensive to implement and interpret. Facilities using Rosemount™ 708 Wireless Acoustic Transmitters now have the option of combining the hardware with the Plantweb Insight Pressure Relief Value application to create an innovative, cost-effective and completely automated PRV monitoring system. With quick installation and minimal configuration, the non-intrusive Rosemount 708 makes it easy to monitor valves and reduce preventable losses. Plantweb Insight's pre-built analytics, based on machine learning techniques, make extensive data collection and analysis and reporting simple.