Trap Safety – Awareness of Normalization of Deviation

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Abstract

Pressurized hydrocarbon is a formidable entity. Although pipeline operators and service providers have developed safe and accepted procedures for managing it, some threats may be dynamic and require efforts beyond the checklist.

For example, the safe management of pressure and vapors during the launching and receiving of cleaning pigs and inspection tools requires continuous monitoring and mitigation. That includes knowing how to manage hydrocarbon, oxygen and ignition sources to keep field personnel safe, and assessing the integrity of the pig trap assembly and its components to ensure the equipment can hold pressure and operate as expected.

Over time, a phenomenon known as normalization of deviation has allowed field practice, culture and tribal knowledge to become the standard for a given process. Normalization of deviation is a gradual process where deviations from established rules, procedures or standards become accepted. Understanding the threats that drove the establishment of safe pig trap procedures will help bring awareness to field practices that may deviate from the approved practices.

The purpose of this paper is to show how products and processes for the operation of launchers and receivers have evolved over time based on feedback from the field, and how to recognize normalization of deviation that can increase operational risk. This paper will discuss pressure management of the trap, management of gases and liquids within the trap, managing potential ignition sources, ensuring trap integrity, and safety practices for traps, components and closures under both normal and abnormal operating conditions.

Introduction

Methods to safely access the interior of pipelines carrying hydrocarbons are an important part of maintenance and the protection of field personnel, the environment and the public. One method for gaining access is by using launchers and receivers, commonly referred to as traps, at an aboveground station or facility (Figures 1 and 2). Pipeline traps are bolted or welded to the main line valve and have few moving parts. Except for the closure assembly and a few valves, the trap can be considered a static system.

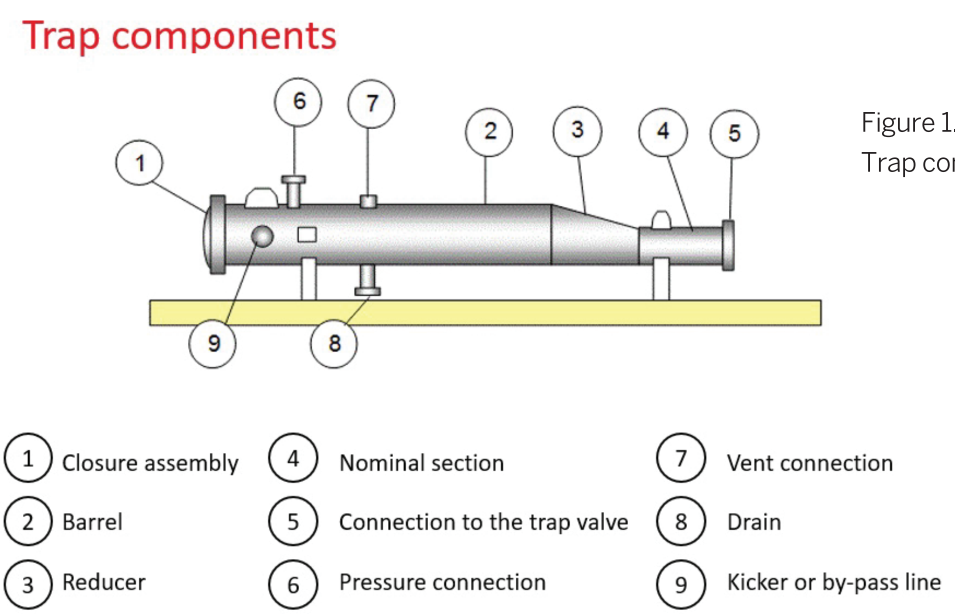


Figure 1.
Trap components

Figure 2.
Pipeline trap.

Traps have been part of pipeline operations since cleaning with pigs became a necessity. How often traps are operated is determined by the pigging frequency established in the pigging program but can be affected by other factors, including whether cleaning is needed after a hot tap operation or if an in-line inspection (ILI) using an instrumented smart pig is required.

Trap equipment design and processes have evolved alongside safety requirements and regulatory guidelines. Still, risks associated with pipeline trap operation remain. Many of the known risks were recognized as the result of years of field experiences, tribal knowledge, shared stories and industry discussions — in other words, they resulted from deviations from prescribed procedures. Moving forward, new situations will require expert evaluation and new procedures to maintain the level of safety expected and demanded by our industry.

Closure safety

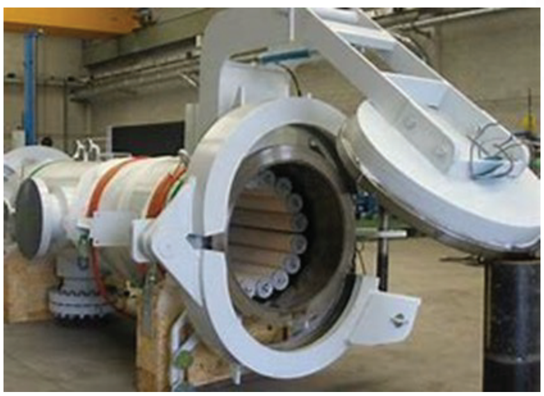
The closure is designed to hold full pipeline pressure without fail or leaking and must be able to be released and opened in a matter of seconds, safely and consistently.

Closure seals must be compatible with the pipeline product and temperature. Seals can be made from a single material, be compatible with multiple materials and be either reusable or have a limited use capacity. Understanding how to activate the closure head seal is essential. In some designs the closing and locking of the closure head will energize the closure head seal while in other designs the seal is energized by differential pressure across the seal (Figure 3). The latter design may be challenging to seal at low pressures due to the differential pressure required.

Debris accumulation, including wax, paraffins or sludge, is a common issue in long-distance pipelines that can compromise the safety and integrity of the closure. It is typically due to wearing components — the weight of the closure head can wear the bearing surfaces; this can also cause the closure head to become misaligned — or from product drop out or build up related to temperature or flow speed changes in the line. If the debris interacts with the closure and seal, it can affect the system's ability to provide a leakproof seal.

Fundamentally, every closure designed to ASME codes will provide safe access to the interior of the trap. The ASME B31Q Operator Qualification (OQ) training covers closures in general and it is the responsibility of the operator to train the field technicians on specific closure operations.

Some closures have the pressure warning device at the top of the closure and some closures have the pressure warning devise within the head or door. How the holding elements are released can be different from closure to closure. It is important for the operator to review the closure's operating manual and verify that field technicians are trained on the safe operation of the closures.



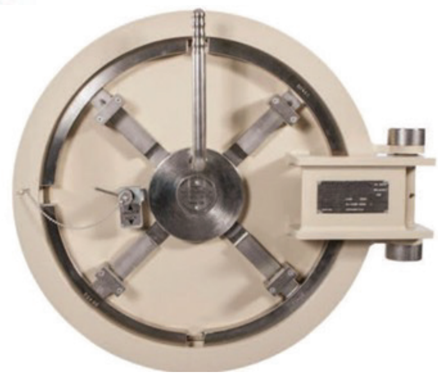


Figure 3. Different closure designs.

Components used on traps and trap piping include ball valves for equalization and plug valves or ball valves for flow control. Drains and vents can use smaller ball valves, and a trap usually includes a pressure relief valve. Holding elements that hold the closure head to the body and keep the seal in position to prevent leakage are considered a structural component because they do not contact pipeline pressure. Examples of holding elements are a clamping ring or a sliding plate that fits into an external ring. Locking elements secure the holding elements in place and prevent unexpected release of the holding elements

On most receivers and on some launchers, there will be a pig signalling device that indicates the pig has left the launcher, is traveling through the pipeline or has arrived at the receiver. Pig signallers have an elastomer seal intended to resist leaking pipeline product to the atmosphere. Although elastomer seals can degrade and begin to leak, they can easily be replaced without special isolation efforts because the trap can be operationally separated from the pipeline at zero pressure.

If the trap is specialized, such as an automated pig launcher, there may be additional components that require scheduled maintenance to preserve their safe operation. For example, launch pins may be used to sequence the release of pigs from an automated launcher (Figure 4).   These pins require a seal at the barrel interface to manage pipeline pressure during launch. The continuous safe operation of these automated launchers depends on the seals containing pressure.

Follow the trap manufacturer's maintenance procedure to keep the automated system in safe working condition.

Pressure management

Pipeline product is used to pressurize traps when pigs are launched and received. (For technical purposes, we will consider the pipeline products to contain some form of hydrocarbons.) Before opening traps to atmosphere, they are completely depressurized. This can involve draining liquids or venting gasses to a planned safe location.

Figure 4. Pipeline trap components.

Trap outlets and valves that drain or vent pipeline product are generally small, on the order of 2 inches or less, depending on the size of the trap and the time expected to drain or vent the pressure.

Unlike draining oil from a vehicle or releasing pressure from a vehicle's radiator cap, sometimes the product being evacuated is not visible to the technician performing the task. In the past, pig trap technicians could occasionally rely on the sound of the liquid draining or the whistle of gas venting through a system to determine if the trap was free of pressure. Today's recommendations are to monitor the pressure within the trap with calibrated gauges suitable for the pipeline product and level of pressure. Note: It is difficult to read low pressure on a high-pressure gage. For example, 5 psi may show as 0 psi on a dial gage rated for 0-1000 psi, but 5 psi equates to a linear force of 1,500 pounds on 20-inch closure head. Releasing a 20-inch closure head with 5 psi pressure within the trap will push open the closure head with 1,500 pounds of force.

Some traps will evacuate more completely than others. Determining factors include the position and location of the drain and whether the trap was built with a dedicated incline to encourage debris and residual liquids to flow toward the drain, which can make the trap susceptible to blockage by debris or sludge settling within it (Figure 5).

Figure 5. Debris from pipeline.

While blockages can occur at any orientation inside the pipeline trap, we generally experience debris in the bottom, or 6 o'clock, position. A blocked vent or drain is difficult to assess. The ASME Boiler Pressure Vessel Code (BPVC), Section VIII, lists a safety provision to be incorporated on all code-compliant pipeline trap closure designs. Closures have different operating designs, but all incorporate a pressure indicating device. The device is intended to alert the technician to the presence of pressure within the closed and sealed trap and to prevent the holding elements on the closure head from being removed while pressure remains.

It is common to view pipeline equipment of a specific size and length as having a specified volume of gas or liquid. This volume can only be accurate if all connected piping and valves are 100% closed and not leaking pipeline product into the trap.

There have been instances where the technician followed all written procedures to evacuate the pressure from the trap, confirmed the absence of pressure and waited before opening the closure, only to find an undetected leaking valve has resupplied the trap with pressure. Note: The pressure-indicating device on the closure should never be used as a vent to manage the pressure within a pipeline trap.

Product management

Once pressure has been mitigated to zero, technicians should monitor whether hydrocarbon vapors are present in the trap and at what level. The presence of hydrocarbon vapors is associated with two significant threats: vapor exposure by personnel and the risk of explosion when hydrocarbon vapors mix with ambient air containing oxygen. The health, safety and environmental (HSE) section of the operator's trap operation manual will include guidelines on acceptable monitoring methods. safe levels of hydrocarbons, the upper explosive limit (UEL) and the lower explosive limit (LEL).

Operators often employ a purging process to push ambient pressure vapors out of the trap to a safe location. Some use the surrounding air as a purging medium, but this increases the potential for a dangerous vapor/oxygen mix. Others purge using inert gas, such as nitrogen. Although this mitigates the risk from vapors that remain in the trap after depressurization, monitoring and minimizing the presence of oxygen is often recommended because reducing oxygen levels can affect personnel health and their ability to safely perform their tasks (Figure 6).

Figure 6. Technicians' proximity to pipeline traps.

Here, too, the position of trap vents and drains is something technicians should be aware of. If a trap is not completely horizontal, venting gas may not be efficient. For example, if the trap is tilted downward to the left at 1 degree and the vent is on the right of the trap, a wedge-shaped pocket of gas will be trapped and unable to be purged under normal conditions.

Both pressure reduction and purging of hydrocarbon vapors are considered hazardous and must be performed only by operator qualified (OQ) personnel.

Ignition source management

An ignition source is one of the contributors to an unplanned reaction between a hydrocarbon and oxygen. Ignition sources have been studied and evaluated over the years. As technology has advanced, so have the types of ignition sources that could be present near an operating pipeline trap. Automations, electronic measurements and controls, remote sensing and reporting have improved the consistency in pipeline operations; however, these advancements bring new sources of ignition.

Ignition sources include:

- Open flames. Matches, lighters, candles, pilot lights and burners.
- Electrical equipment. Switches, contacts, sparks from a circuit, poor wiring and electrical or gas/diesel/ natural gas motors.

- Static electricity. Generated by friction or when non-metallic materials are rubbed against each other or against a metallic or fibrous surface. Humidity may or may not be a factor in creating static electricity.
- Hot surfaces. Exhaust systems, furnaces, hot plates, heaters.
- Mechanical sparks. Generated by friction or impact between metallic materials, such as grinding, hammering or cutting operations. Tool use can be a source of ignition.
- Chemical reactions. Certain chemicals can produce heat or sparks when placed into contact with other substances.
- Smoking materials. Cigarettes, pipes, vaping material, lighters and other smoking materials.

Managing the risk from these ignition sources begins with education and written procedures, coupled with a demonstrated culture of safety by all levels of management. Safeguards include designating smoking areas to keep this source of ignition away from traps that are in operation, selecting non-carbon steel tools that are effective but reduce the chance of sparks occurring and specifying intrinsically safe measuring equipment and lighting to manage the risk from circuitry. When static electricity is expected, external grounding to the approved work structure will help to minimize the possibility of sparks.

Personnel positioning

Pipeline equipment is designed with safety in mind, and documentation and training help minimize incidents in the field.

Best practices include:

- Staying out of the 'line of fire.' Operating a waist- or chest-high closure can be hazardous for anyone standing directly in front of it. If a closure's holding elements are released while the trap is under pressure, it could cause fatal injuries. Staying at least two feet to the side of the closure can reduce this risk.
- Controlling personnel proximity. Only essential personnel should be near any task. The OQ tasks may allow a span of control for personnel assisting the person performing the task. It is everyone's responsibility to be aware of the tasks being performed and the risks associated with the tasks. Personnel interested in observing must remain in a safe location.
- Managing vapor release. Technicians should identify and understand the direction of drained, vented, or purged vapors, especially if they are not contained within a collection vessel. They should also be aware of wind direction and strength to prevent the uncontrolled spread of vapors.
- Ensuring safe spill response. Only appropriately trained personnel should mitigate spills.

Trap integrity

During fabrication, pipeline traps are subjected to a hydrostatic strength test and a lesser pressure leak test, similar to the baseline inspection and proof test for a new construction pipeline. Yet while pipelines are regularly assessed to verify fitness for purpose and identify metal loss, deformation, cracking and other defects that could reduce their pressure-carrying capacity, the same can't be said for traps. Assessment is often not regularly scheduled nor are the assessment methods well-defined. That is the case even though the traps experience the same pressures and sometimes the same flow as the pipeline itself.

Although the conventional methods for assessing pipeline are not suitable for pipeline traps, traps do have the advantage of being above ground, which means they can be inspected with handheld ultrasonic (UT) gauges. There may be difficult areas near supports, but most of the trap is usually accessible full circumference (Figure 7).

Figure 7. Measuring wall thickness.

Depending on the results of the UT inspection, additional services such as radiographic inspection of welds, hardness testing for hard spots and magnetic particle and dye penetrant inspection can provide additional information.

Repurposed /rental traps

Pipeline traps can be repurposed or rented for specific operational needs, but unfamiliar equipment, even if inherently safe, can pose a risk to field personnel. Operating and maintenance manuals are often unavailable in the field, leading to reliance on hands-on learning, even for OQ technicians.

Repurposing traps. Traps can be moved between pipelines, such as repurposing a liquid pipeline trap for gas pipeline use, provided the design parameters are reviewed and approved. However, liquid traps are built slightly different than gas traps and are fabricated and inspected to different ASME codes. This means modifications may be required, such as adding a vent for gas service to a trap originally designed for liquid drainage.

Rental traps. Right-of-way restrictions and short-term needs may prevent permanent trap installation or make it impractical. As with any rental equipment, the physical condition of a rental trap may be less than like-new, and the closure heads may be configured differently from the permanent traps in the operator’s pipeline system. Training may be needed to become familiar with different closure operations.

Loading and unloading traps

Loading and unloading procedures for cleaning pigs and inspection tools are detailed in the operator’s Integrity Management Plan (IMP), varying by trap design.

Figure 6. Technicians’ proximity to pipeline traps.

Some launchers have specialized ports used to pull inspection tools into the trap. Other loading methods involve manually inserting pigs into the reducer using lightweight, spark-resistant pusher poles (which should be grounded to prevent static charge).

The pig or tool slides easily into the trap's wider section because the urethane cups and discs are not engaged. Telescopic poles aid safe insertion into long launchers and are also useful for retrieval, allowing technicians to insert the pig deep into the receiver without reaching or leaning in themselves.

Large pigs require cranes or lifting methods for safe alignment before insertion (Figure 8). Trays designed to protect sensitive sensors and instruments are used for inserting larger inspection tools into launchers.

Naturally occurring radioactive materials (NORMS)

Naturally occurring radioactive materials (NORMS) can accumulate within the pipeline receiver and on cleaning pigs and ILI tools that contact the pipeline inner wall. It is difficult to predict when levels of NORMS will exceed the safe levels defined by the operator's HSE team. Visually, the amount of debris from the pipeline is not directly related to the level of measured radiation, meaning a small amount of debris can emit a large amount of radiation and a large amount of debris can be free of radiation. Using handheld meters to monitor and measure the presence and radiation level of NORMS during pipeline cleaning and inspection will help determine the level of mitigation needed.

Decontamination of affected surfaces involves liquids, brushes and chemical agents, used individually or in combination. Personnel performing the decontamination will wear recommended personal protective equipment (PPE) to minimize exposure. Any runoff from washing or scraping should be collected and classified as either hazardous or non-hazardous then disposed of and documented according to the operator's written plan. Equipment should be isolated and personnel not involved with measuring and remediation should be kept away from the NORM source. Communication during the detection and measurement process must be transparent.

Abnormal operating conditions (AOCs)

Pipeline operating conditions can vary by the product being transported, operating pressures, product cleanliness and temperature within the pipeline. Overpressurization of a trap can cause the pressure relief valves to activate. Underpressurization of a trap can cause a pig to fail to launch from the trap. Excessive temperature or a change in the chemistry of the pipeline product being transported, or both, may affect the seals on the closure and other trap components. Environmental conditions such as wildfires, hurricanes, lightning and seismic activity can also affect trap operations, with valves not opening or closing completely and pig signalers failing to indicate the pig's passage.

Normalization of deviation

This phenomenon occurs when a deviation from an established procedure or process being considered acceptable rather than risky or problematic by an organization or team. The pipeline industry is not immune to normalization of deviation. In the most serious instances, safety rules and defenses are routinely circumvented to complete a task. Management can unknowingly support and foster this occurrence by recognizing or rewarding results while ignoring the methods for achieving them.

Other contributors to normalization of deviation are:

- A change in the expected procedure that does not have immediate or catastrophic results.
- Changes in equipment put in use before procedures can be formally updated.
- "Looking the other way," meaning procedure deviations are not identified or managed.
- Safety rules or operational procedures are not practical in the operating environment.
- Extended time is allowed between the reporting of safety issues and their resolution.
- Maintenance activities are not prioritized or not executed as planned.
- Procedures are not routinely audited for accuracy, completeness or effectiveness.

The concept of normalization of deviation was popularized during the evaluation of the Space Shuttle Challenger disaster in 1986. What they discovered is that the teams in charge of evaluating and rebuilding the solid rocket had noted levels of burn-through near the seals in the boosters, but each launch was successful, and the minor burn-through occurrences did not result in catastrophic results. As a result, it became normal to accept some level of burn-through. Yet the written instructions from the solid rocket booster's manufacturer stated that no burn-through near the seals was acceptable. On that cold day in January 1986, conditions existed to allow the burn-though to extend further than measured on previous successful flights, resulting in the catastrophic failure of the shuttle system and the loss of lives.

In the oil and gas industry, normalization of deviation occurs most often in trap maintenance. Because of its mechanical nature and moving parts, the closure requires the most maintenance of any trap component.

One serious concern is the accumulation of debris affecting closure operation. As noted earlier, debris often occurs when the weight of the closure head wears the bearing system, which can cause misalignment of the closure head. Misalignment near the mating parts can make the closure difficult to operate, but because debris buildup may occur over a long period of time, the differences in closure operation can be difficult to detect from day to day.

Technicians may try to overcome these problems by using force multipliers to secure the closure. Because operating and maintenance manuals are rarely available in the field, over time it becomes "acceptable" for technicians to use additional force to open or close a closure. This deviation can become the norm — and the need for more closing force goes unnoticed. But think of it like this: If your car door suddenly became difficult to close, would you use a stronger force to close it or look for and remove an obstruction such as the seat belt then close the car door with normal force?

In this case, what is really needed is an evaluation of the worn or misaligned components or a thorough cleaning to remove debris build-up. Those measures are likely part of the written procedures for trap maintenance. Using excessive force is not.

Allowing deviations to prescribed trap operating processes and pressurized hydrocarbon management can constitute a serious risk to life, property and the environment. Addressing and mitigating normalization of deviation requires:

- Leadership commitment to doing things by the book.
- Consistent messaging.
- Thorough, ongoing training.
- Field personnel knowing they are expected to follow written procedures and understanding the risks if they don't.
- Employees feeling comfortable reporting deviations without fear of repercussions.
- Platforms for employees' concerns to be heard.
- Consistent procedural audits and sharing "lessons learned."
- Enforcement across all departments and regions.

Refer to the manufacturer's recommended maintenance procedures and plan to keep this important equipment in good working condition.

Conclusion

Normalization of deviation is a silent threat to pipeline trap safety. When technicians rely on doing things "the way they've always been done" instead of according to written procedures, it adds operational risk and can have catastrophic results.

To mitigate these threats, operators must actively cultivate a culture where deviations are identified, reported and addressed promptly. Written procedures are the result of thoughtful planning, strategic insight and documented best practices from years of pipeline operation. Adhering to them can prevent the normalization of deviation and ensure a safe environment for field crews, assets, the public and the planet.

The topics covered here are intended to be informative but, more importantly, thought-provoking to technicians and operations personnel who work with pipeline traps. As new equipment designs and innovation improve the oil and gas industry, the threats to the technicians may be reduced or eliminated or may migrate to other parts of the process. Awareness, recognition and mitigation are at the forefront of keeping everyone working on a project safe.

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