Trap Safety – Awareness of Normalization of Deviation

Alan Morton, Jim Kay
R.B. Williamson Energy Advisors

PPIM 2025
PIPELINE PIGGING & INTEGRITY MANAGEMENT
JANUARY 27-31 • HOUSTON

Organized by
CLARION
TECHNICAL CONFERENCES

 https://doi.org/10.52202/078572-0031

https://doi.org/10.52202/078572-0031

Abstract

Pressurized hydrocarbon is a formidable entity. While 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 they 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. 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 the 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. This paper will discuss pressure management with 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

Safe methods to access the interior of a pipeline carrying hydrocarbons have been an important part of maintaining pipelines and protecting field personnel and the environment; and the affected public. One process to gain access to the interior of a pipeline is by the launchers and receivers, commonly referred to as traps, at a point aboveground at a station or facility. See Figure 1.

 https://doi.org/10.52202/078572-0031

Figure 1. Pipeline trap.

Traps can be operated on different schedules as determined by an established pigging program, or a special need for cleaning after a hot tapping operation, or to conduct an in-line inspection using an instrumented smart pig. Traps have been part of pipeline operations since cleaning with pigs has been a necessity. The need for additional safety and the regulatory guidelines for trap equipment has evolved and the industry continues to review the equipment designs and processes to improve the overall safety of pipeline operations. Here we will present different risks associated with pipeline trap operation and offer thoughts on methods to mitigate these risks. While this collection of risks comes from years of field experiences, tribal knowledge, shared stories, and industry discussions, there will continue to be new situations that develop that will require evaluations by safety experts to consider new procedures to maintain the level of safety expected and demanded by our industry.

Management of pressure

Pipeline traps are pressurized using pipeline product when launching or receiving pigs and are depressurized completely prior to opening the trap to atmosphere. Depressurizing can involve draining liquids or venting gasses to a planned safe location. For our technical purposes here and throughout the paper we will consider the pipeline products to contain some form of hydrocarbons. The outlets and valves on the traps used to drain or vent pipeline product are generally small on the order of 2-inch and below, depending on the size of the trap and the expected time to drain or vent the pressure. Unlike draining oil from a vehicle or release pressure from a vehicle's radiator cap, sometimes the product being evacuated is not visible to the technician performing the task. In the past some technicians could rely on the sounds of the liquid draining or the sound or whistle of gas venting through a system to determine if the trap is 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.

https://doi.org/10.52202/078572-0031

Note: it is difficult to read 5 psi on a dial gauge rated for 1000 psi and 5 psi equates to a linear force of 1,500 pounds on 20-inch closure head. Saying this again, releasing a 20-inch closure head with 5 psi pressure within the trap with push open the closure head with 1,500 pounds of force.

When the trap is designated free of pressure, the technician has followed the written procedure to remove this risk from the equipment. The technician is cautioned to consider the drain and vent locations on the traps. The location of these vents and drains are susceptible to blockage by debris or sludge that has settled within the trap. See Figure 2.

Figure 2. Debris from pipeline.

While blockages can occur at the any orientation around the pipeline trap, we generally experience debris in the bottom, or 6 o'clock, position of the trap. 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. On each closure is a pressure indicating device with the purpose of alerting or indicating the presence of pressure within the closed and sealed trap prior to removing the holding elements on the closure. Meaning, before any steps are taken to release the holding elements of the closure head, the pressure indicating device is will alert the technician of pressure remaining within the pipeline trap prior to removing the device.

When working with pipeline equipment having a specific size and length, is it common to view the trap as having a specified volume of gas or liquid. This 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 and waited a time before opening the closure. An undetected leaking valve can resupply an enclosed trap

 https://doi.org/10.52202/078572-0031

that has been previously confirmed free of pressure and evacuated. As listed earlier, the pressure indicating device on the closure is an indicator as to the presence of pressure and should never be used as a vent to manage the pressure within a pipeline trap. Each closure has a different operating design. See Figure 3.

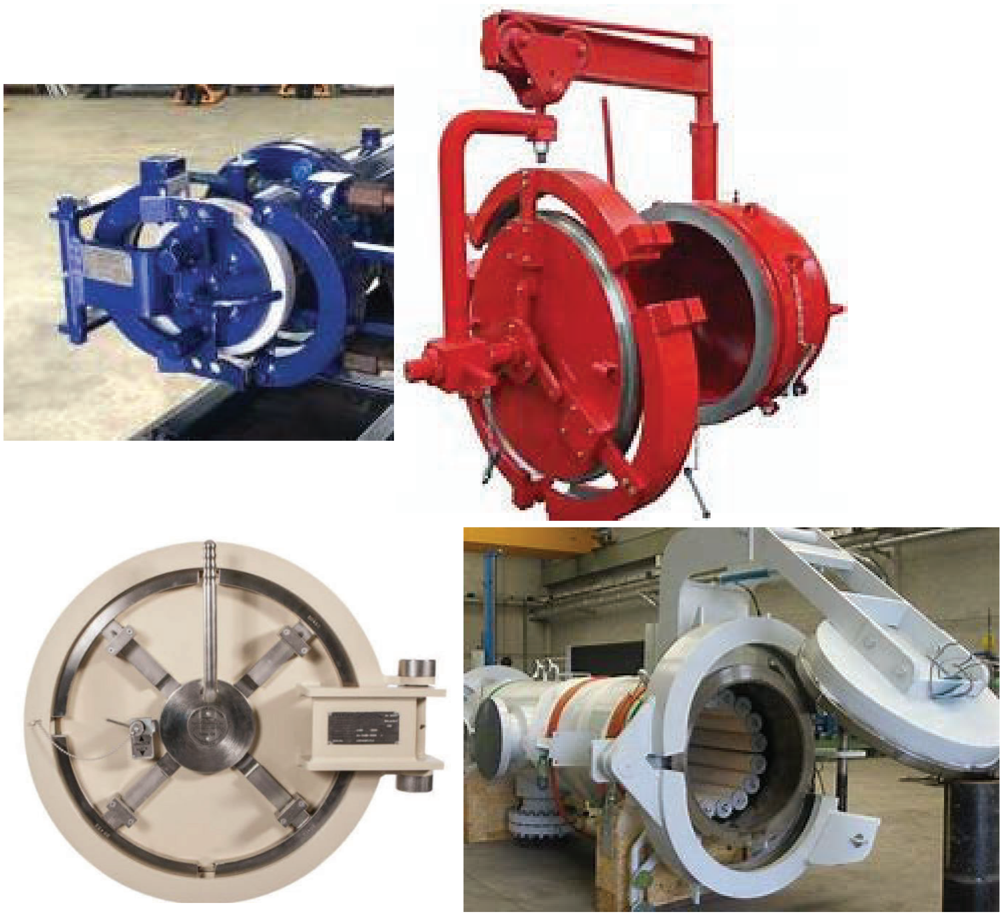

Figure 3. Types of closure designs.

Management of product

Once the pressure within the pipeline trap is mitigated to zero and the trap pressure equals ambient pressure, the hazard of hydrocarbon vapors should be monitored. Vapors exist at ambient pressure and blend with surrounding air. There are two separate threats from hydrocarbon vapors. One threat is the impact to the health of the personnel near the vapors and the exposure time. The second threat is the explosive risk as the hydrocarbon vapors mix with ambient air containing oxygen. The Health, Safety and Environmental (HSE) section of the operator's trap operation manual will have guidelines

https://doi.org/10.52202/078572-0031

on safe levels of hydrocarbons, the Upper Explosive Limit (UEL) and the Lower Explosive Limit (LEL), and acceptable methods to monitor the vapors.

When the trap is relieved of 100% pressure and the closure head is safely opened, the hydrocarbon vapors begin to mix with air and oxygen. At ground level, these mixed vapors are in proximity to pipeline personnel. Some operators include a purging process to push the ambient pressure vapors out of the trap to a safe location. Available purging gas is usually surrounding air. Purging with air does change the vapors within the trap prior to opening the closure head, however the threat remains of mixing hydrocarbons with air and oxygen. Some operators have supply onsite of inert gas, usually nitrogen, for pushing or purging the hydrocarbons from the closed trap. From this example, the hydrocarbon vapors within the trap are replaced with an inert gas at ambient pressure, thereby mitigating both risks from the hydrocarbon vapors left in the trap from depressurization.

Operators that purge the vapors from the trap prior to opening the closure head will sometimes continue a flow of purging gas through the trap to mitigate any fugitive hydrocarbon vapors from leaking valves. Recall in previous paragraphs the threat of latent build-up pressure from unsuspecting leaking valves. These unsuspecting valves can release hydrocarbons into a trap that was previously considered evacuated of all hydrocarbons. With inert gases, it can be recommended to monitor oxygen levels as well as hydrocarbon vapor levels. Efforts to minimize the presence of oxygen near hydrocarbons must be planned, communicated and monitored. The lowering of oxygen in work areas could affect the health of the personnel and their ability to safely perform their tasks. See Figure 4.

Figure 4. Technicians' proximity to pipeline traps.

 https://doi.org/10.52202/078572-0031

Depending on the position and location of the drain and if the trap has been built with a dedicated incline to encourage debris and residual liquids to flow towards the drain, some traps will evacuate more completely than others. The position of the vent has a similar concern. If a trap is not completely horizontal, venting gas may not be efficient. If the trap is tilted downward to the left at 1 degree and the vent in on the right of the trap, a wedge-shaped pocket of gas will be trapped and not able to be purged under normal condition.

Managing sources of ignition

When understanding the chemistry of potential explosions, an ignition source is one of the contributors to an unplanned reaction with a hydrocarbon and oxygen. Ignition sources have been studied and evaluated over the years. As technology advances, so have the types of ignition sources that could be present near an operating pipeline trap. Here is a short list of ignition sources:

- **Open Flames**: Matches, lighters, candles, pilot lights, and burners.
- **Electrical Equipment**: Switches, contacts, sparks from a circuit, poor wiring, electrical or gas/diesel/ natural gas motors.
- **Static Electricity**: Generated by friction or movement of materials, non-metallic material rubbed across a metal or fibrous surface. Humidity may or may not be a factor in creating static electricity.
- **Hot Surfaces**: Any exhaust system, furnaces, hot plates, heaters, furnaces.
- **Mechanical Sparks**: Generated by friction or impact between metallic materials, an example would be 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, followed by a demonstrated culture of safety by all levels of management. Designated smoking areas pre-determined to eliminate this source of ignition near an operating trap. Selection of non-carbon steel tools that are effective in completing a task and reduces the opportunity for a spark to occur. Specifying intrinsically safe measuring equipment or lighting to manage the risk from circuitry. When static electricity is expected, external grounding to the approved work structure will help to minimize the opportunity for a spark to happen.

Personnel positioning.

Written procedures and current training that accompany pipeline equipment that has been designed with safety in mind will minimize incidents in the field. Up to now the pressure reduction and purging of hydrocarbon must be considered hazardous and are limited to being performed by

https://doi.org/10.52202/078572-0031

Operator Qualified (OQ) personnel. Best practices are to limit the proximity of personnel not related to a covered task and to identify the direction of drained, vented, or purged vapors, if not specifically contained within a collection vessel. Awareness of wind direction and wind strength can contribute to the safety of the task. Any spills are to be addressed per the written procedures and the area is limited to personnel with the task of mitigating the spill.

The closure operation process is different for each design of closure. Closures can share common components in name only as their materials and interactions with the closure systems will be somewhat different. Closures are located at the end of the traps and are the access to the inside of the pipeline. One common feature on pipeline traps is the relationship between the closure head and the pressure within the trap. The resulting force on a closure head is in line with the trap length. These closures are generally waist or chest high in relation to the technician that is operating the closure. Closure heads provide access to the interior of the pipeline trap. Considering the previous cautionary statements made earlier about reducing the trap internal pressure 100% and the resulting forces on the closure head that could occur if opening was attempted under pressure, the area directly in front of the closure should be considered hazardous and not occupied by any personnel while the closure head's holding elements are released and the closure head is opened. Simply standing two feet at the side of the closure head during opening can greatly reduce the risk of injury or death.

Trap integrity

During fabrication, the pipeline traps are subjected to a hydrostatic strength test and a lesser pressure leak test before being delivered to the field. This is like the baseline inspection and proof test for a new construction pipeline. Pipeline are assessed at intervals to verify their fitness for purpose. Some inspections will look for metal loss, deformation, cracking, and other defects that could reduce the pressure carrying capacity of the pipeline. These assessment intervals are established by the operator's IMP and are based upon the regulations. The pipeline continues to be assessed years and decades after construction. Hiding in plain sight may be an overlooked risk.

Traps are generally designed with two different diameters of pipe, one section of nominal pipe size of the pipeline, and one section of oversized pipe called the barrel. These traps continue to experience the same pressures and sometimes the same flow as the pipeline itself, yet the intervals of assessment or methods of assessment are not well defined. In some companies, the Mechanical Integrity team will be accountable for assessing the fitness for purpose of the traps. The conventional methods for assessing pipeline are not suitable for assessing pipeline traps. The traps do have an advantage over the pipelines when it comes to assessment methods and that is because the traps are generally all above ground and can be inspected with handheld ultrasonic gauges. See Figure 5.

 https://doi.org/10.52202/078572-0031

Figure 5. Measuring wall thickness.

There may be difficult areas near supports, but the larger amount of the traps is usually accessible full circumference. Depending on the details of a trap inspection, services such as radiographic inspection for weld and hardness testing for hard spots can provide additional information about the trap. Magnetic particle inspection and dye penetrant inspection are some additional inspection methods.

Repurposed / rental traps

Sometimes the need for a longer trap is needed for a specific purpose. Traps can be removed from the pipeline and moved to another pipeline. In one application, a trap designed to support a liquid pipeline could be repurposed to support a gas pipeline in another region, after the trap design parameters were reviewed and approved for gas pipeline use. Modification may be needed in this instance to add a method to vent the trap during operation, since the traps original design would have drains to support the liquid pipeline.

In other applications, right of way restrictions may prevent a trap installation on a permanent base and the operator would rely on a temporary rental trap to conduct pigging operations. On a short-term basis, a rental trap can have a financial advantage. As with any rental equipment, its physical condition may be less that like-new, and the closure heads may be of a style of configuration that is different from the permanent traps within the operator's pipeline system. Training may be needed to become familiar with different closure operations.

Closure safety

Pipeline traps are bolted or welded to the main line valve and have few moving parts. Beyond a few 90-degree-turn ball valves, the trap can be considered a static system, except for the closure assembly. By the nature of its design, the closure is accountable to hold full pipeline pressure without fail and without leaking and be released and opened in a matter of seconds, safely and consistently. Closures

https://doi.org/10.52202/078572-0031

have holding elements that hold the closure head to the body, keeping the seal in a position to prevent leakage. Locking elements secure the holding elements in place and prevent unexpected release of the holding elements. Examples of holding elements would be a clamping ring or a sliding plate to fit into an external ring. Holding elements are considered a structural component because the holding elements do not contact the pressure from the pipeline. As noted earlier, the pressure indicating device is a requirement for pipeline closures. Where the pressure indicating device is located on the closure will determine where the technician will stand to have access to the device. Standing along the side of the closure assembly while opening the closure is the safe place to stand.

The seals of the closure can be a single material seal, can be reusable or have a limited use capacity, or the seal can be composite with more than one material used for sealing. With respect to sealing the closure head, it is recommended to understand how the closure head seal is activated. 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 a differential pressure across the seal. The latter design may be challenging to seal at low pressures due to a required pressure differential. Independent of seal shape and design, the seal material must be compatible with the pipeline product and temperature.

Transporting hydrocarbon products over long distances can generate an amount of pipeline debris, either from wearing components or drop out or build up from the product itself **due to** changing from temperature or flow speed in the line. At times the debris, such as wax. paraffins or sludge, can interact with the closure and seal, impacting the system's ability to provide a leakproof seal. The design of the closure and the location of the head seal can influence the detrimental effects of pipeline debris. Closures should consistently operate over the life of the equipment. Simple to close, good alignment, all hand operation are the features of a new closure.

Over time, the weight of the closure head can wear the bearing surfaces and cause the closure head to become misaligned. Misalignment or the accumulation of debris, or both, near the mating parts can make the closure difficult to operate. Sometimes the difficulty is overcome by using force multipliers to secure the closure, when what is needed instead is an evaluation of worn or misaligned components or a thorough cleaning to remove a build-up of debris. As an example, if your car door suddenly became difficult to close, would you use a stronger force to close the car door? Or would you examine the door and find the seat belt obstructing the opening, remove the seat belt obstruction and close the car door as normal. A build-up of debris may occur over a long period of time and the differences in closure operation would be difficult to detect from day to day. Refer to the manufacturer's recommended maintenance procedures and plan to keep this important equipment in good working condition.

 https://doi.org/10.52202/078572-0031

Component safety

Components used on traps and trap piping to support trap operations will 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. On most receivers and on some launcher, there will be a pig signalling device to indicate the movement of a pipeline pig. Positioning and placement of pig signallers will assist in determining if a pig has left the launcher or has arrived at the receiver. These components will have an elastomer or seal to resist leaking pipeline product to the atmosphere. The liability exists when these components with elastomer seal degrade and begin to leak. The benefit is in their maintenance because the trap can be isolated from the pipeline closing the main line and kicker valves and conduct maintenance on these components. If the trap is specialized, such as automated pig launcher, there may be additional components that require scheduled maintenance to preserve their safe operation. Launch pins can be part of the larger system used to automatically launch pigs from a launcher. See Figure 6.

Figure 6. Pipeline trap components

As noted earlier in the section of pressure management and product management, valves that are part of the trap piping system and the main line valve should be verified to isolate pipeline product from the trap without leaking.

Loading and unloading traps

Methods used to load and unload cleaning pig and inspection tools will be listed within the operator's IMP. These methods can differ due to the design of the pipeline trap. Some launchers have a variety of ports used to pull inspection tools into the trap, securing the drive cups into the reducer. Other methods include pushing the pigs into the reducer using a tool known as a pusher pole or pig pusher. These tools are designed to support the safe insertion of pigs into the launcher, especially in cases where the launcher is long. The poles can be a benefit when receiving pigs at the receiver, allowing the technician to reach deep into the receiver with the pole without reaching or leaning into the

https://doi.org/10.52202/078572-0031

receiver. The pusher pole can be telescopic, allowing for adjustable length, and is often made from lightweight materials for ease of handling. Along with being lightweight, these poles can be fabricated from materials that will not create a spark if impacted with the trap. It is recommended these poles are grounded to minimize the risk of a static charge.

Trays can be used to handle the larger inspection tools and will protect the sensors and instruments on the tool during handling and insertion. Larger pigs may require a crane or lifting method to safely position the pig in line with the launcher prior to pushing the pig into the launcher. See Figure 7.

Figure 7. Lifting a pig.

Naturally occurring radioactive materials (NORMS)

It is difficult to predict when levels of NORMS will exceed the safe levels as 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. It is recommended to monitor and measure the radiation levels of pipeline debris that is present during pipeline cleaning and inspections with inline tools. Knowing the presence of NORMS and the related values will determine the methods to mitigate the radiation and make the equipment safe. Handheld meters are available to detect the presence of NORMS, for both airborne particles and solids.

The written procedures with the IMP or the HSE documents will recommend an inspection routine to collect measurements and where to record the data. A potential source of NORMs is the accumulated material within the pipeline receiver and on the cleaning pig used to clean the pipeline.

 https://doi.org/10.52202/078572-0031

Inline inspection tools are another potential source of accumulated NORM material due to the direct contact between the inspection tool and the pipeline inner wall, and the many spaces within an inspection tool for debris to collect.

Decontamination of the cleaning pigs, the inspection tools, and the receiver will involve mechanical efforts to remove debris from all surfaces using liquids, brushes or chemical agent, or a combination of these items. Personnel conducting the decontamination effort will wear recommended personal protective equipment (PPE) to minimize exposure. Any runoff from washing or scraping should be collected, classified as either hazardous or non-hazardous. Once classified, follow the operator's written plan for disposal and documentation. Be transparent in communicating during the evaluation process of detecting and measuring NORMs, isolate the equipment and keep personnel not involved with the measuring and remediation task away from the NORM source during the mitigation process.

Abnormal operating conditions (AOCs)

Pipeline operating conditions can fluctuate in the form of the product being transported, the operating pressures, product cleanliness, and temperature within the pipeline. Projects like trap operation are coordinated with the operations team and pipeline control to set the expected operating conditions at the time of the project. 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 elements that can impact trap operations include wildfires, hurricanes, lightning, and seismic activity. Valves can fail to open completely or close completely. Pig signalers can fail to indicate the passage of a pig.

Normalization of deviation

This phenomenon is described as the acceptance to deviate from an established procedure or process. The procedure can be related to operations, to safety, or any discipline. Our pipeline industry is not immune to this occurrence. In the most serious instances, safety rules and defenses are routinely circumvented in order to complete a task on time or within budget, using limited resources. Management can unknowingly support and foster this happening by recognizing and rewarding results while ignoring the methods. Other contributors to normalization of deviation are:

- Procedure deviations are not managed or identified. Looking the other way.
- 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.
- Processes are not routinely audited for accuracy, completeness, or effectiveness.

https://doi.org/10.52202/078572-0031

Applying uncheck deviations to the trap operating processes and the management of pressurized hydrocarbon listed within this paper can portray a serous risk to life, property, and the environment. To address and mitigate normalization of deviation, start with a strong leadership commitment and lead by example. Communicate the expectation to follow written procedures and explain the risks that are managed by the procedures. Grow an environment where employees feel comfortable reporting deviations without fear of retaliation, while providing the platform for employees to be heard if they have concerns about a written process. Be consistent with procedural audits and enforcement across all departments to avoid sending mixed messages.

Conclusion

Threats exist within the operations of pipelines systems that are designed to transport hydrocarbons and other products under pressure. Experience nor training will eliminate these threats but will aid in creating a safe environment to complete tasks in the field. Awareness, recognition, and mitigation are at the forefront of keeping yourself and others working with you safe. Written procedures are the result of thoughtful planning, strategic insight, and documented best practices from years of pipeline operation. As new equipment designs and innovation improve our industry, the threats to the technicians may be reduced or eliminated or may be migrated to other parts of the process. The topics covered within the paper are intended to be informative but, more importantly, thought-provoking to the technicians and operations personnel that work with pipeline traps.

https://doi.org/10.52202/078572-0031