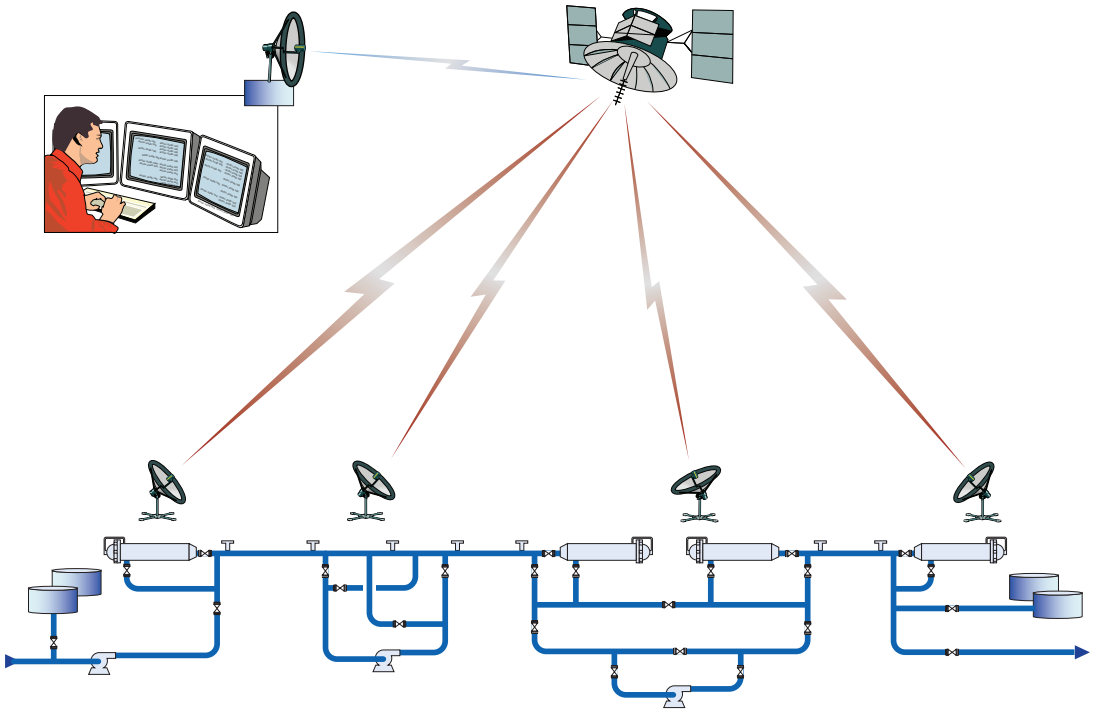
Training Module

Pig Mainline Liquids Pipelines



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- Training Module and Self-Check
- Knowledge Check and Answer Key
- Blank Answer Sheet
- Performance Check

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Contents

Training Objectives

Upon completion of this training kit, you will be able to:

- Describe the purpose and importance of pigging operations for mainline liquids pipelines
- Describe reasons for pigging mainline liquids pipelines
- Describe different types of pigs and their uses
- Describe components of mainline liquids pipeline pigging systems
- Describe barrel-shaped pig launching and receiving equipment
- Describe pig launching and receiving practices
- Describe methods used to clean a pig
- Describe methods used to locate and free stuck pigs
- Launch and receive pigs

1 Introduction

A vast network of pipelines transports natural gas, crude oil, and other refined products across the world. Pipelines gather gas and crude oil from the field and transport these field products to gas plants and refineries for processing. After processing, pipelines transport the refined products—natural gas, oil, liquefied petroleum gas, gasoline, etc.—to markets and the end user. Pipelines are also used to transport products such as water, paint, pharmaceuticals, food ingredients, and beverages.

Maintaining pipeline integrity and ensuring the efficient, economical, and safe transportation of product is of highest importance to pipeline operators. Pigging is one of the principal methods used to ensure efficient pipeline operation.

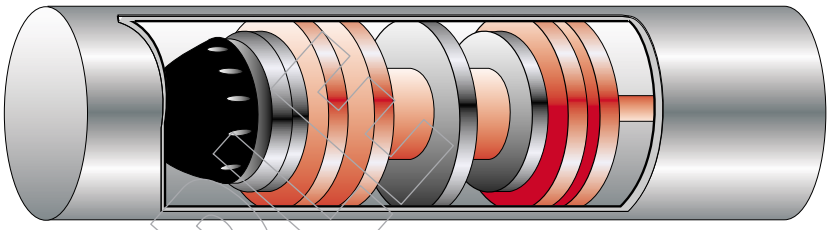
Pigs are tools that are inserted into the pipeline and that move in the pipeline, pushed by the flow of product. Pigs—also known as scrapers—have many uses. Pigs are used during pipeline construction and commissioning to clean the pipeline of construction debris and to test the pipeline; pigs are used during daily operations to inspect the pipeline, to remove wax, standing liquids, and water, and to treat the inner surfaces of pipelines with protective chemicals; pigs are also used to separate product batches within the pipeline to prevent the batches from mixing.

This training kit focuses on pigging mainline hydrocarbon liquids pipelines. There is great variation in the meaning of the term *mainline pipeline*, and the distinction between gathering system pipelines and mainline pipelines is not always clear cut. In this kit, the term mainline pipelines refers generally to pipelines which transport liquids and have a pump at the upstream end. Most mainline liquids pipelines feature:

- centralized, remote control
- booster stations with pumps
- metering stations

Also, most mainline liquids pipelines are equipped with barrel-shaped pig launchers and receivers.

Figure 1—
Pig in a Line



This training kit focuses on the safe and efficient launching and receiving of pigs in mainline liquids pipelines. The kit is aimed primarily at field operators who are responsible for local pigging operations. The kit also provides an overview of pigging operations which would be useful for control center operators. The kit includes:

- pigging applications
- a description of pigs and pigging components and their operation
- roles and responsibilities of field personnel and Control Center Operators during pigging operations
- pigging practices for barrel-shaped pig launchers and receivers
- procedures related to pig launching and receiving
- locating lost pigs and removing stuck pigs
- a description of inspection pigs

2 Reasons for Pigging Mainline Pipelines

Pigging is an integral part of a company's efforts to maintain pipeline integrity and transport product efficiently. Pigs are used for the following reasons:

- to clean and test the pipeline after construction

- to inspect and gauge the line
- to improve flow by cleaning deposits from internal surfaces and by removing pockets of gas and water
- to separate product batches
- to treat the line with protective chemicals

Line Cleaning and Testing After Construction

After a pipeline is built or repaired, a pig is used to remove the dirt and debris which found its way into the line during construction. Dirt, mill scale, weld bead slag, rust, and debris left in the pipeline can contaminate the product and cause severe damage to filters, pumps, and valves.

After a new pipeline is built and cleaned, a pig is used to gauge the line; gauging verifies internal diameter and may indicate pipeline damage during construction.

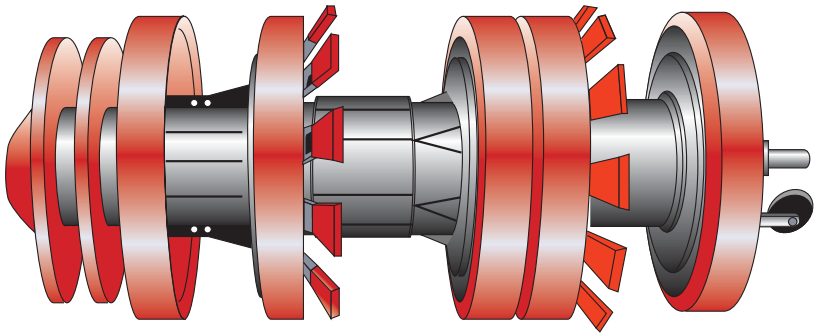
After gauging, the line is hydrotested: the line is filled with water and then pressurized to ensure line integrity. Before filling the pipeline with water, a pig is launched; this pig separates the air in the line from the water. After the hydrotest, the line is purged with air or nitrogen to displace the water. Another pig is used to separate the water and the purge gas.

A series of pigs is used to dewater and thoroughly dry the line before the pipeline is filled with product. After dewatering, a pig is used to separate the air in the line from the product. The pig prevents the air in the line and vapor off the product from forming a combustible mixture.

Line Inspection and Gauging

Pigs can be configured with inspection tools to detect pipeline dents, buckles, wrinkles, cracks, diameter changes, slope changes, construction damage, corrosion, and to determine wall thickness. Pigs can be used to inspect the internal surface of an entire pipeline and store the data in memory for interpretation of findings.

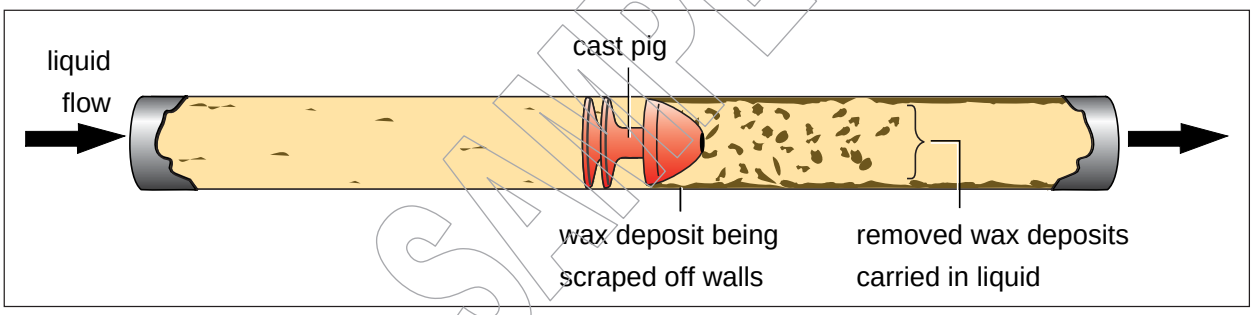
Figure 2— Pig Used for Gauging



Line Cleaning

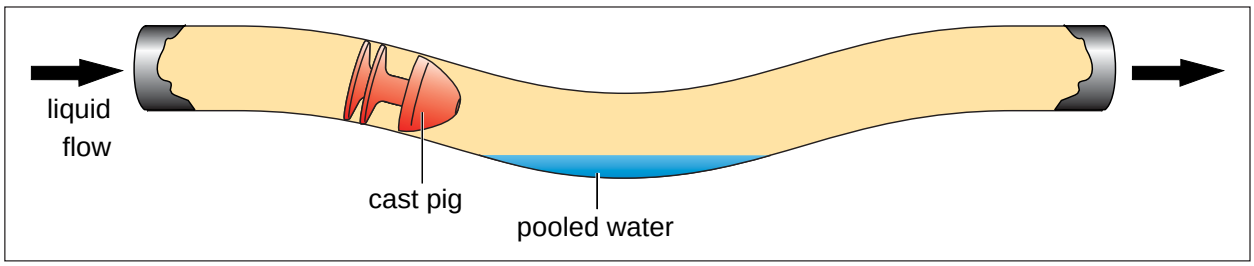
Pigs are used in hydrocarbon liquids pipelines to remove waxy deposits and free water. Waxy deposits tend to build up on pipeline walls, reducing flow, and preventing protective chemicals from reaching the pipeline walls. Pigs scrape the wax from the pipeline walls. The frequency of pigging depends on a number of factors, such as the amount of waxy content of the transported product and seasonal temperatures.

Figure 3—Pigging to Remove Waxy Deposits



Water is more dense than most hydrocarbon liquids and tends to settle in low-lying areas. Water is a major factor in line corrosion. Pigs are used as squeegees to push the water ahead of the pig, preventing the water from pooling.

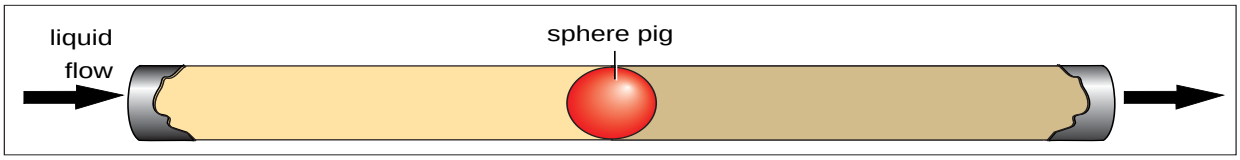
Figure 4—Pigging to Remove Pooled Liquids



Product Batching

When dissimilar liquid products, such as diesel fuel and gasoline, are shipped through the same pipeline, pigs may be used to separate the batches. The pigs keep the products from mixing in the pipeline.

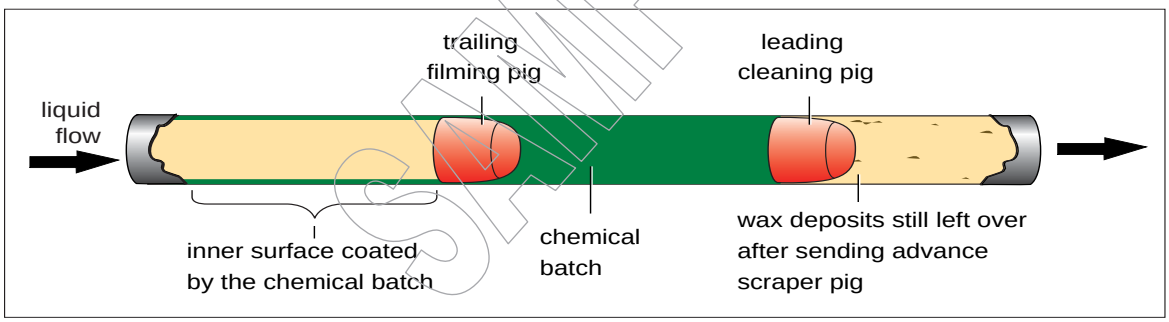
Figure 5—Pigging to Separate Product Batches



Batch Treating

In batch treating, a protective chemical is batched between two pigs. The first pig removes wax, water, or sediment deposits and cleans the inside of the pipe. The protective chemical, isolated from the produced fluids in the line by the two pigs, adheres to and protects the internal surface of the line.

Figure 6—Batch Treating



3 Types of Pigs

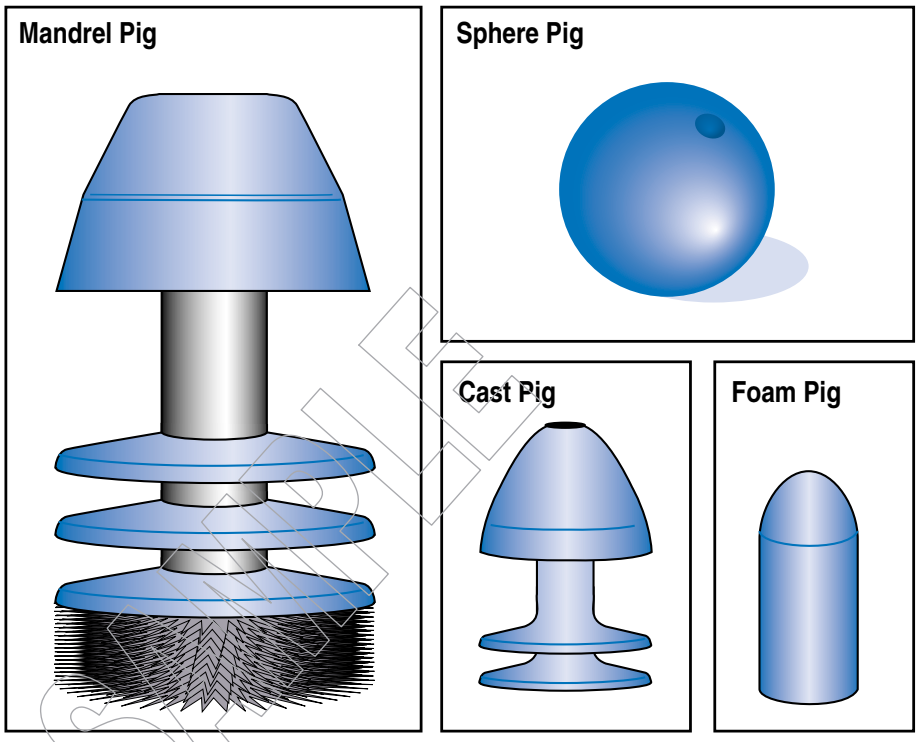
Mainline pigs come in many different shapes, materials, and sizes:

- **spheres**—Most sphere pigs are made of polyurethane and are filled with a water/glycol mixture.
- **foam pigs**—Foam pigs are made of an open cell polyurethane foam. Foam pigs may be coated with wire brush straps, silicone carbide chips, or steel studs.
- **mandrel pigs**—Discs are mounted on a central mandrel. The discs can be replaced or reconfigured, allowing for changing job requirements. Some discs have brushes to provide more scraping edges; these are called disc scraper pigs. Some disc pigs have specialty tools attached for

gauging or inspection. Some disc pigs have strong magnets to remove ferrous debris.

- **solid cast pigs**—Solid cast pigs are similar to mandrel pigs, but are cast in one piece.
- **gel pigs**—Gel pigs are viscous gelled fluids used alone or in conjunction with mechanical pigs.

Figure 7— Types of Pigs



Common Uses of Pigs

The type of pig is chosen according to the specific requirements of the line. Common uses for each type of pig are:

- **spheres**—sealing: batch separation, hydrostatic line testing, line maintenance (batch treating), meter proving. Sphere pigs are particularly useful for negotiating tight 90° bends.
- **foam pigs**—sealing and cleaning: drying, wiping, dewatering, scraping (especially when coated with brushes, chips, or studs)
- **mandrel pigs**—sealing and cleaning: brushing, dewaxing, descaling, gauging, inspecting.
  - When fitted as gauging pigs: determining internal diameter, locating dents and slope changes.
  - When fitted as inspection pigs: detecting metal loss, including corrosion and cracks.

  - When fitted as magnetic pigs: removing ferrous debris such as welding rods and mill scale after construction or before running an inspection pig.
- **solid cast pigs**—sealing
- **gel pigs**—cleaning: picking up deposits and debris scraped off inner pipeline walls by mechanical pigs

Pig Size and Fit

Pigs must be able to:

- negotiate bends, curves, and dents in the pipeline
- pass check valves and tees without buckling, tearing, or shredding
- resist rapid wear and wear evenly

Pigs come in standard sizes to fit tightly into standard diameter mainline pipelines. Pigs must fit tightly in the line for several reasons:

- A tight fit prevents produced fluids from flowing past a pig. Product builds up pressure behind a pig: the upstream pressure (behind the pig) becomes greater than the downstream pressure (in front of the pig). This difference in line pressure across a pig (differential pressure) pushes the pig down the line.

  On disc pigs, the upstream pressure pushes the discs forward. This action forces the discs tightly against the pipe walls. For disc pigs, the greater the differential pressure, the tighter the seal.

- A tight fit permits the edges of the pig to firmly scrape along the inner surface of the flow line, scraping off wax and sediment deposits. The scraped-off deposits collect ahead of the pig. Some pigs are equipped with bypass holes. Because of the pressure differential across the pig, the holes create a jet action: fluid from behind the pig pushes through the holes, keeping the scrapings ahead of the pig.

- For batch treating, a tight fit prevents the corrosion inhibitors, which are batched between two pigs, from mixing with the normal production stream and/or with the material that is being scraped off the inner surfaces of the flow line.
- A disc pig used for line gauging is typically equipped with a metal gauge plate that is approximately 90 to 95% of the internal diameter of the pipeline.

4 Pigging Components

The basic components related to pigging mainline pipelines include the following (see figure 8):

- remote operation from a control center via a data communication system
- pig launchers
- pig signals
- station bypass facilities
- pig receivers
- metering facilities

4.1 Remote Operation

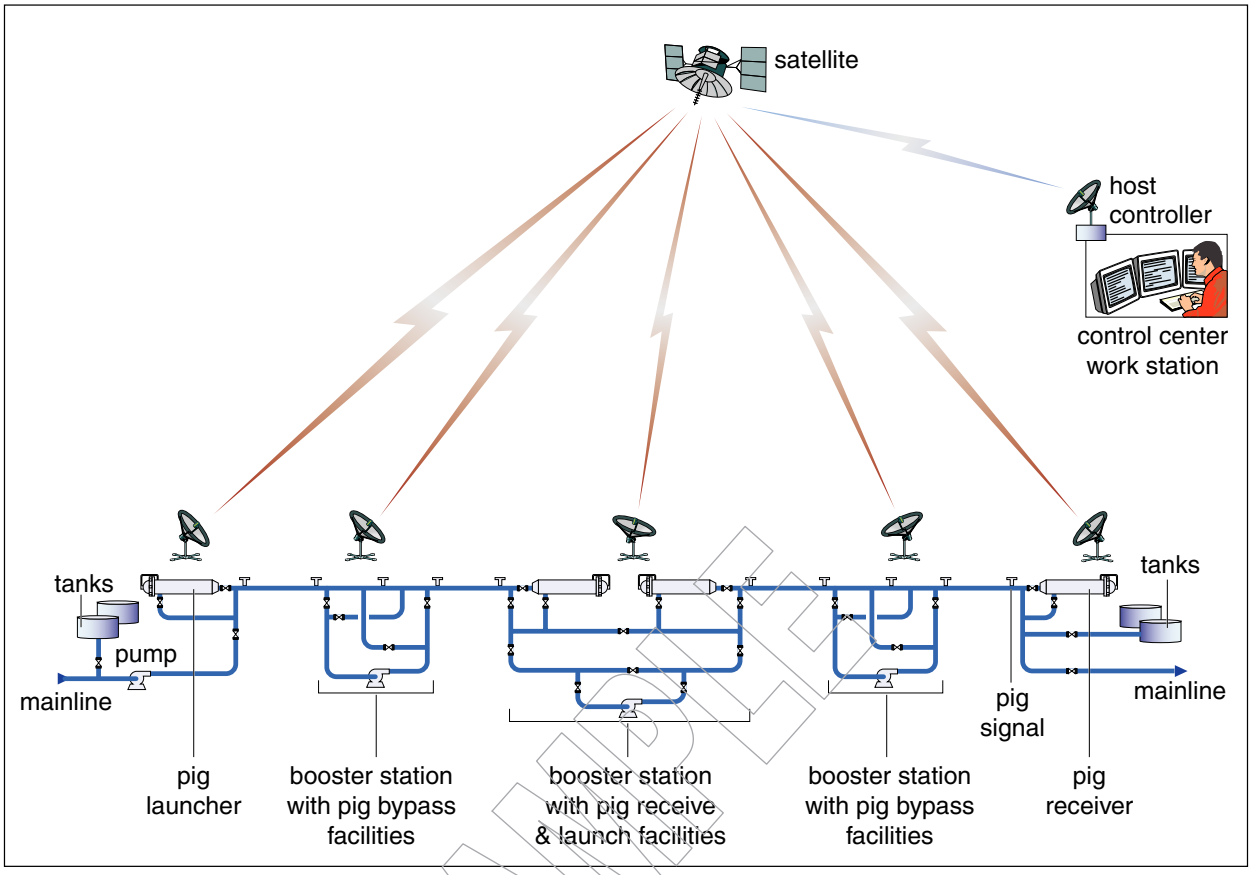
Most mainline pipelines are operated remotely from a central control center by means of a SCADA (supervisory control and data acquisition) system. SCADA systems:

- monitor variables such as pressure, flow rate, temperature, density, and tank levels
- control equipment such as pumps, valves, and pig launchers

SCADA systems consist of:

- a host computer that supervises and manages data
- data transmission equipment that transmits and receives data signals between pipeline locations and the host computer, and includes land lines, microwave, or satellite facilities
- central control center workstation that receives data signals from the host computer
- local workstation (i.e., a workstation at a mainline pump station) that receives data signals from the pipeline and from the host computer

Figure 8—Basic Pigging Components of a Mainline Liquids Pipeline



Pipelines equipped with SCADA systems can be operated in the following ways:

- remotely from the central control center workstation
- remotely from the local workstation
- manually at the equipment

Under remote control from the central control center workstation, the Control Center Operator uses the SCADA workstation to monitor and adjust pipeline operations, including launching pigs and tracking pig movement. (Note that on some pipelines, pig launchers and receivers can only be operated manually.) The SCADA system calculates and displays the movement of pigs through the pipeline, determining a pig's current location and estimated time of arrival at various sites along the pipeline.

Figure 9— SCADA Workstation

Under remote control from a mainline station, a Field Operator can monitor and adjust pipeline operations from the local workstation. The local workstation is used if communication is lost between the central control room and the mainline station, usually as a result of data transmission equipment or host computer failure.

A Field Operator can operate the pipeline equipment manually. Equipment is operated manually if communications are lost between the equipment and the station controller. At some stations, pig launchers and receivers are not linked with the station controller and can only be operated manually.

4.2 Pig Launchers and Receivers

A pig launcher is located at the upstream end of a mainline pipeline; a pig receiver is located at the downstream end. Pipelines may have intermediate pig launch/receive stations and pig bypass stations (refer to figure 8). Pipelines are designed with intermediate pig launch/receive stations to remove waste material in front of the pig and thus prevent excessively large buildups.

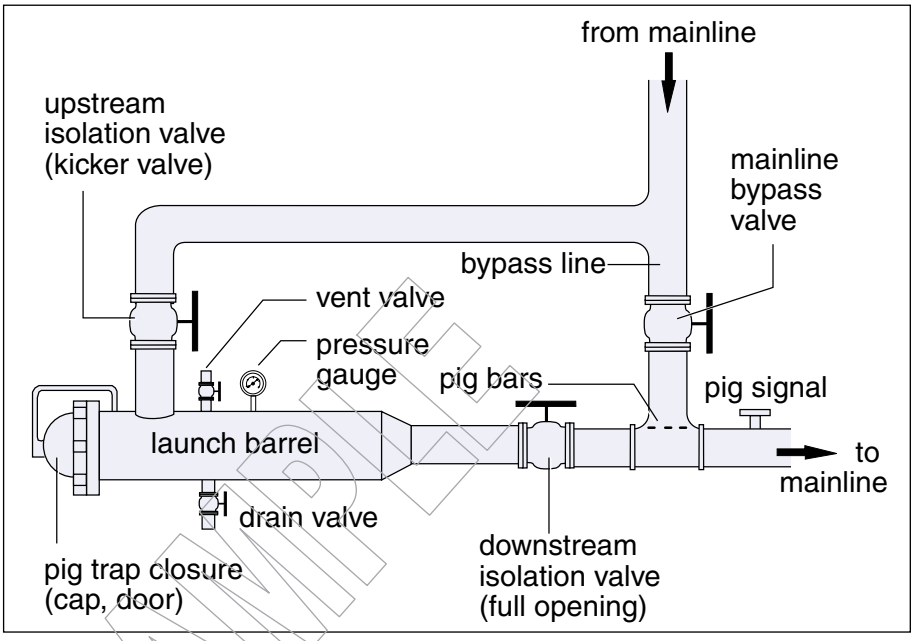
The pig launchers and pig receivers on mainline pipelines are generally barrel-shaped units (see Figures 10 and 11). The barrel diameter is larger than the diameter of the pipeline and 1.5 to 2.5 times longer than the pig. A pipe with a bypass valve connects barrel pig launchers and receivers to the mainline pipeline.

Launchers and receivers are often called pig traps.

WARNING

Companies and manufacturers use different terms for pig trap piping and valves. The terms used in this training kit may be different from the terms your company uses. When working with pig traps, make sure you understand the use of terms at your site to prevent confusion.

Figure 10— Barrel-shaped Pig Launcher



To load a pig in the launcher, the launch barrel is isolated from the mainline. To launch a pig, flow through the launch barrel is established. Depending on the pipeline, pigs can be launched remotely from the central control room, remotely from the local station, or manually.

Pig bars at the intersection of the bypass line prevent the launched pig from entering the bypass line. A pig signal is tripped when the pig enters the pipeline; the pig signal may be transmitted to the host computer at the central control center.

When a pig arrives at the pig receiver, a pig signal is tripped. The signal may be transmitted to the host computer. Pig bars prevent an incoming pig from entering the bypass line. The receiver barrel is isolated to remove the pig.

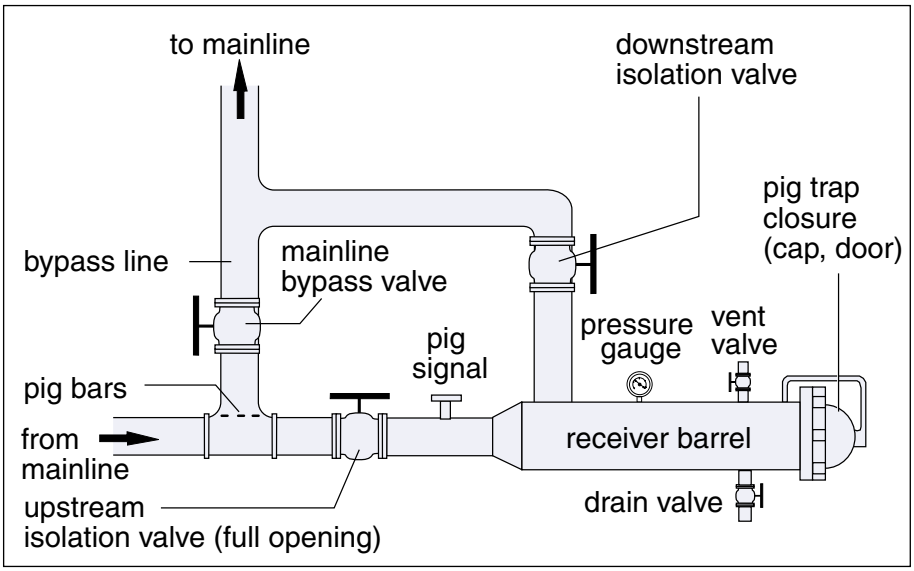


Figure 11— Barrel-shaped Pig Receiver

Mainline pipelines and the pigs used in the lines range in diameter from about 168 mm to 1220 mm (nominal 6 in. to 48 in.). Larger pigs can weigh more than 450 kg (1000 lbs.). Depending on the size and weight of a pig, pig launchers and receivers are equipped with jib arms, hoists, launch/receive trays, and hydraulic rams.

All pig launchers and receivers are equipped with pressure gauges, vents, and drain valves.

Pig Trap Closures

There are many different types of trap closures, some of which allow rapid access to the barrel. The most common are:

- threaded
- clamp ring
- band lock

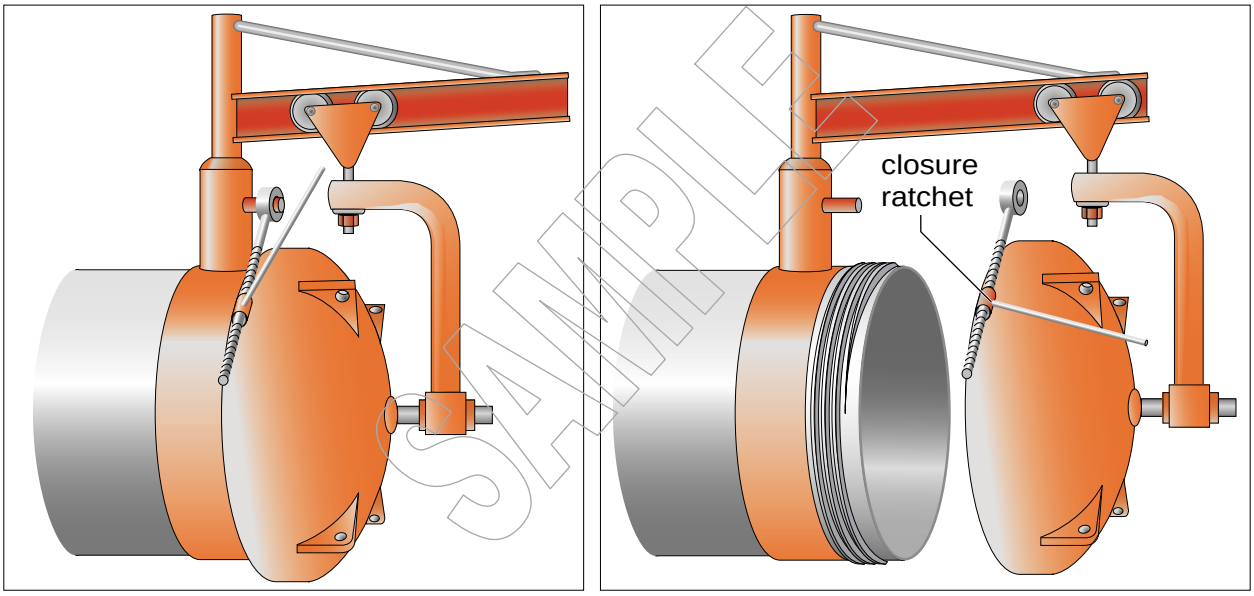
Most pig trap closures are equipped with the following features:

- an O-ring which provides a seal between the door (cap) and the barrel.
- a strong hinge mechanism or jib arm-type system to support the door when it is open and allow the door to be positioned correctly when it is closed
- a pressure warning device that warns the operator if the barrel is still pressurized. Some pressure devices prevent the door from being opened until all pressure in the barrel has been relieved.

O-rings must be inspected every time the pig trap is opened. Look for blistering, swelling, and delamination. Make sure you have a correctly sized replacement before removing an O-ring from a closure because it is very difficult to re-install a swollen O-ring.

Threaded Closures—Barrels with threaded closures are opened by rotating the end cap (door). Larger closures are equipped with a hinge mechanism or jib arm to support the open cap; smaller threaded closures may not have a hinge. Some Yale closures have a closure ratchet which aids the initial opening and final closing of the end cap.

Figure 12—Yale Threaded Closure



After a threaded closure has been newly installed, it is important to open and close the closure at least twelve times to remove any rough spots on the threads.

Over-tightening threaded closures can damage the O-ring and threads. Close tight arrows are placed on both the closure and the hub to indicate when a closure is sufficiently tight: when the arrows are aligned, the seal is sufficient. If a new closure does not have close tight arrows, follow this procedure to mark the closure:

- remove the O-ring
- clean opposing surfaces thoroughly
- screw on the cap until it is in metal-to-metal contact

- use a low stress stamp to incise matching lines on both the hub and the cap

Make sure the stamp is low stress rather than sharp. A sharp stamp can fracture the metal.

To open a threaded closure, after isolating, depressurizing, and draining the barrel:

- If the closure is equipped with a pressure warning device on the cap, open the device. If the valve hisses, there is still pressure in the barrel. Check status of all valves. Wait until the warning device stops hissing before proceeding.
- Loosen the cap with a lug wrench, cat bar, or, if present, the closure ratchet.

Manufacturers discourage the use of hammers to open and close threaded caps. Hammer impact can cause surface stress cracks and severely reduce closure life.

- Manufacturers discourage the use of backhoes to loosen or tighten threaded closures. Using a backhoe can damage the cap and related equipment.
- Companies who do use a backhoe use a sling to hook the cap to the hoe; a designated signal person directs the backhoe operator.

Stand to one side when removing the cap. Pressure in the trap can cause the pig to shoot out at high velocities. The pig and the cap can cause serious injury.

- After the cap is loosened, manually rotate the cap until it is disengaged from the barrel.

If it is difficult to rotate the cap manually, the barrel may still be pressurized. Ensure all pressure in the barrel is relieved before removing the cap. Check the status of all valves.

- For caps without a hinge device, after the cap is disengaged from the barrel, lift off the cap and place it on the ground.
- For caps equipped with a hinge or jib arm mechanism, after the cap is disengaged, use the hinge to swing the cap open and away from the barrel opening.

To close a threaded closure:

- Clean the O-ring and the threaded surfaces on the cap and barrel. Make sure the treads are cleaned to the bare metal.
- For smaller caps, position the cap and screw it on.
- For larger caps, use the hinge or jib arm to support the cap, position the cap on the barrel, and screw it on. Tighten the cap with a lug wrench, cat bar, or closure ratchet.

Do not over-tighten; over-tightening may damage the O-ring.

Clamp Ring Closures—Clamp ring (yoke) closures feature a hinged clamp which encircles the cap/barrel interface (see Figure 13). A latch mechanism locks and unlocks the clamp.

To open a clamp ring closure, after isolating, depressurizing, and draining the barrel:

- Unlatch the latching mechanism.

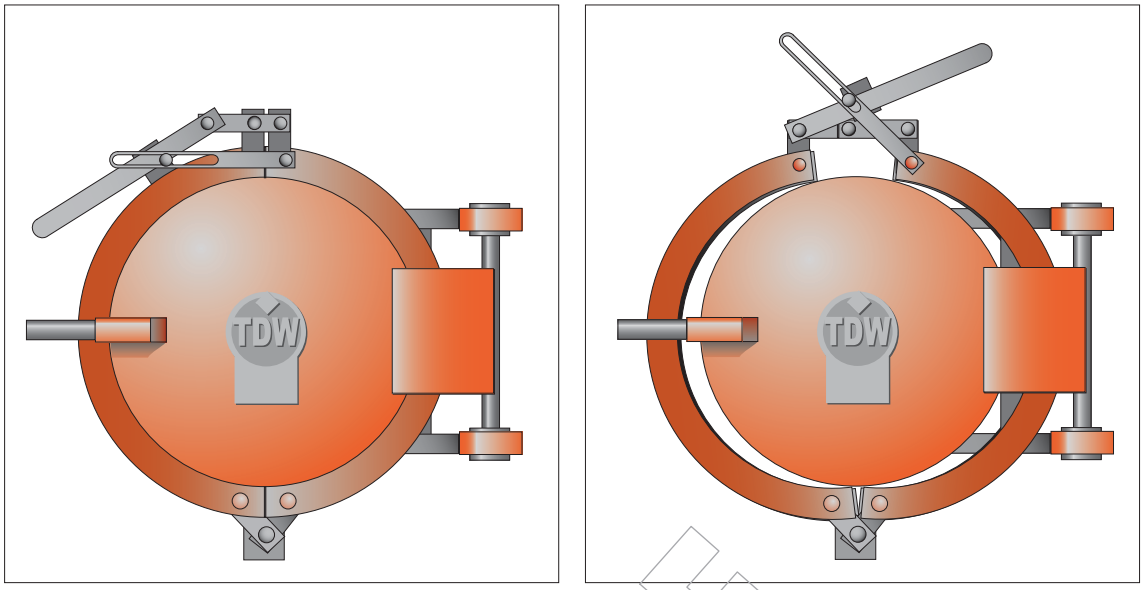
Stand to one side when removing the cap. Pressure in the trap can cause the pig to shoot out at high velocities. The pig and the cap can cause serious injury.

- Swing open the cap on its hinge.

To close a clamp ring closure:

- Clean the O-ring and the opposing surfaces on the cap and barrel.
- Close the cap.
- Latch the latching mechanism.

Figure 13—T.D.Williamson Clamp Ring Closure



Bandlock Closures—Bandlock closures, manufactured by GD Engineering Inc., feature a locking band, fitted between the door and the barrel neck, which engages in a locking groove on the barrel (see Figure 14).

To open the bandlock closure, after isolating, depressurizing, and draining the barrel:

End of Sample

A full licensed copy of this kit includes:
- Training Module and Self-Check
- Knowledge Check and Answer Key
- Blank Answer Sheet
- Performance Check