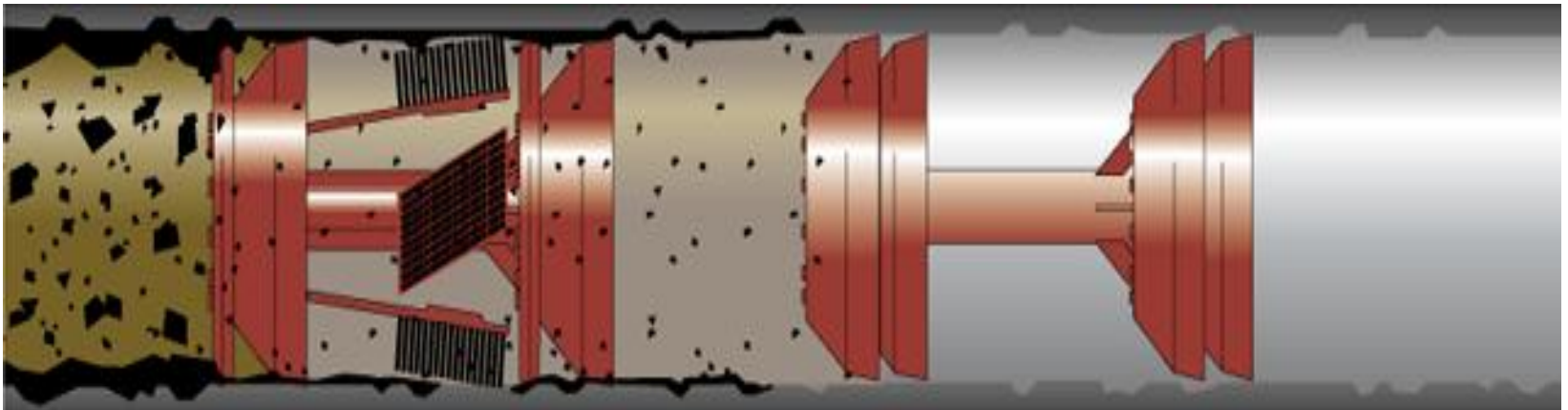


Difficult to Pig Pipelines

David Wint
Manager, Global Services Development
TDW Services, Inc.
David.wint@tdwilliamson.com



Regulations

- In 1994, §192.150 / §195.120 regulations were passed that required each new transmission line and each replacement of line pipe, valve, fitting, or other line component in a transmission line must be designed and constructed to accommodate the passage of instrumented internal inspection devices.
- Design & Construction Standards to reduce internal corrosion on Gas Transmission Pipelines – Final Rule May 23, 2007
 - New and replaced gas transmission pipelines must be configured to reduce the risk that liquids will collect in the line
 - Have effective liquid removal features
 - Allow use of corrosion monitoring devices in locations with significant potential for internal corrosion

All About Pigging

- What is Pigging ?
- Why Pig ?
- Pipeline Design
- Pipeline Operations
- Types of Pigs
- When to Pig ?
- Pigging Safety
- Pipeline Cleaning
- Geometry Inspection
- Metal Loss Inspection
- Crack Inspection
- Inhibition

What is Pigging?

A widely utilized process which is the act of propelling a properly sized spherical or cylindrical device through the interior of a pipeline by manipulating the pressure & flow of the existing media, or by artificially introduced media or by mechanically pulling the device through the pipeline for the specific purpose of cleaning, inspecting or distributing inhibitor throughout the pipeline.

Why Pig a Pipeline?

During the 1940s, pipelines in the United States were mainly pigged to remove paraffin to increase efficiency in crude oil pipelines in order to maximize flow conditions for the war effort. The pigging equipment utilized at that time was limited to a few applications while being very crude in nature. In today's world, pipelines are pigged for a variety of reasons and the pigging equipment used is designed by engineers to perform particular functions.

Piggability

RECOMMENDED PRACTICES

- NACE 35100 In-Line Inspection Non-Destructive Testing of Pipelines
- NACE RP0102-2002 In-Line Inspection of Pipelines

Piggability

- Physical Characteristics (Pipeline Design)
- Line Pipe Grade
- Type of Welds
- Length
- Fittings
- Internal Diameter
- Elevation Profile
- Tees
- Bends
- Valves
- Spans

Piggability

Line Pipe Grade

Class Location Definition §192.5

The *class location unit* is an onshore area that extends 220 yards on either side of the centerline of any continuous 1-mile length of pipeline.

- The class location is determined by the buildings in the *class location unit*. For the purposes of this section, each separate dwelling unit in a multiple dwelling building is counted as a separate building intended for human occupancy.

Piggability

- A *Class 1* = 10 or less buildings intended for human occupancy or an offshore area.
- A *Class 2* = Greater than 10 but less than 46 buildings intended for human occupancy.
- A *Class 3* = 46 or more buildings intended for human occupancy; or

Piggability

- *Class 3* - where the pipeline lies within 100 yards of either a building or a small,

Well-defined Outside Area

- Playground
- Recreation Area
- Outdoor Theater

Occupied by 20 or more persons on at least 5 days a week for 10 weeks in any 12-month period

Piggability

- *Class 4* - where buildings with four or more stories above ground are prevalent.

§192.105 - Design of Steel Pipe

$$P = (2St/D)(F)(E)(T)$$

P = Design Pressure

S = Yield Strength

D = Outside Diameter

t = Wall Thickness

F = Design factor - §192.111

E = Longitudinal joint factor - §192.113

T = Temperature de-rating factor - §192.115

$$P = \frac{2St}{D} (F)$$

Class location	Design factor (F)
1	.72
2	.60
3	.50
4	.40

§192.111

Type of Welds (Connections)

- Acetylene welding was first used around 1911 to join pipe segments together (girth welding) and just prior to 1920, arc welding was introduced.
- Chills Rings are sometimes called backup rings or spacers. These rings are machined pieces of metal that conform to the dimensions of the joint design used. Bell-to-bell joints that were welded together with the use of a chill ring.

Type of Welds (Connections)

Chill Rings



Type of Welds (Connections)

Dresser Coupling



Types of Welds (Connection)

Dresser Coupling Pumpkin Repair Sleeve



Types of Welds (Connection)

Zap-Lok Connections



Piggability

Length

- The distance between two pig traps is a variable and must be determined for each specific pipeline.
- Some considerations:
 - Wear on the Pigs
 - Pipeline Product
- The following pipeline lengths are not uncommon;
- Natural Gas pipelines 50-100 miles between traps
- Refined Products Pipelines 100-150 miles between traps
- Crude Oil Pipelines 150-200 miles between traps

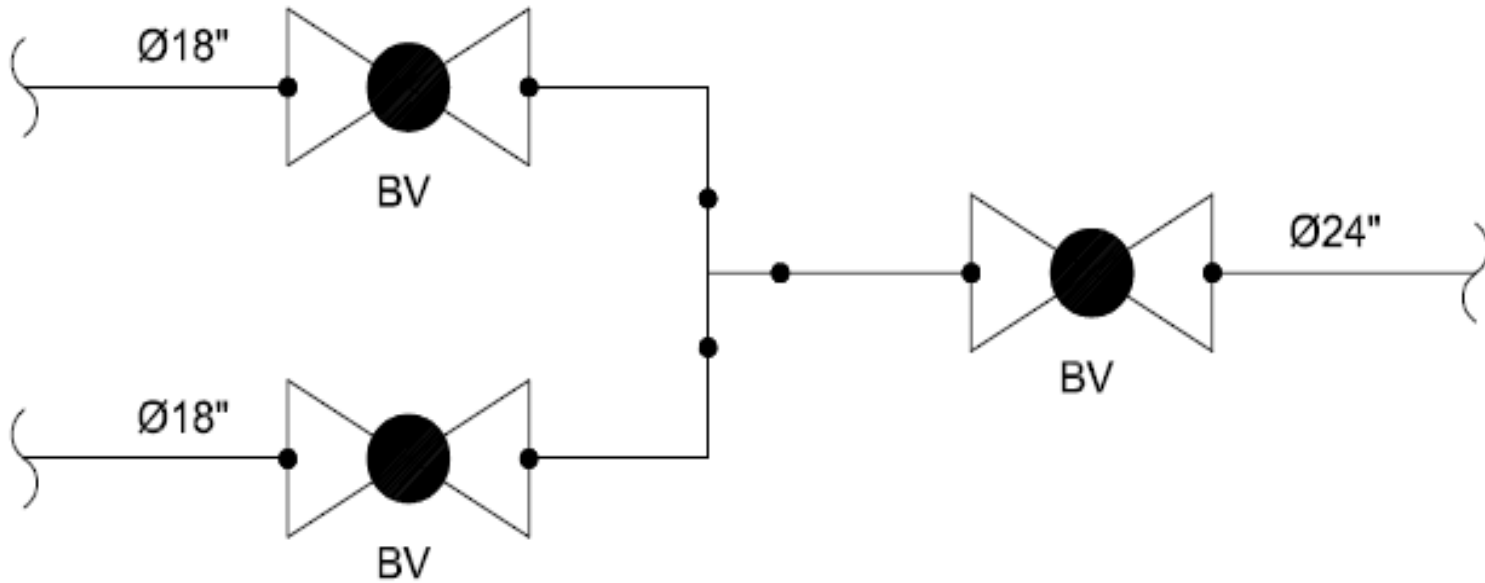
Piggability

Dual Diameter Pipelines

- Pipelines that have been designed to accept input along their length may need to increase in diameter as the through-put increases. Instead of having traps installed at each change in pipe size reducers are used. Concentric reducers should be used for changes in diameter within a pipeline so that the center line of the pig can remain on the same plane as it makes the transition from one size to another.

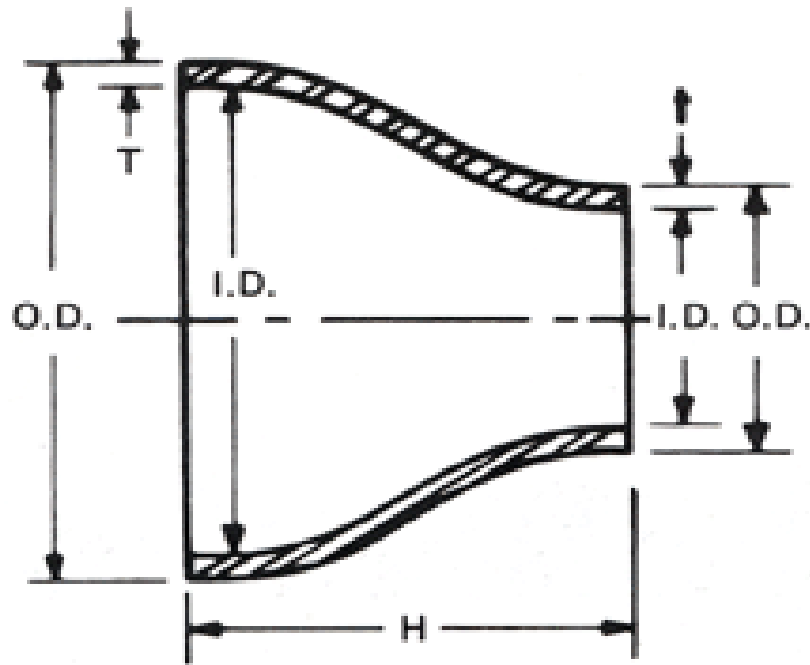
Piggability

Dual Diameter Pipelines

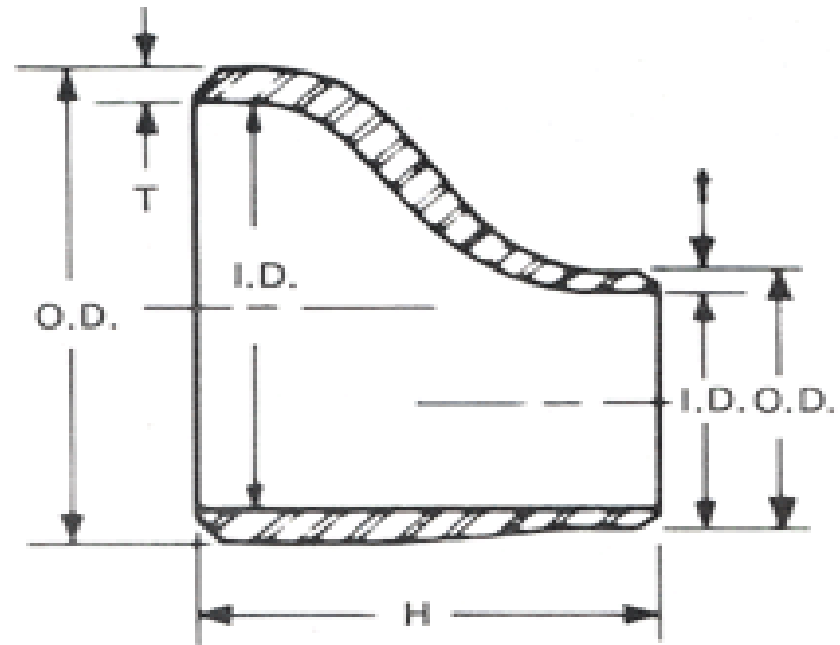


Piggability

Reducers – Typical Applications



Concentric - used in line



Eccentric - used in Traps

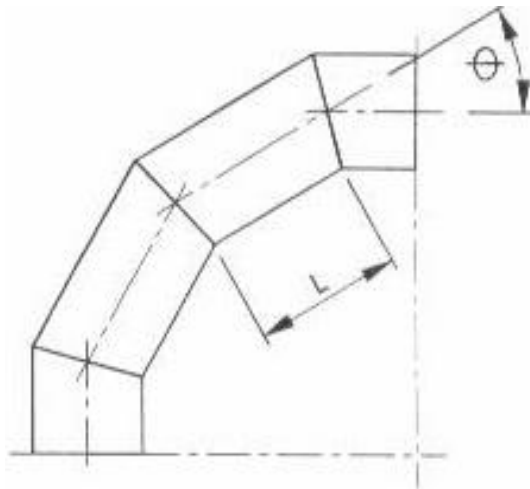
Piggability

Linings

- Pipelines are lined to help protect the inside of the pipe from the effects of the product and to create less flow resistance. Natural gas pipelines are usually internally coated with an epoxy fusion bonded coating applied under controlled conditions at the factory or a special field site. Wire brush pigs should not be used on pipelines that have been internally coated. A combination of Urethane blades, discs and cups should be used for maintenance pigging.

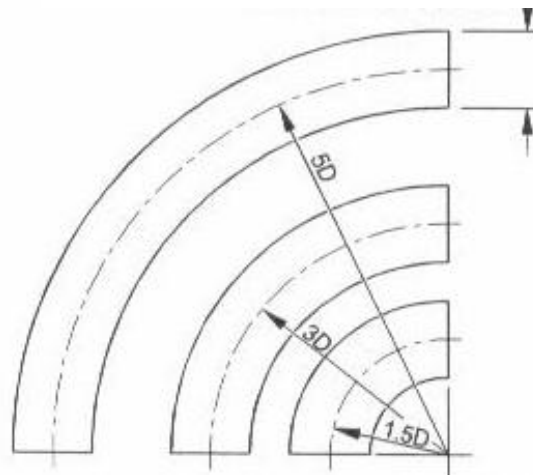
Piggability

Bends



Typical Miter Bend

Miter Bends are very uncommon in the gas industry and are located as a result of In Line Inspection



Dimensions of common factory bends

Examples of common Factory Bends w/ 5D, 3D and 1.5D Radius



Greater than 5D Factory Bends and/or Field Bends can be produced w/ a little advanced planning

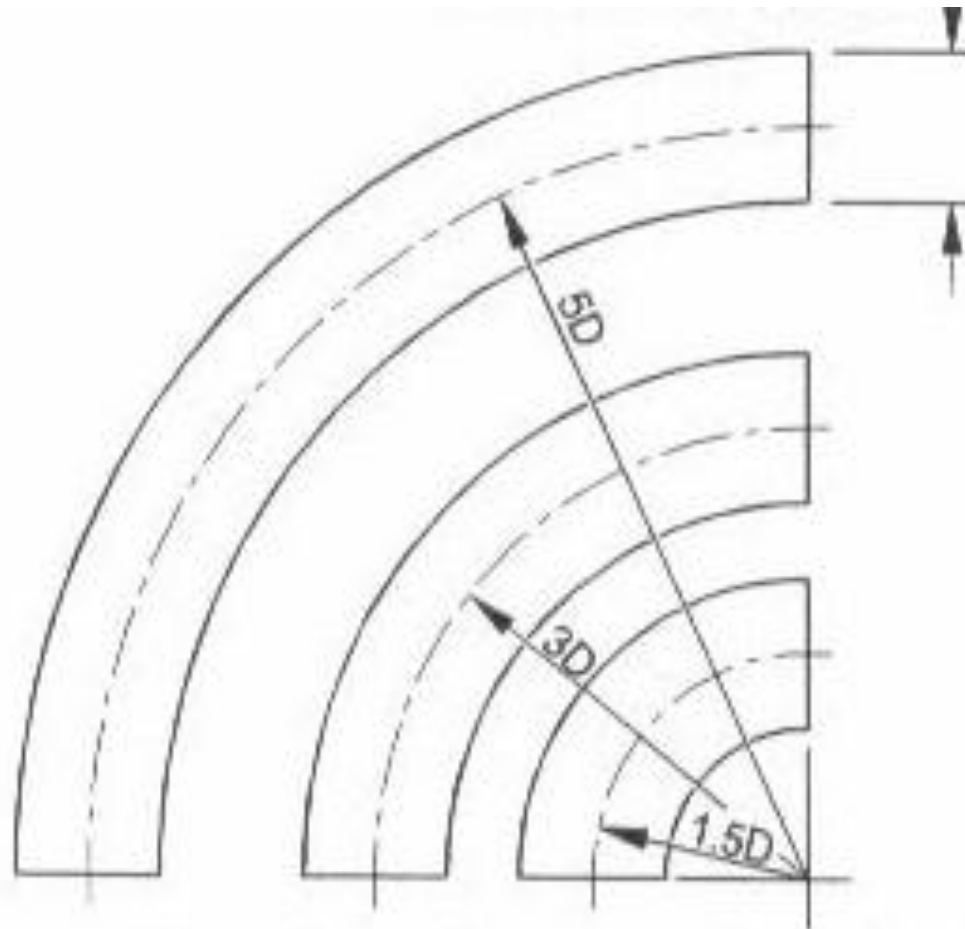
Piggability

Forged Bends

- Bends with a relatively short radius must be factory made and are usually forged to a number of different standard radii. The radius of a bend is measured to its center line. Short radius (one D) bends should not be used in pipelines if you intend to pig the pipeline.

Piggability

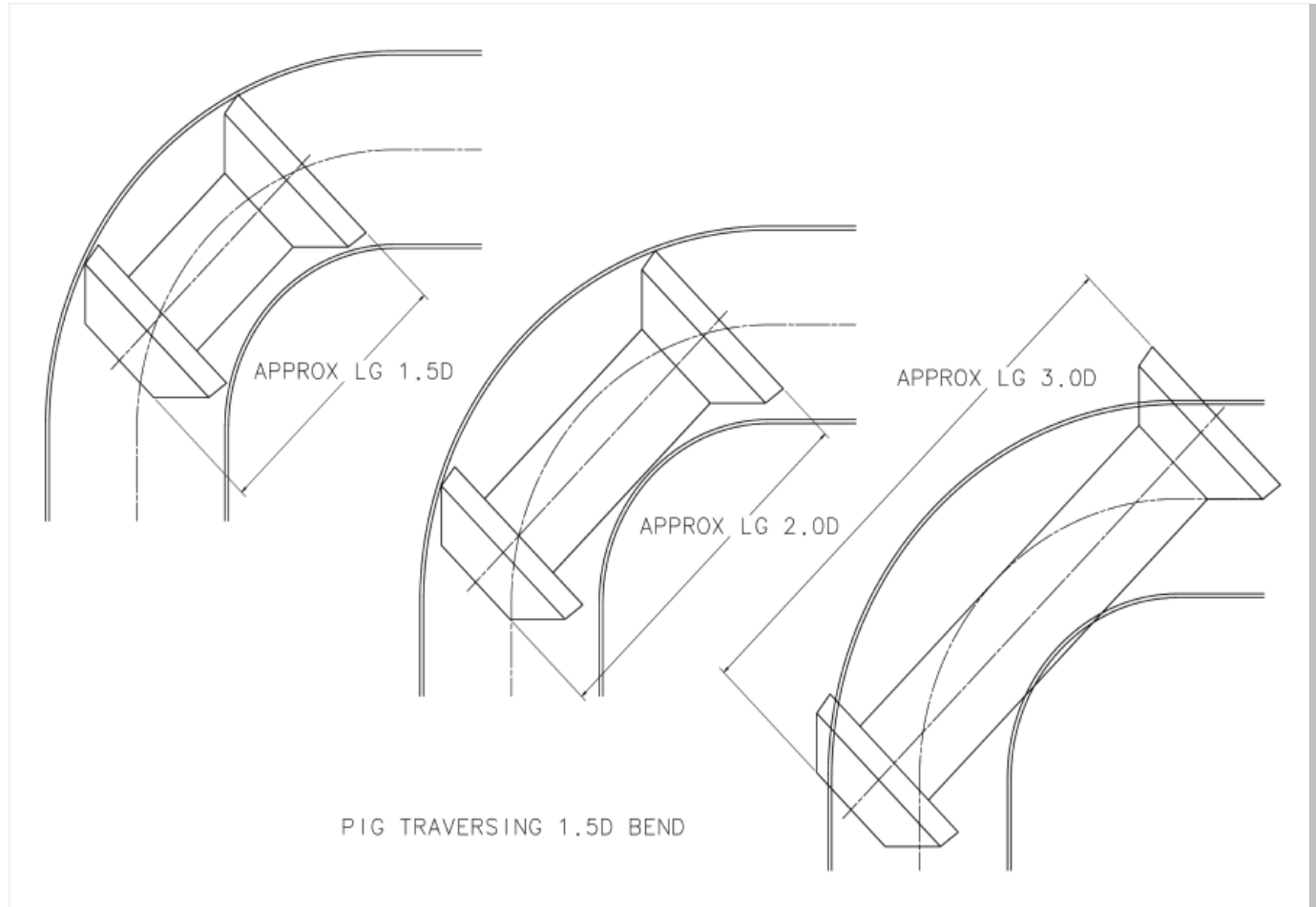
Bends



Dimensions of common factory bends

Piggability

Bends



Piggability

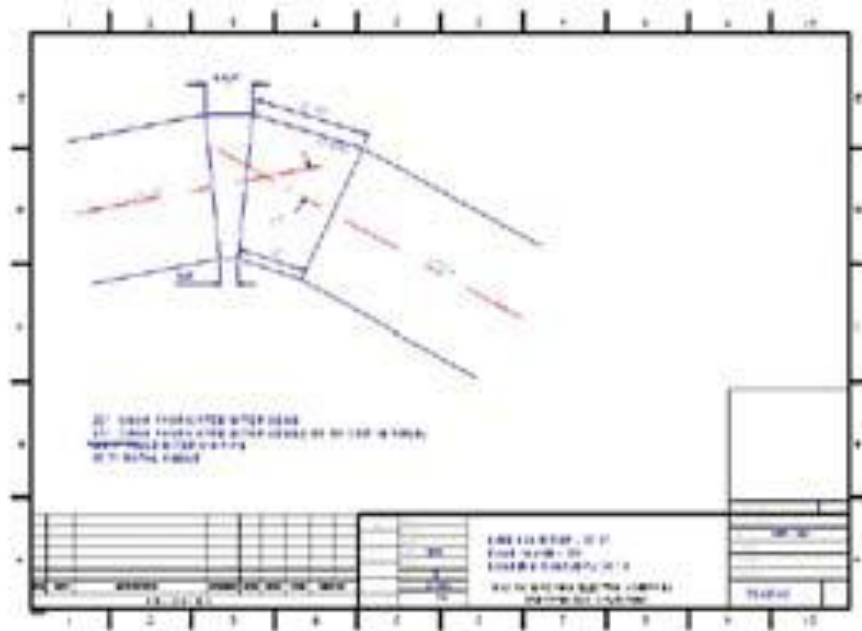
Field Bends

- Field bends are often referred to as “cold bends” and when they are being formed it is important not to exceed the allowable yield stress of the pipe material. Field bends are normally $5 D$ and larger. Field bends should be of a uniform radius and not contain any flat spots or any other localized deformation. For pigging requirements any local deformation should not exceed 2 or 3% of the pipeline diameter.

Piggability

Miter Bends

Miter bends are made by cutting the end of the pipe at an angle to achieve a change in direction of the pipe. In general, miter bends should be avoided if you intend to pig the pipeline. If for some reason there is a miter bend in the line, you should contact your pig supplier and give them the dimensions of the miter bend so they can determine if your pig will pass through the miter bend.



Piggability

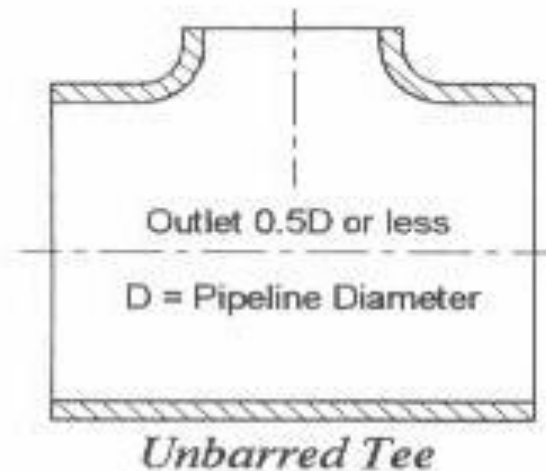
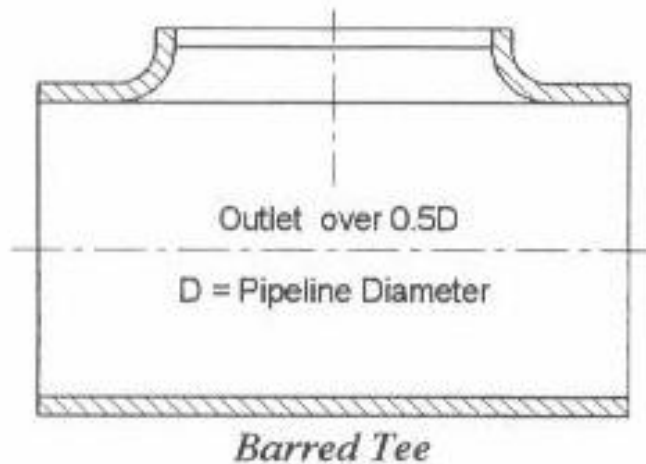
Diameter and Wall Thickness

- One of the largest cost of a pipeline is the cost of the pipe. In the process of the design engineering phase the through-put is used to determine the pipe diameter and the pipe wall thickness.
- The wall thickness may vary due to external conditions such as High Consequence Area's, Road Crossings, Railroad Crossings, etc.
- As long as the wall thickness is such that the inside pipe diameter is within the tolerances allowed by the pig manufacturer the varying wall thickness should not be a problem.

Piggability

Tees

Tees with outlets greater than 50% of the main diameter should be barred to reduce the risk of sticking pigs. This is especially true in laterals with high flow conditions



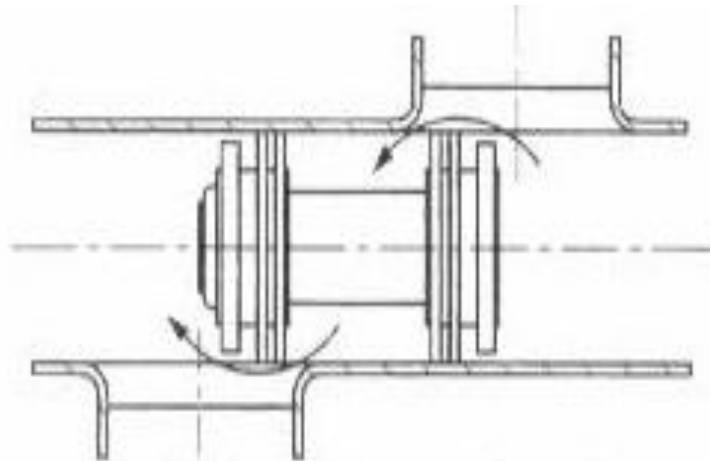
Piggability

Off-Takes

- Unbarred Tees
- Forged tees are usually used for installing off takes (outlets) in a pipeline during construction. Most conventional pigs will safely transverse tees with outlets up to 60% of the nominal line size. However it is good practice to install guide bars in all outlets above 50%.
- Off takes should not be installed adjacent to one another. At least three diameters of straight pipe should be installed between any two fittings.

Piggability

**A perfect condition for
a “stalled pig”**



Pig Stalling Between Two Tees

Pigs can typically be configured to accommodate back to back laterals by lengthening the pig to avoid modification of the laterals.

Piggability

Barred Tees

- Any off take that is more than 50% of the pipeline size should have bars installed to assist the pig past the opening without any damage.
- The bars should be installed parallel to the axis of the pipe and spaced from about 2" apart for small off takes to about 4" apart for larger sizes.

Piggability

Laterals/Tees

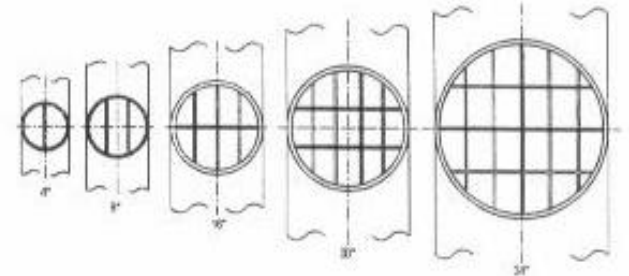
Generic Suggestions for Barred Tees:

Minimum Requirements

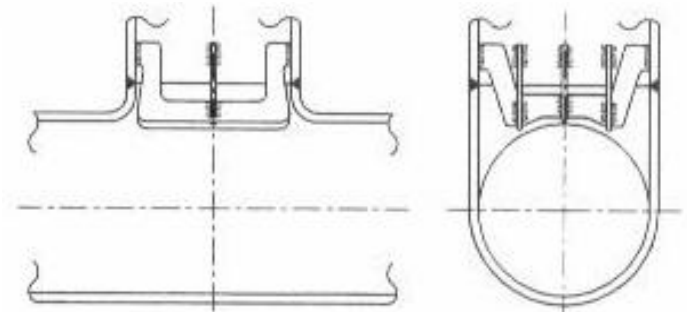
- ▶ 4" to 8" laterals – 1 single bar centered in tapped hole.
- ▶ 4" thru 10" Laterals w/ bars ¼" thick
- ▶ 10" and larger laterals – 2 bars equally separated in tapped hole.
- ▶ 12" and larger laterals bars ½" thick

Conservative Specifications

- ▶ 4" thru 10" - ¼ " bars w/ 2" spacing
- ▶ 12" and larger – ½" bars w/ 2" spacing



Typical Arrangement of Bars in Tees of Different Branch Sizes



Typical Method of Installing Bars in Tees

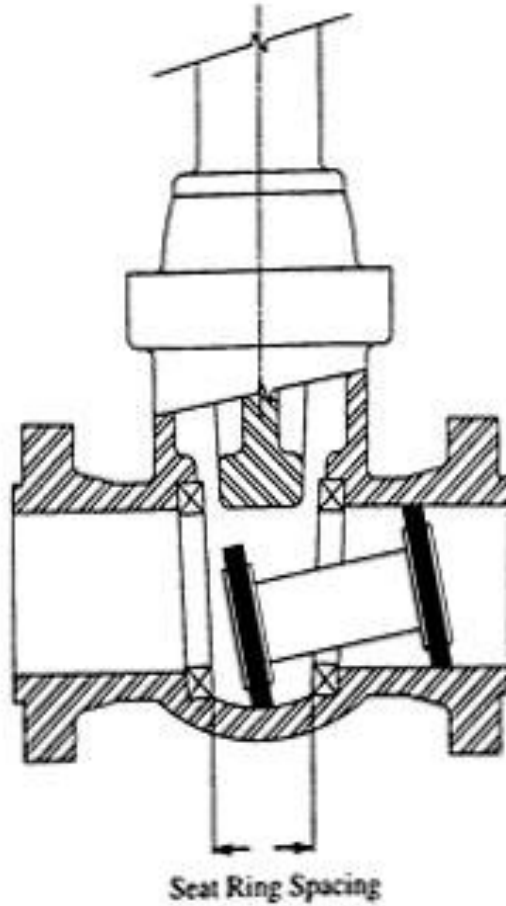
Piggability

Valves

- Valves are the biggest single cause of pigging problems. Full bore valves are more or less essential. If gate valves must be used, they should be the through conduit type so that no voids, seat rings or other features are present which might affect the smooth passage of a pig. The inlet and outlet bores must also be concentric.
- If wedge gate or parallel slide valves are installed, it is important to know the dimensions of the gap between the seat rings to be able to select the proper pig for the line.

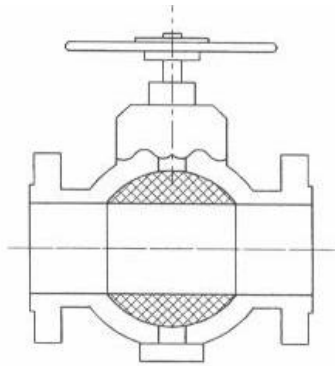
Piggability

Seat Ring Spacing



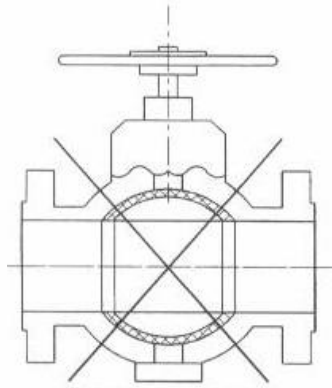
Piggability Valves

Valves can be a significant source of aggravation relative to Stuck Pigs. Appropriately designed valves should be considered when making piping systems piggable. Full bore or Pipeline ID is recommended.



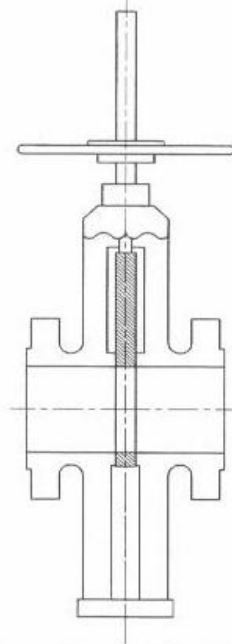
Solid Ball Valve

Solid Ball



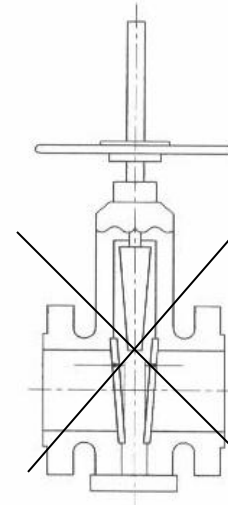
Hollow Ball Valve

Hollow Ball



Through Conduit Gate Valve

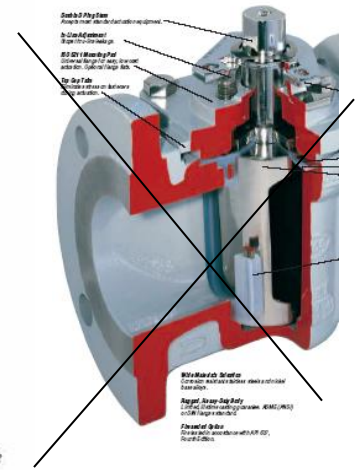
Thru-port Gate



Gate Valve

Wedge Gate (shown) or Parallel Slide

Wedge Gate



Tapered Plug

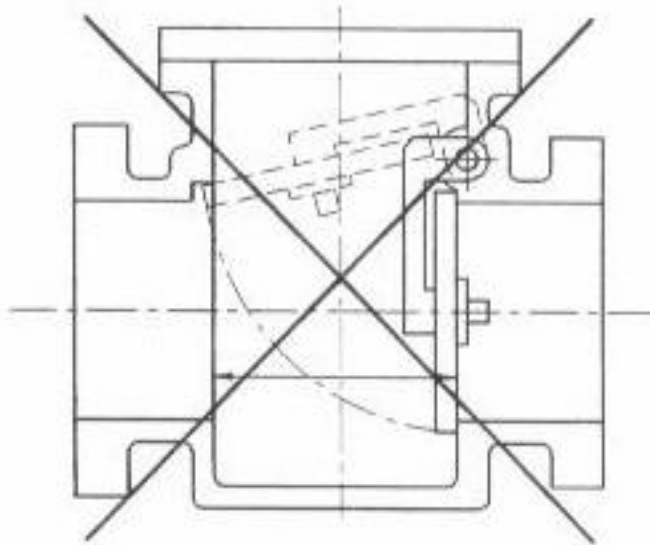
Piggability

Check Valves

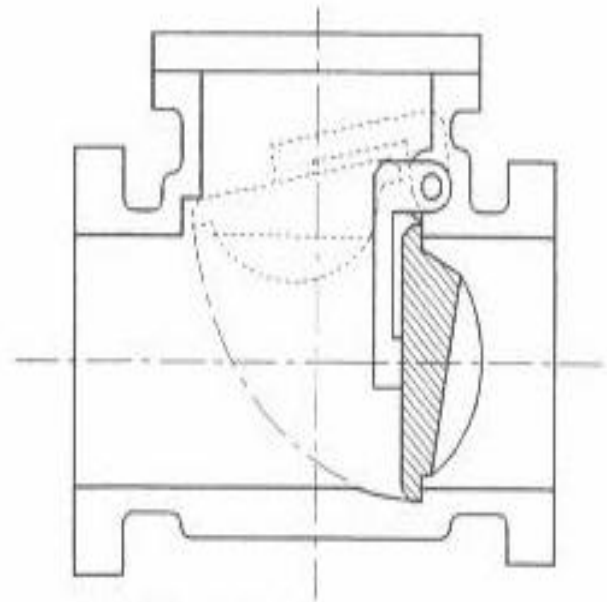
- By the nature of their design, check valves require an area in the valve body that is larger than the pipe inside diameter. This requires the cups and/or discs on the pig to be spaced far enough apart to span the oversized area in the valve body. In addition the pig must provide the force required to open the check valve fully for it to pass through.
- Spheres are not suitable for pigging lines with check valves. The sphere will drop into the oversize body and bypass. You must use the bump and run method if you are going to pig with spheres.

Piggability

Check Valves



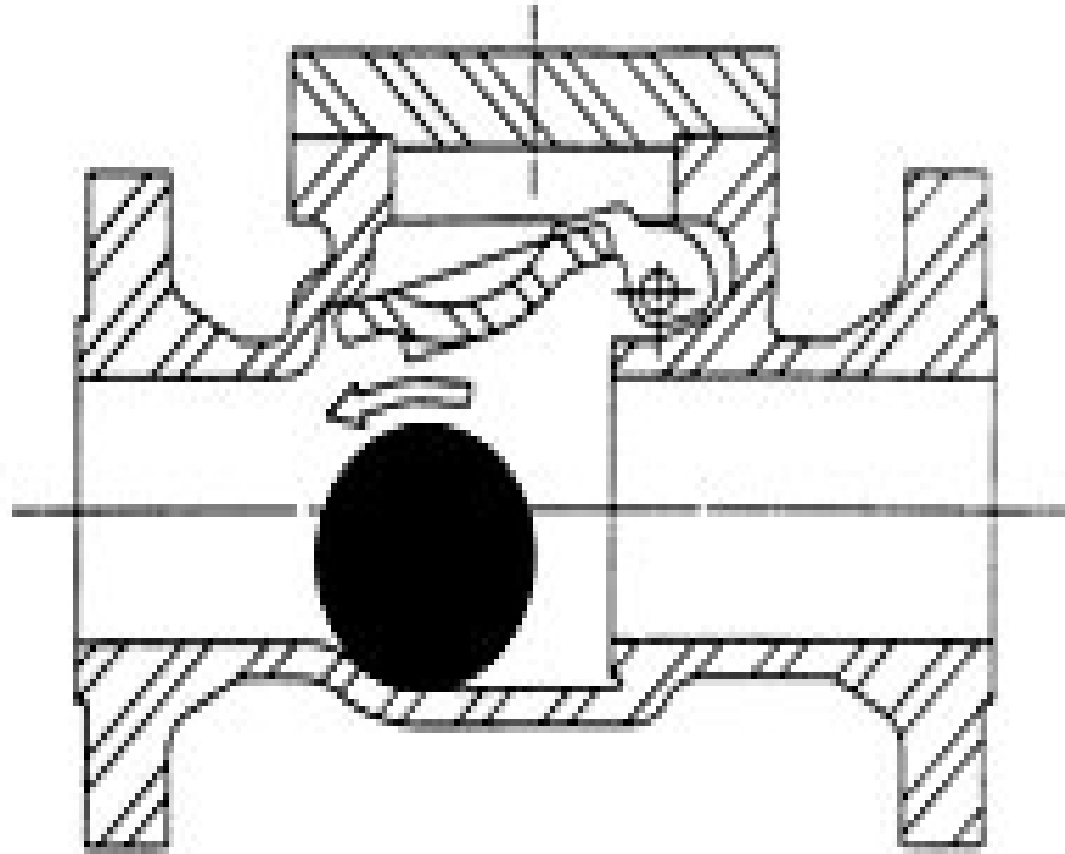
Check Valve Unsuitable for Pigging



Check Valve for Pigging

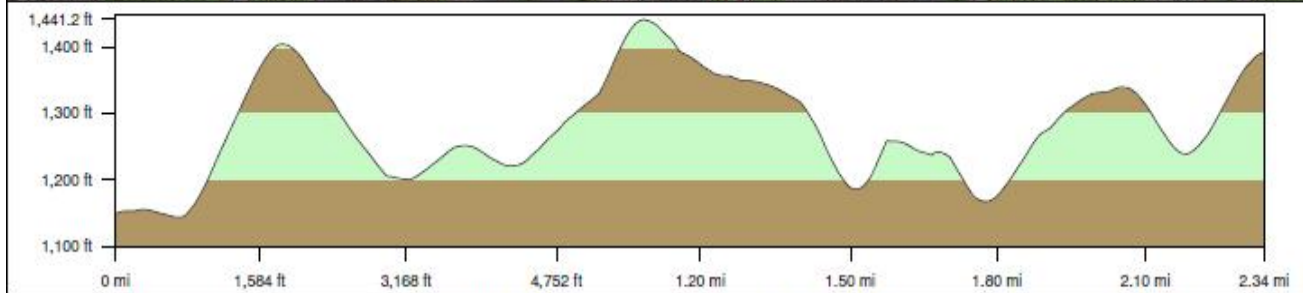
Make Piggable

Check Valves



Piggability

Elevation

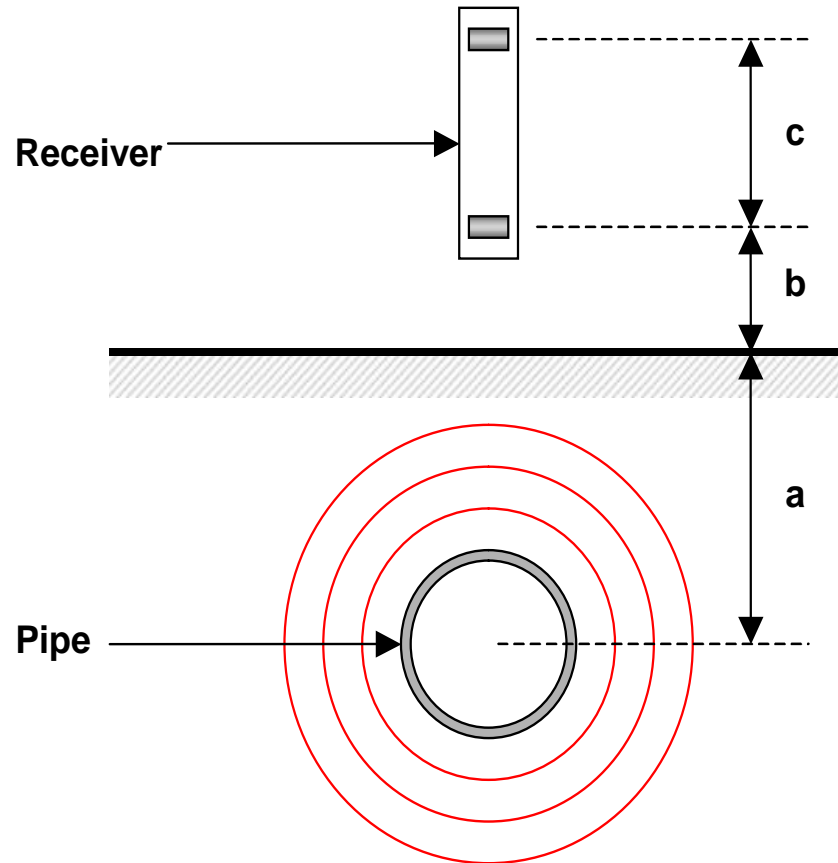


Lin Dist: 2.3 mi	Terr Dist: 2.3 mi	Elev Gain: 243.9 ft	Avg Grade: 13
Climb Elev: 942.8 ft	Desc Elev: 698.9 ft	Max. Elev: 1,441.2 ft	Min. Elev: 1,143.6 ft
Climb Dist: 1.2 mi	Desc Dist: 1.2 mi		

Piggability

Elevation

Depth of Cover (DOC)



Piggability

Spans



Piggability

Spans



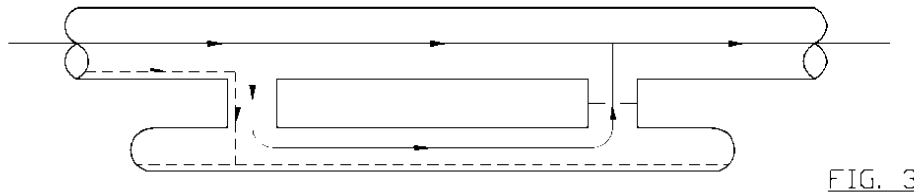
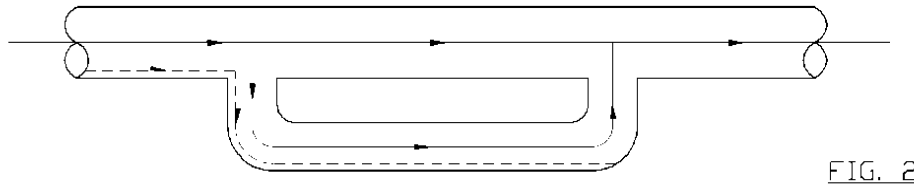
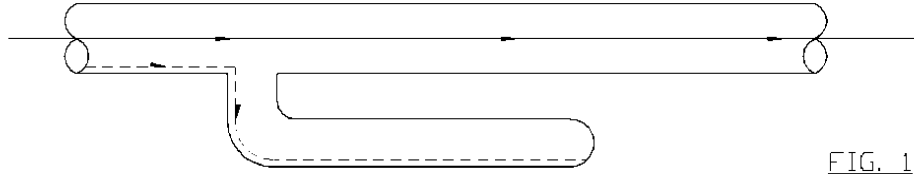
Piggability

Non-Engineered Spans



Piggability

Drips



—— GAS FLOW
- - - - LIQUID

Piggability

Drips



Piggability

Other

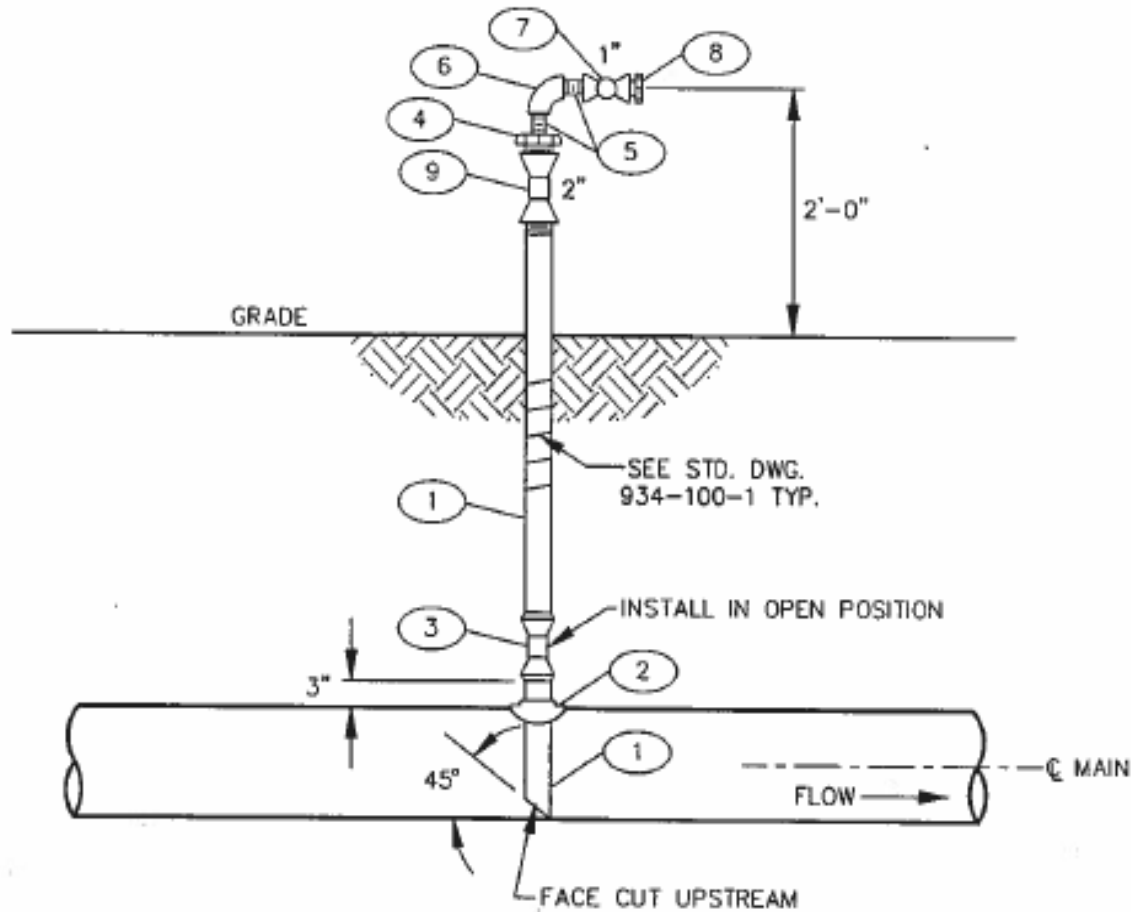
Intrusive Repairs – Pipeline Carrot



Piggability

Other

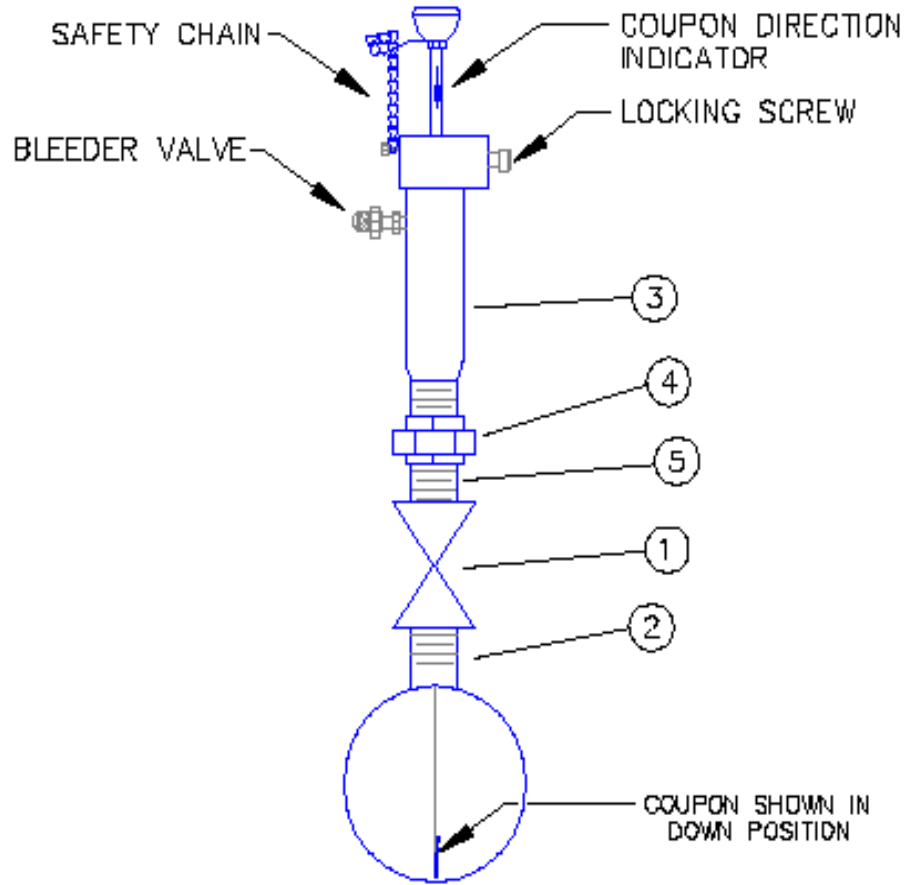
Siphons



Piggability

Other

Coupon Holders



Piggability

Operations

Product

- In the hydrocarbons field, refined products must be monitored as their composition or the additives may change, even though the same generic name is used for their description. For example gasoline has been a product in pipelines for many years and has been pigged with many types of pigs. However, more recently, special chemicals have been added to gasoline for environmental purposes and some elastomers that have been used in the past may now be unsuitable.
- Special considerations must be made for products such as ammonia.

Piggability

Operations

Pressure

- Most utility pigs are molded or fabricated from materials normally considered as solids and therefore are affected very little, if any by pressure.
- Most foam pigs are open cell and also are not affected by pressure while inflatable spheres should be full of liquid and are also unaffected.

Piggability

Operations

Pressure

- Typical Differential Pressure (DP) Required to Drive a pig:
- $DP \text{ (bars)} = \frac{K \text{ (type of pig)}}{\text{Nominal Diameter (inches)}}$

K (Types of Pigs)

- Sphere and Foam Pig = 1
- 2 Cup Pig = 4
- 4 Cup Pig = 7
- Disc Pig = 9
- Cup Brush Pig = 12
- Disc Brush Pig = 15
- UT ILI Tool = 19
- MFL ILI Tool = 24

Piggability

Operations

Pressure

- Typical Differential Pressure (DP) Required to Drive a pig:
- DP (bars) = $\frac{K \text{ (type of pig)}}{\text{Nominal Diameter (inches)}}$
- Example: 10-inch Disc Brush Pig (K factor = 15)

$$\text{DP (bars)} = \frac{15}{10\text{-inch}}$$

$$1.5 \text{ bars} \times 14.5 \text{ psi} = 21.75 \text{ DP (psi)}$$

Piggability

Operations

Flow Rate

- Most cleaning, batching and swabbing applications are run on-stream and will have to be carried out at the velocity of the product stream.
- Pigs are most effective if run at a near constant speed. When the flow rate is low the pig may run in a series of start and stop motions, and it will not be very effective under these conditions.
- Pigs will not be effective if run at too high a velocity. This is seldom a problem with on-stream pigging as the flow rates are usually quite moderate. However, during construction, flow rates cannot always be controlled and it is then difficult to achieve maximum effectiveness.

Piggability

Operations

Flow Rate

The following are considered to be typical speeds for utility pigging and are given as reference only.

<u>Application</u>	<u>Speed (Mph)</u>
New Construction	1 - 5
On-Stream Gas	2 - 8
On-Stream Liquids	1 - 8
ILI Tools	2 - 7

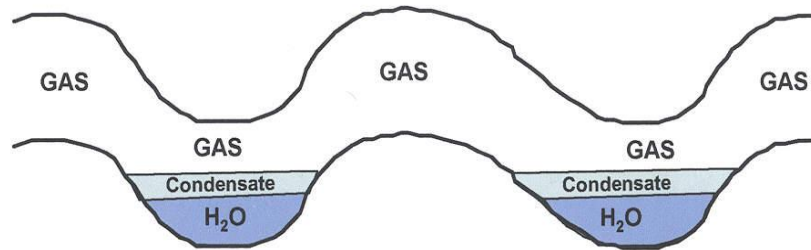
Piggability

Operations

Flow Rate

Gas velocity (Mph) is calculated with the following formula:

$$\frac{(31210) (\text{mmcf/d})}{(\text{psi})(d^2)}$$

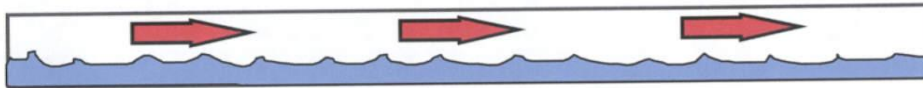


Piggability

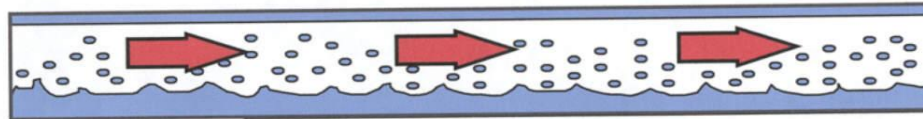
Operations

Flow Rate

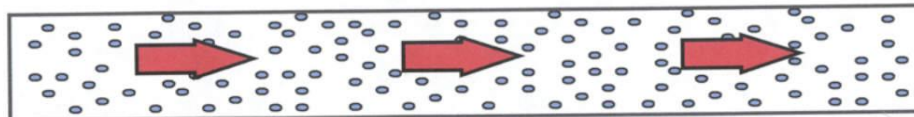
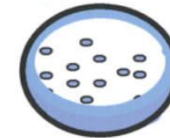
LIQUID MOVEMENT IN GAS PIPELINES



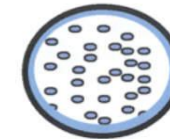
STRATIFIED FLOW
(LOW GAS VELOCITY)



ANNULAR-MIST FLOW
(INTERMEDIATE GAS VELOCITY)



MIST FLOW
(HIGH GAS VELOCITY)



Piggability

Operations

Temperature

Most pigs use polyurethane seals and the allowable temperature range for this material is generally between 32° F. and 180° F. (0° and 82° C.) Since most pipelines operate at ambient temperatures within this range, this does not normally create any problems for utility pigs.

Piggability

Operations

Contaminants

- Acid Gases
 - Hydrogen Sulfide
 - Carbon Dioxide
- Oxygen
- Bacteria
 - Sulfate Reducing Bacteria
 - Acid Producing Bacteria

Piggability

Operations

Contaminants

- Hydrogen Sulfide
 - Acute poisoning (>20 ppm)
 - Explosive (4% - 44% in air)
- Mercaptan
 - Unnecessary calls to emergency response personnel
- Carbon Dioxide
 - Asphyxiation
 - Frostbite
- Oxygen
 - Explosive in Methane

Piggability

Operations

Contaminants

- Bacteria
 - Sulfate Reducing Bacteria (SRB) - SRB's use the sulfate ion in water as a food source. Through their metabolic process, the sulfate is converted to H₂S.
 - Acid Producing Bacteria (APB) - APB's produce carboxylic acids and/or CO₂ as a by-product of their metabolic process

Piggability

Operations

Contaminants

Solids

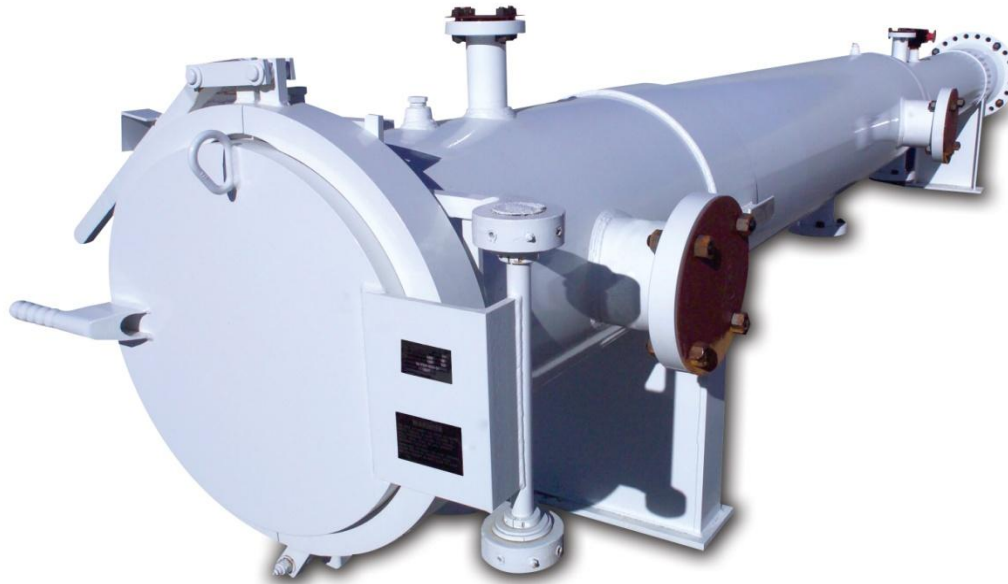
- Iron Sulfide (pyrophoric material will ignite spontaneously in air)
- Iron Carbonate
- Iron Oxide

Other

- PCBs (acute poisoning – source is typically from compressors)
- NORMS (Natural Occurring Radioactive Materials) – source is radium-226 and radium-228 are the decay products of uranium and thorium that are present in subsurface formations.

Piggability

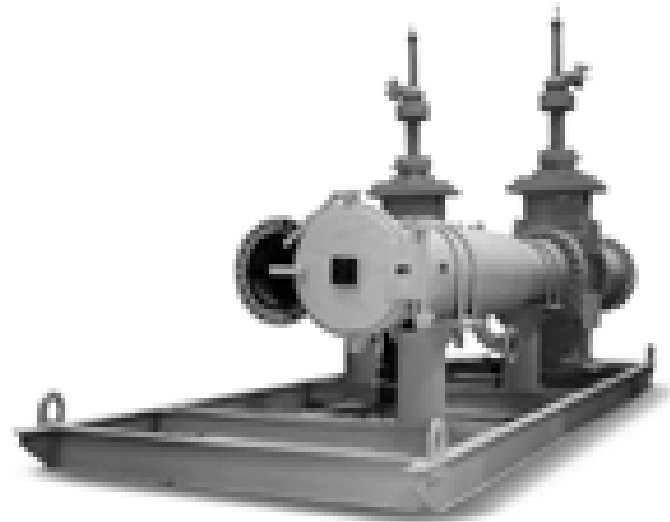
Launcher Receiver Design



Make Piggable

Purpose of Launcher & Receivers

- The primary purpose of a Pig Launcher and Receiver is to Launch and/or Receive a pipeline pig into a pipeline system without interruption of the flow.



Piggability

Launcher & Receivers

Utility Pigs

- The “rule of thumb” for the length of the launcher barrel is 1.5 times the length of the longest pig to be used.
- It is often the case that the pigs have not been selected at the time the traps are designed so an alternative “rule of thumb” for the length of the barrel, assuming single module pigs will be used, is $2.5D$.

Piggability

Launcher & Receivers

In-Line Inspection Tools

- Many In-Line Inspection, or “ILI” tools, are typically constructed of several modules joined together. When these and similar “extra-long” ILI tools are to be used, the launcher barrel should be at least 1D longer than the overall length of the longest pig. Except for the length, all other dimensions will be the same as for utility pigs.

Piggability

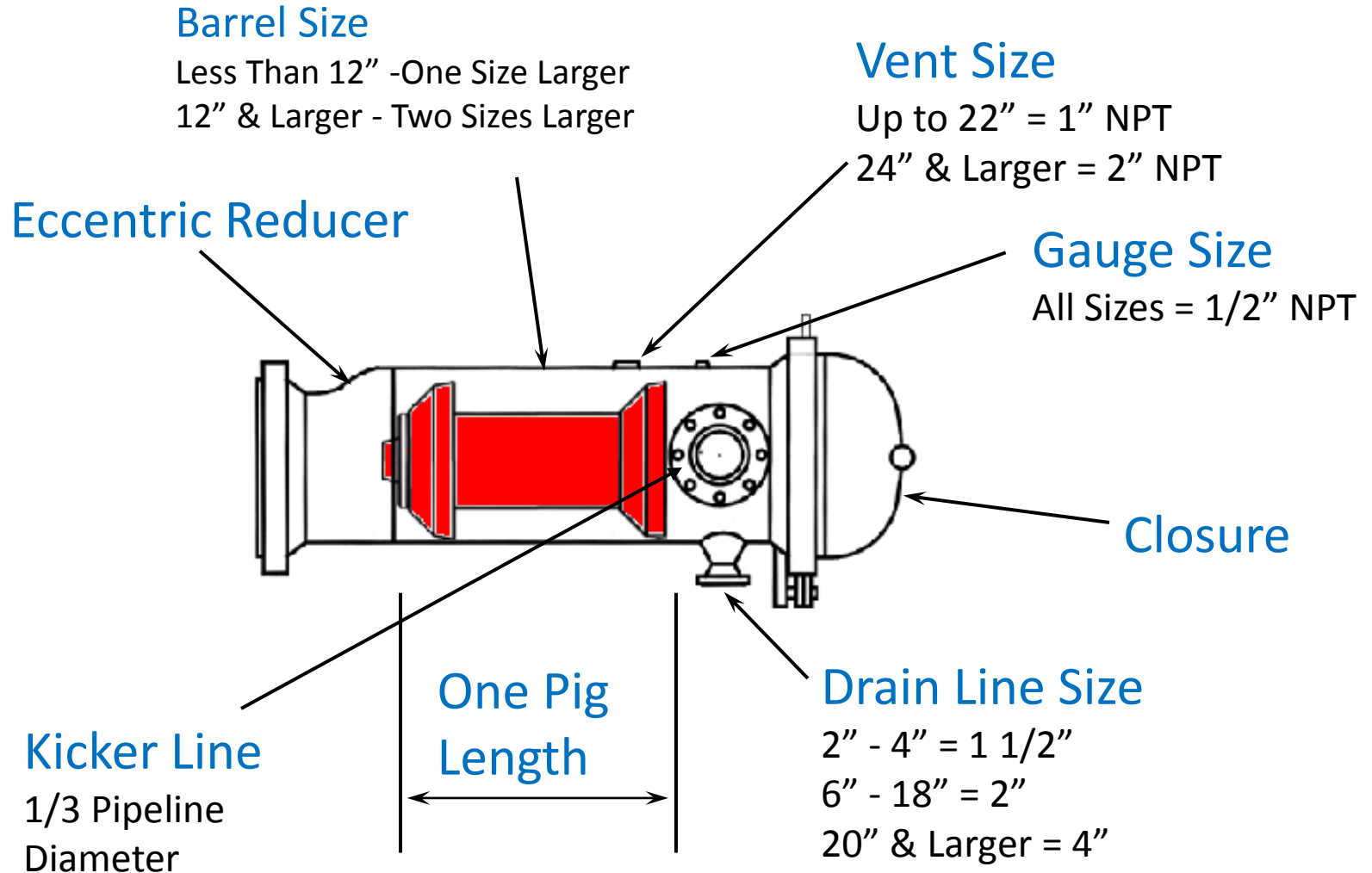
Launcher & Receivers

Spheres

- Spheres have a single line of seal and therefore, must be treated differently than pigs that will have at least two and often four or more seals per pig. Since spheres are the same dimension in all directions, they are not self-guiding and will try to follow the flow within the pipeline even through smaller pipe sizes.

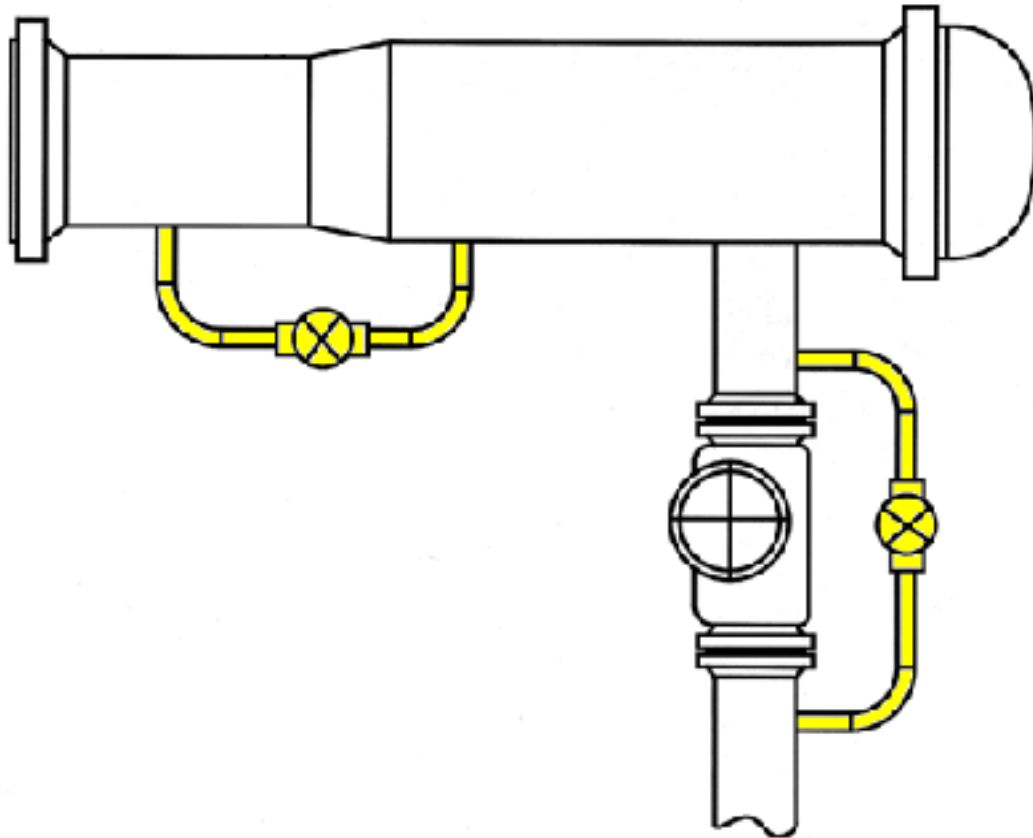
Launcher: Rule-of-Thumb

Nozzle Sizing



Performance Enhancing Features

Launcher With Equalization Lines



Receiver: Rule-of-Thumb

Nozzle Sizing

Vent Size

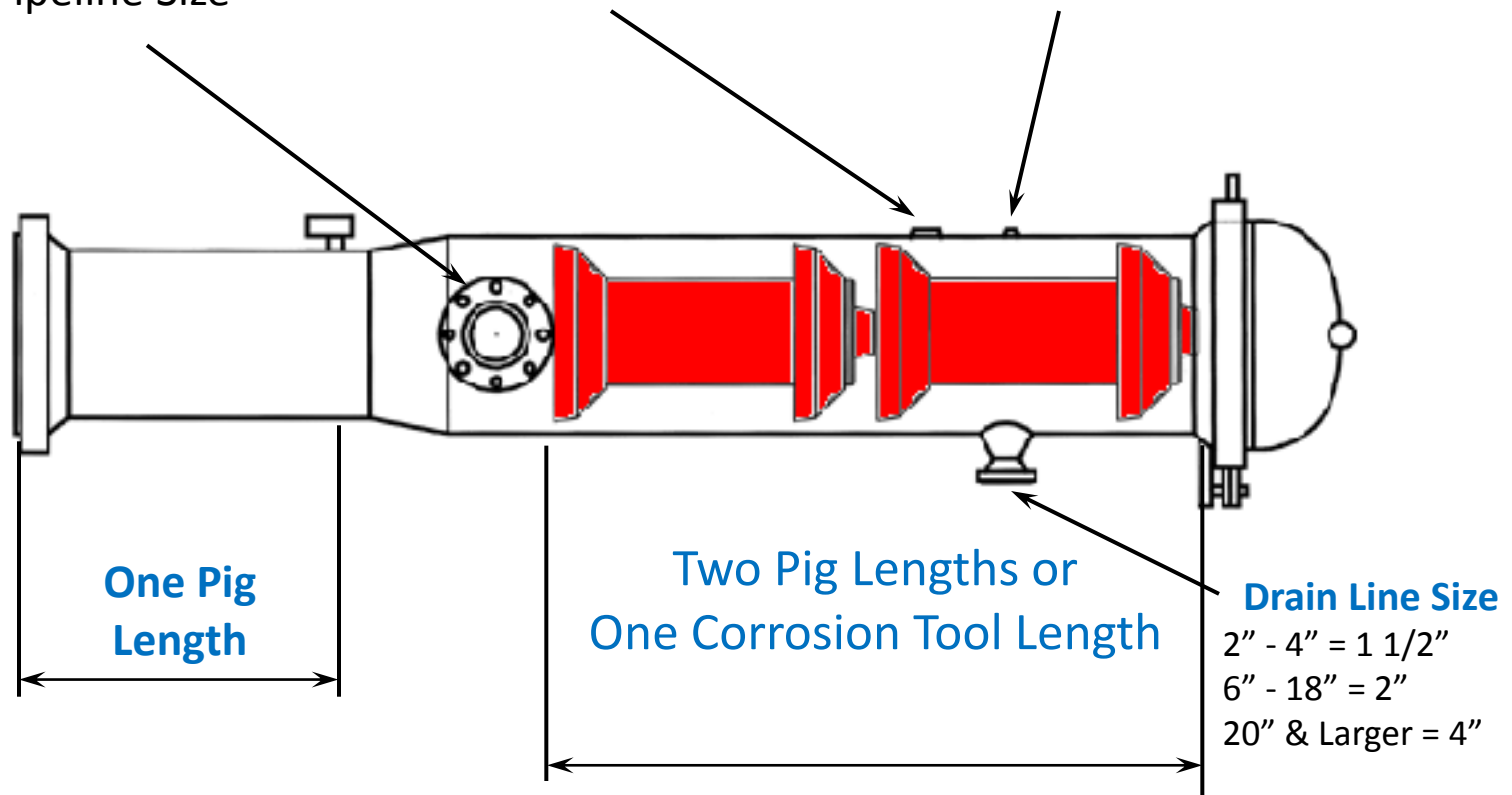
Up to 22" = 1" NPT
24" & Larger = 2" NPT

Gauge Size

All Sizes = 1/2" NPT

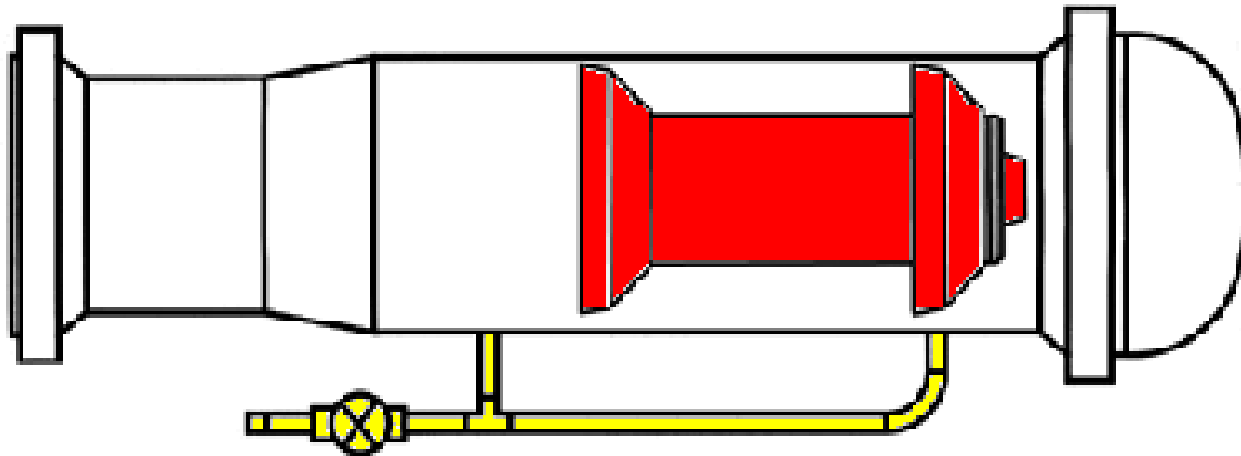
By-Pass Line

1/3 Pipeline Size



Performance Enhancing Features

Receiver With Drain Lines



Closures

- Closures are used for scraper traps, filters, strainers, scrubbers, blow-downs, meter provers, storage tanks, terminal manifolds, test chambers and other types of vessels and piping.



Design Codes

- Pig launching and receiving systems should be designed according to the following design codes:
 - ASME B31.4 – Liquid Pipelines
 - ASME B31.8 – Gas Pipelines
 - ASME B31.3 – Process Piping
 - ASME Section VIII
 - Other

Launcher & Receiver Types

Pigging Systems



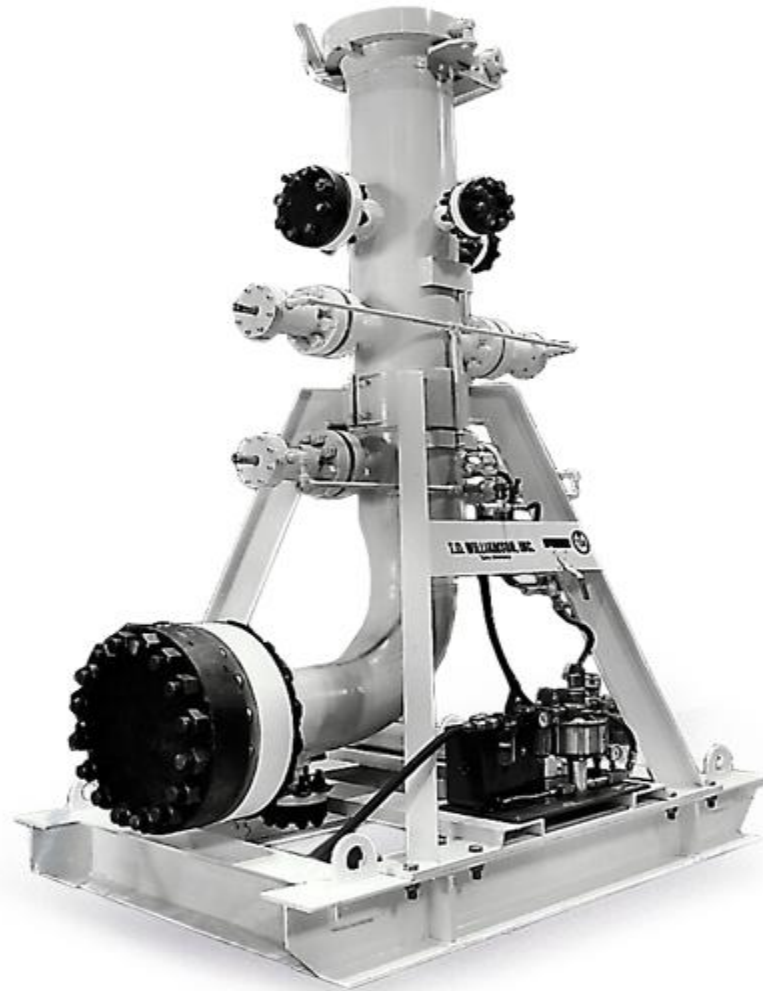
Launcher & Receiver Types

Automated Sphere Launching Systems



Launcher & Receiver Types:

Vertical Automated Systems



Launcher & Receiver Types:

Sloped Automated System



Launcher & Receiver Types

Automated Batch System



Launcher & Receiver Types

Temporary Launcher & Receivers

Temporary launchers are sometimes used for the following purposes:

- Clean Short Pipeline Segments such as HCAs
- Perform Hydrostatic Pressure Tests
- Decommissioning of Pipeline from Service
- Economic Purposes – Rent instead of Purchase
- Specialty Pigging Operations such as Blow Through Cleaning and Inspection
- Proving Pigging Operations
- New Construction Cleaning & Inspections
- Off-line Pigging Operations

Launcher & Receiver Types:

Specialty Pigging - Tethering



Pig Handling Equipment

- These trays are equipped with a push-pull mechanism to either push the pig into the launcher barrel or pull the pig from the receiver barrel.
- They allow for ease of handling of the pigs.



Pig Receiving



Pigging

- Why Pig a Pipeline
- Pipeline Pigs
 - Pigging during Pipeline Construction
 - Pigging during Operation
 - Cleaning
 - Batching
 - Displacement
 - Inspection

Pigging During Construction

During pipeline construction it is not uncommon that a certain amount of debris will find its way into the pipeline. This debris must be removed prior to commissioning the pipeline and it is normally removed by pigs that the contractor will run after construction with compressed air.

Pigging During Construction



Pigging During Construction

Once the debris is removed from the pipeline it is not uncommon to run the following tools;

- Gauging Pig
- Kaliper Tool
- Deformation Tool

These tools are run to determine if there are any abnormalities in the pipeline such as reductions and out of round conditions.

Pigging During Construction

Gauging Pig



Pigging During Construction

Kaliper Pig



Pigging During Construction

Detectable Pipe Features



Conventional
Kaliper

- Bends
- Valves
- Wall thickness changes
- Tees
- Taps
- Girth Welds
- Dents
- Ovalities
- Other
- Misalignments
- Mitre Bends
- Wrinkles/Buckles



Pigging During Construction

Types of Geometry Pigs

- Mechanical:

- Movement is detected in mechanical “arms” oriented at the rear cup as tool traverses the pipeline



Hi – Resolution Deformation

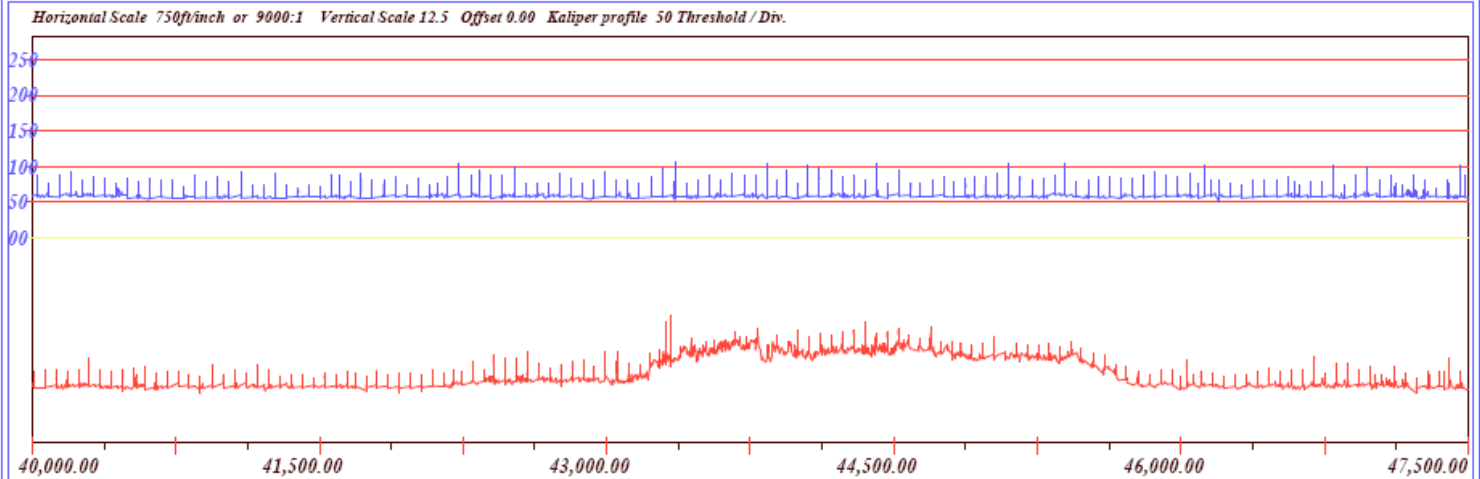
- Electronic Clock Kaliper



Pigging During Construction

Kaliper Pig

There are no significant indications throughout this section of the survey



Engineer - Bob Leishman

Pigging During Construction

Deformation Tool



Pigging During Construction

Cleaning

Providing the pipeline is free of any major abnormalities the contractor will then use some aggressive wire brush pigs to remove any rust, scale, weld slag, etc., to clean the line prior to hydrostatic pressure testing.

Vantage V DCDC-BR

Ideal for removing hard deposits:

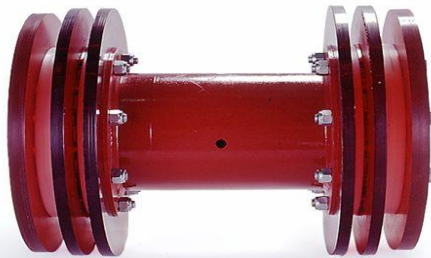
- (Rust)
- (Scale)
- (Hard Wax)



Pigging for Hydrostatic Testing

Displacement of Air

During the hydrostatic testing process batching pigs are used to displace the air from the pipeline during the fill-water process. The batching pig is placed into the pipeline first and then moved through the pipeline by the fill-water process to displace any air in the pipeline.



Pigging for Hydrostatic Testing

Drying

Once the pipeline has been hydro-tested the contractor will dewater the pipeline using a series of pigs pushed through the pipeline with dry compressed air. After the water has been displaced the pipeline normally needs to be dried. This is accomplished by blowing dry air or nitrogen through the pipeline in conjunction with running numerous foam pigs.



Pigging for Hydrostatic Testing

Commissioning

When the pipeline is dried to specification, the next step in the process is to commission the pipeline. The commissioning process is almost always accompanied by the utilization of pipeline pigs, which are usually pushed through the pipeline with its product.



Operational Pigging

Essentially there are four main reasons why a pipeline needs to be pigged during operation;

- Cleaning
- Batching
- Displacement
- Inspection

Operational Pigging

Cleaning

Cleaning a pipeline during operation is considered to be a maintenance procedure that needs to be done on a regular predetermined frequency using pigs adequately designed for the proper cleaning application. The pigging operation will almost always increase the flow efficiency and reduce operating costs.

Operational Pigging

Cleaning

In pipelines that have low flow conditions it is more prevalent to see an increase in the collection of free water in the bottom of the pipeline, even in crude oil lines. In low flow conditions you need a mechanical means (pigs) to remove both the solids and liquids that collect in the bottom of the pipeline to help prevent the process of internal corrosion.

Operational Pigging

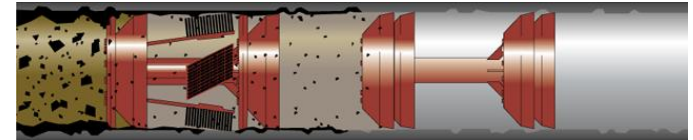
Cleaning

After a pipeline has been in service for a period of time, 100% efficiency cannot reasonably be expected. However, routine pigging can keep a pipeline operating at 90 to 95 percent capacity. It is not uncommon to increase the flow rate of a pipeline by 3% with a single cleaning pig run. The cleaner the pipeline is, the more effective the throughput. Higher effective throughput means lower transportation costs for the pipeline company.

Operational Pigging

Online

- Mechanical or Fluid Enhanced Gas/Liquid Separators
 - Design pressure 1440 PSIG, ASME Class 600.
 - Nominal Capacity 400 MMSCF/D
 - Site glasses and liquid level controllers.
 - 140 BBL/M liquid dump rate.
 - 3" Relief valve & 4" rupture disc pressure protection.
 - Specifically designed for On-stream pipeline cleaning of gas lines.



Operational Pigging

Off-line

- Mechanical or Fluid Enhanced
- Media to propel pigs
 - Water
 - Air
 - Nitrogen
 - Wire-line Equipment
- Determine velocity to propel pig at appropriate speed
- Determine differential pressure
- Determine quantity of propellant

Operational Pigging

Magnetic Cleaning Pig for Ferrous Materials

- Debris such as welding rods, bolts, tools, etc., is very difficult to remove with conventional pigs as the pigs typically push these objects for some distance and then ride over them.
- The removal of this type of debris is a must before attempting to run Corrosion Inspection Pigs.



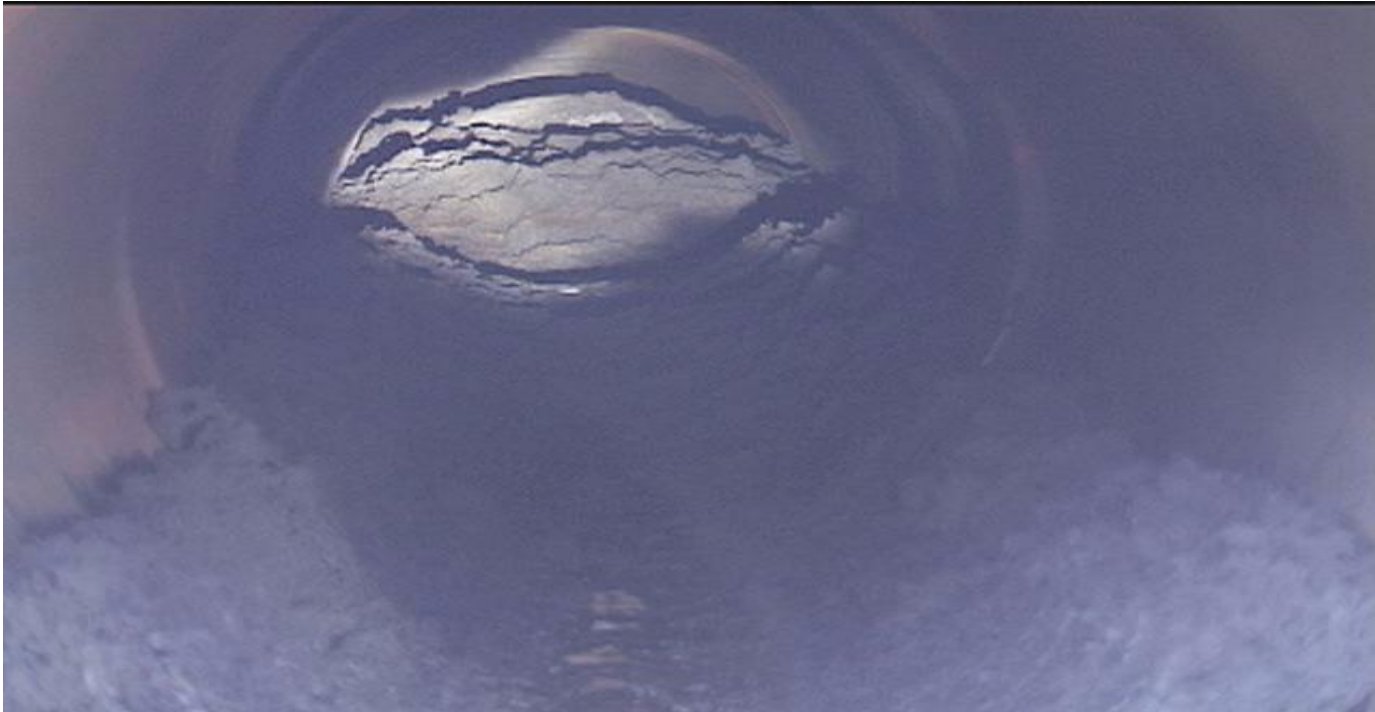
Operational Pigging

Dummy Tools (w/gauging plate)



Operational Pigging

Black Powder



Typical results of using mechanical brush cleaning pigs for removal of black powder.

Operational Pigging

Black Powder



Effective results of using cleaning fluids and brush pigs with RealSeal Cups.

Operational Pigging

Benefits of Cleaning

- Increases Throughput/Efficiency
- Prepares Pipeline for In-Line Inspection
 - Prevents Tool Damage
 - Allows the Collection of Critical Data
 - Reduces Project Cost
- Removes corrosive materials from pipeline
 - Oxygen
 - Carbon Dioxide
 - Salts, Acids, Water
 - Rust & Scale
 - Hydrogen Sulfide
 - Black Powder
 - Miscellaneous

Operational Pigging

Advantages of Cleaning w/Detergent

Chemically enhanced line cleaning produces:

- Project total time lengths are compressed
(results in cost saving in most cases)
- Solids in suspension move through the line easier
- Dry Iron Oxides are flammable in contact with O₂

Operational Pigging

Batching

Batching is the process of moving different products through the same pipeline. It is much more economical to move several products in one pipeline than to lay dedicated pipelines for each product. Batching pigs are used to separate the products and are normally made up of either two or four cups. Cups are flexible and provide a better seal than discs for product separation.

Operational Pigging

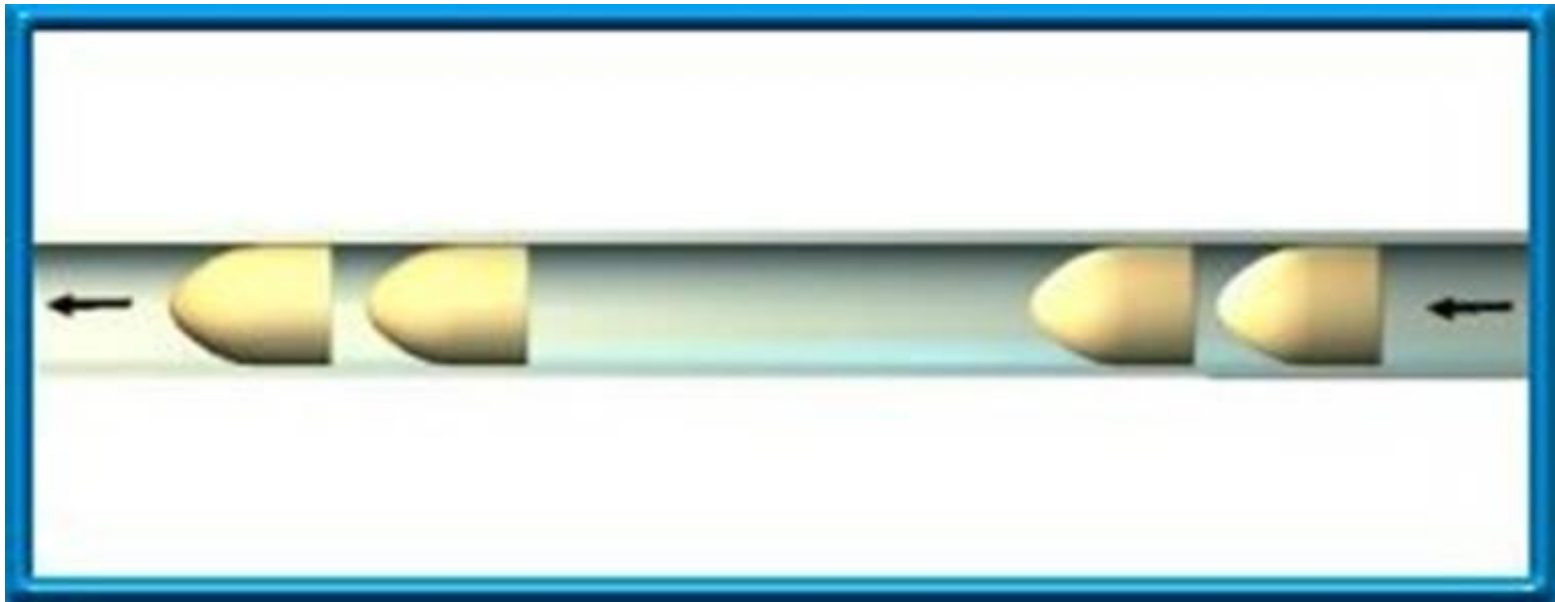
Batching with Inhibitors

- The pipeline must be clean for the inhibitor to be effective.
- The inhibitor must contact the pipe to be effective.
- The inhibitor application must be effective.
- The quantity of inhibitor must be calculated for 100% coverage.

Operational Pigging

Batching with Inhibitors

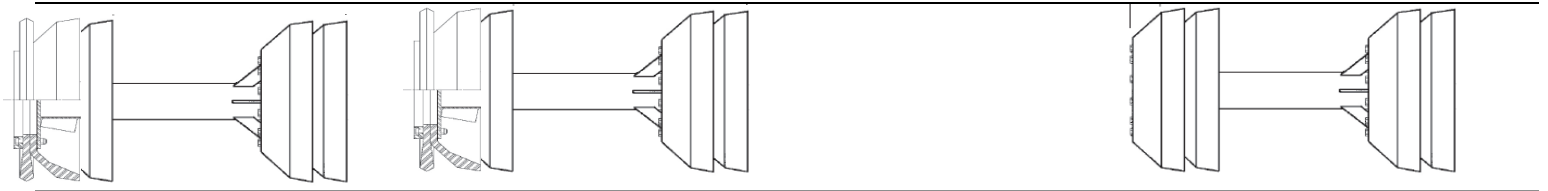
Introducing a column of liquid between pigs for the purposes of applying Inhibitor, biocides or internal coatings can be an effective method to apply these materials.



Operational Pigging

Batching with Inhibitors

- Best configuration to hold the chemical batch together.
- Two batching pigs in front and one batching pig in the rear.



Operational Pigging

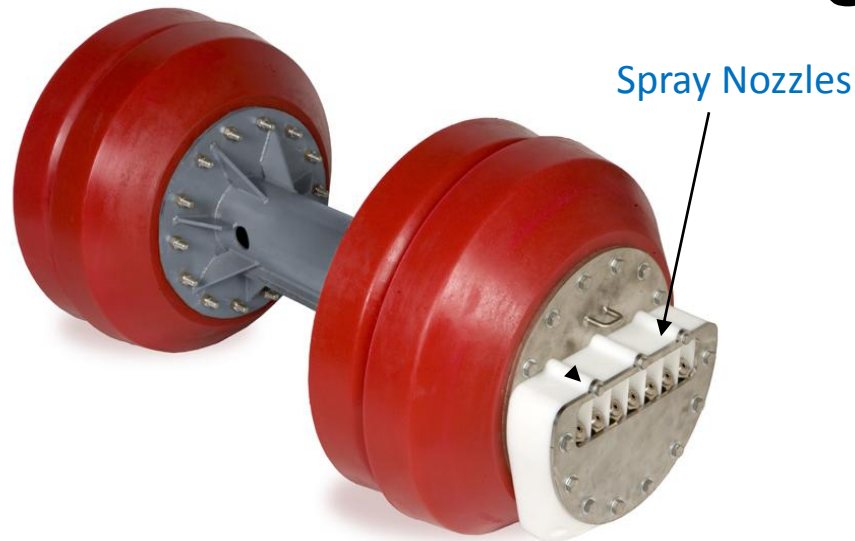
Inhibitor Application with V-Jet Pig



Operational Pigging

Inhibitor Application with V-Jet Pig

V-Jet® Pig

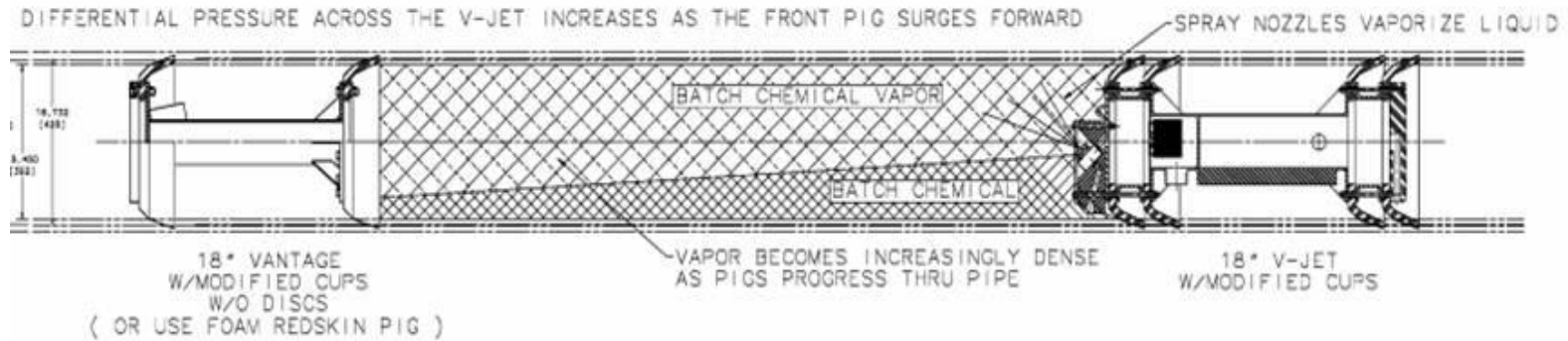


Inhibitor Application Pig

- The spray head applies corrosion inhibitor fluid to the top quadrant of the pipeline.
- The V-Jet is designed to act as its own reservoir in the event that it should pass a section of pipe that would be void of corrosion inhibitor.
- The V-Jet pig can be used as the front and/or rear pig in a batching process.
- Excellent de-watering pig.

Operational Pigging

Inhibitor Application with V-Jet Pig



- Inhibitor **batching** may also be made by introducing a “slug” of inhibitor solution.
- With the spray pig **at the front** of the slug (with a batching or foam pig at the back).
- Or with the spray pig **at the back** (w/ a batching or foam pig at the front of the slug).
- It has been found that the spray pig is **more effective at the back** – allowing gas flow through **to energize the spray**.
- Alternatively, the spray pig has been run **as a de-watering pig**.
- Serves to effectively re-distribute inhibitor-containing liquids to the top of the pipe.
- Creates an **increasingly dense vapor cloud** in front of the spray pig.
- *The spray pig has been highly effective at controlling top of the line corrosion in multi-phase gas gathering lines. In one case, corrosion rates dropped by an order of magnitude from 5 mills per year (mpy) to less than 0.2 mpy.*

Operational Pigging

Inspection

- Magnetic flux leakage (MFL) tools for corrosion metal loss.
- Ultrasonic tools for corrosion detection & crack inspection.
- Kaliper tools for geometry inspection.
- Deformation tools for geometry and bend inspection with telemetry data.
- Crack detection tools for determining circumferential cracking.
- Survey or mapping tools with telemetry data.

Line Cleanliness is Critical

- MFL Tools are the best & most expensive cleaning pigs available. Sensor “Lift Off” will reduce the intensity of the magnetic signal and will affect data quality.

You don't want MFL Tools to be a Cleaning Pig!



Pigging

What Should My Cleaning Strategy Be?

Basic Questions

- How many runs does it take to clean a pipeline ?
- What kind of pigs should I use ?
- How often should I pig ?
- Can a single “Pig Train” run reap the same benefits of multiple pig runs ?

In Order to Establish an Effective Pigging Program

- Know your pipeline.
- Measure the results of your efforts.
- If your program isn't working, try something different.
- Stay open to new ideas and technology.

Types of Pigs

- Mandrel Pigs
- Blade Pigs
- Brush Pigs
- Magnetic Pigs
- Spherical Pigs



Select A Pig For Cleaning Applications

- The best choice is a pig with discs, conical cups, spring mounted brushes and bypass ports.
- **Discs** are effective at pushing out solids while also providing good support for the pig.
- **Conical cups** provide excellent sealing characteristics, good support and long wear.
- **Spring mounted brushes** provide continuous forceful scraping for removal of rust, scale and other build-ups on the pipe wall.
- **Bypass ports** allow some of the flow to bypass through the pig and helps minimize solids build-up in front of the pig. Also used for slowing the speed of the pig down.

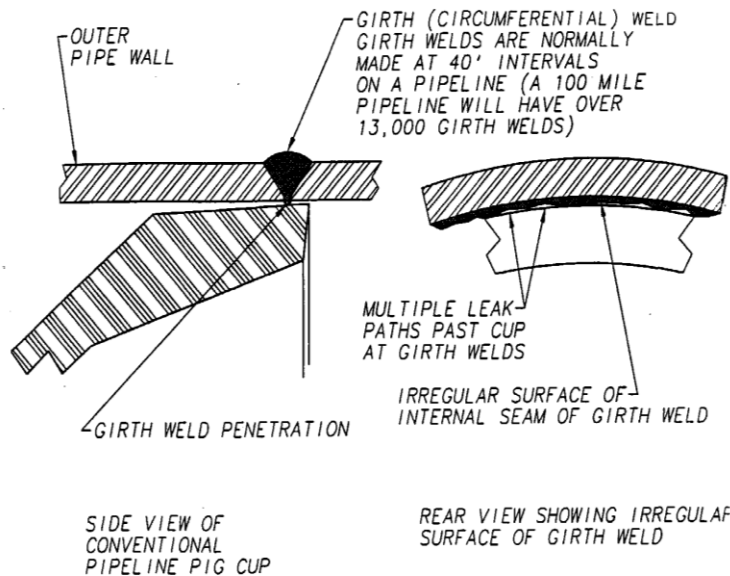
RealSeal™ Cups



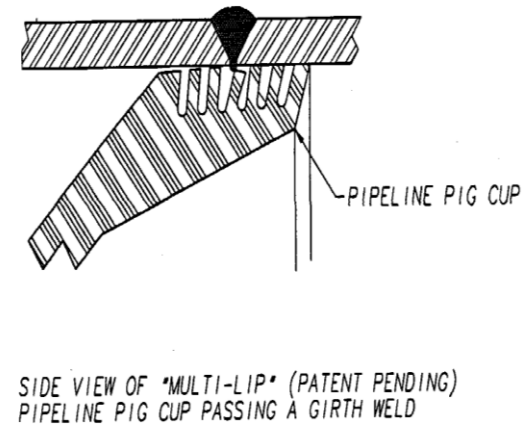
Independent Sealing Lips

- RealSeal features multiple sealing lips, which means more effective seal throughout the pipeline run.
- With the RealSeal cups, sealing as the pig passes girth welds in a pipeline become a non-issue.
- Available in Vantage cups, heavy duty cups and Ultra multi-lip discs.
- Critical sealing applications such as nitrogen purges, line filling for hydrostatic testing and cleaning.
- Very effective in commissioning of lines, displacement and batch separation.
- Also effective in cleaning operations – acts like multiple scraper discs

Conventional Cup vs. RealSeal Cup Design



VS.



Conventional cups allow by-pass due to irregularities on the internal contour of girth welds

TDW's Multi-Lip "RealSeal" cups and discs are designed for applications in which effective sealing and extended life of pig cups are critical.

Sealing lips are always ahead or behind the girth weld when the cup is passing—*continuously maintaining a seal.*

Approaches to Pipeline Cleaning

- Special features that can be added to pigs:



TDW 8" 3C-MAG Magnetic Cleaning Pig
after 177 mile (285 km) run

Magnets



**Blades for
Wax Removal**



**Wear-Compensating
Brushes**



Studded Pig

Special Purpose Pigs & Components

- Wear-compensating / pit-cleaning brushes
- Wear-compensating brush pads and wax-scraping blades
- Scraper discs
 - Discs tend to do a much better job of scraping than cups which tend to ride up over debris.
 - Discs can be quite effective at removing loose powders, light debris and soft wax.



Scraper Discs



Scraper Blades
& Brush Pads



Pit-Cleaning Brushes

Bi-Direction Pigs

- Each pig is equipped with six discs.
- Outside discs are used as guide/support discs (these discs are made of a harder material).
- Typically pigs are used for hydrostatic testing and as displacing pigs.
- Can also be equipped with brushes for cleaning purposes as well.
- Available in sizes 4" thru 60".
- All three can traverse 1.5 DR bends.



4D-BR (Brushes)



6D



6D-BR (Brushes)

Cast Urethane Pigs



5D1C

← Undersized Guide Disc



4D2C

- Multiple discs with single cup on rear.
- Multiple discs with cup on front and rear.
- RealSeal configuration option for rear cup.
- Brush wrap, gauging plate and bypass option. Will also hold transmitter and or trip magnet.
- Undersized front disc or cup to aid in launching of pig.
- Available in 4" to 12"



5D-Offshore



4D2C-Gauging Plate



4D2C-Brushes

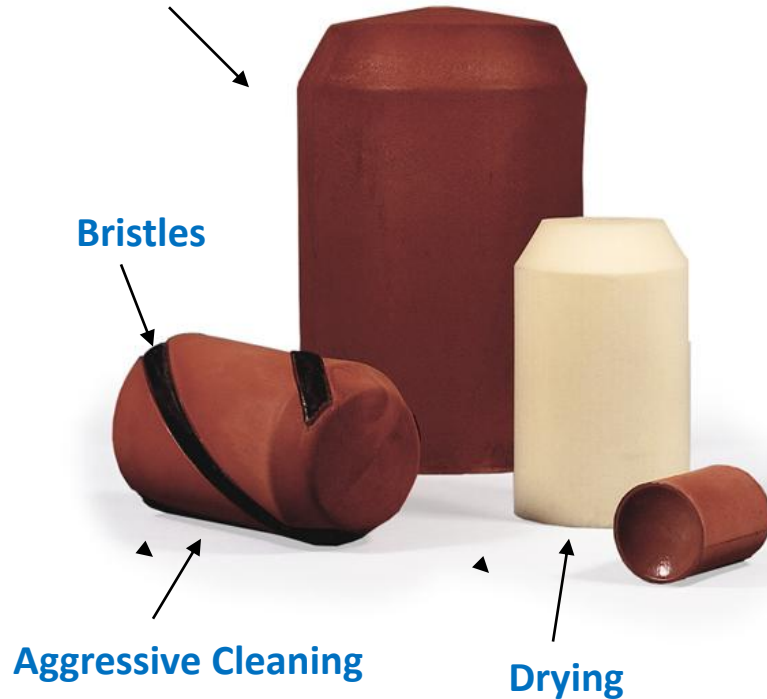
Sphere Pigs



- 99% of the time, spheres are used to push liquids out of natural gas gathering lines.
- Gravity allows the automated launching and receiving of spheres which makes them very easy to use and very cost effective.
- Typically, lines have been designed to handle spheres.
- Seamless, one-piece, inflatable.
- Spheres are filled with liquid and can also be inflated to compensate for wear.

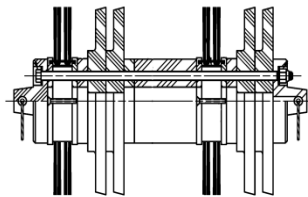
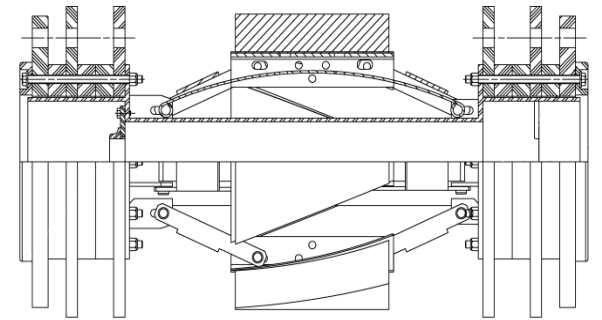
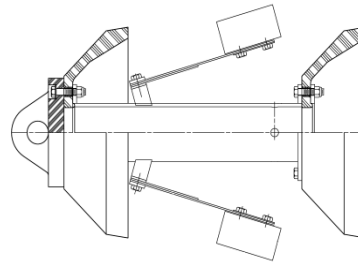
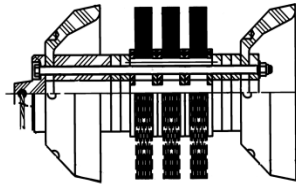
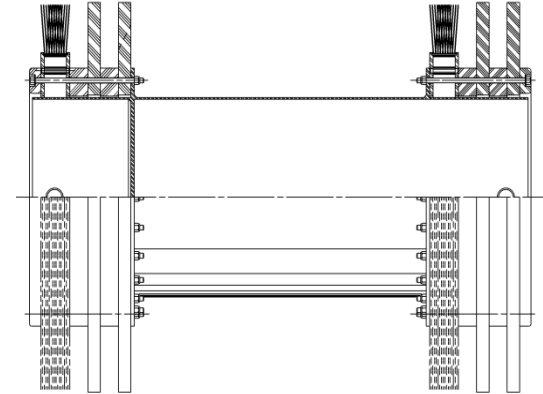
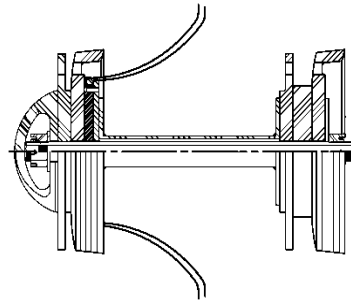
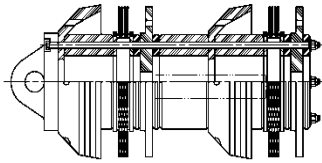
Foam Pigs

Light/Medium Cleaning



- RS-7-Abrasion resistant polyurethane foam with honeycomb texture-wiping and scraping effect.
- RBR-7 (Bristle)-Effective cleaning and removal of solids.
- RRR-7 (Rough Rider) Used for internally coated lines and crude oil lines containing paraffin.
- Whiteskin-Shorter runs primarily for drying after dewatering of lines that have been hydrostatically tested.
- (Redskin pigs also have the ability for bypass to be added

Brush Pig Configurations

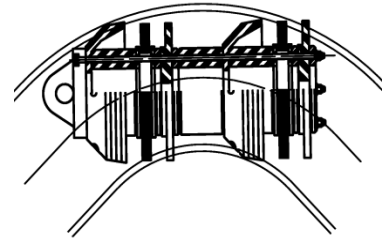


What Type of Brush Should I Use?

Circular Brushes

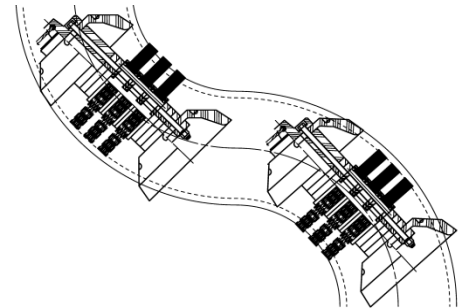
Advantages

- Bi-Directional
- Come in all sizes
- Can be stacked in dense cleaning packs
- Provide good centering guide in the pipeline



Disadvantages

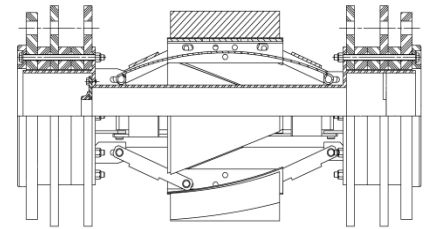
- Not effective in cleaning deep pits
- Not effective in pipelines with multiple ID's
- Can be Damaged in tight bends and pipe ID anomalies



Pad Type Brushes

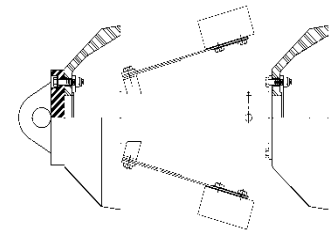
Advantages

- Pads are wear compensated & can conform to bends.
- Effective in multi-diameter pipelines.
- “Buggy spring” mounted pads are Bi-Directional.
- Can articulate thru pipeline anomalies.

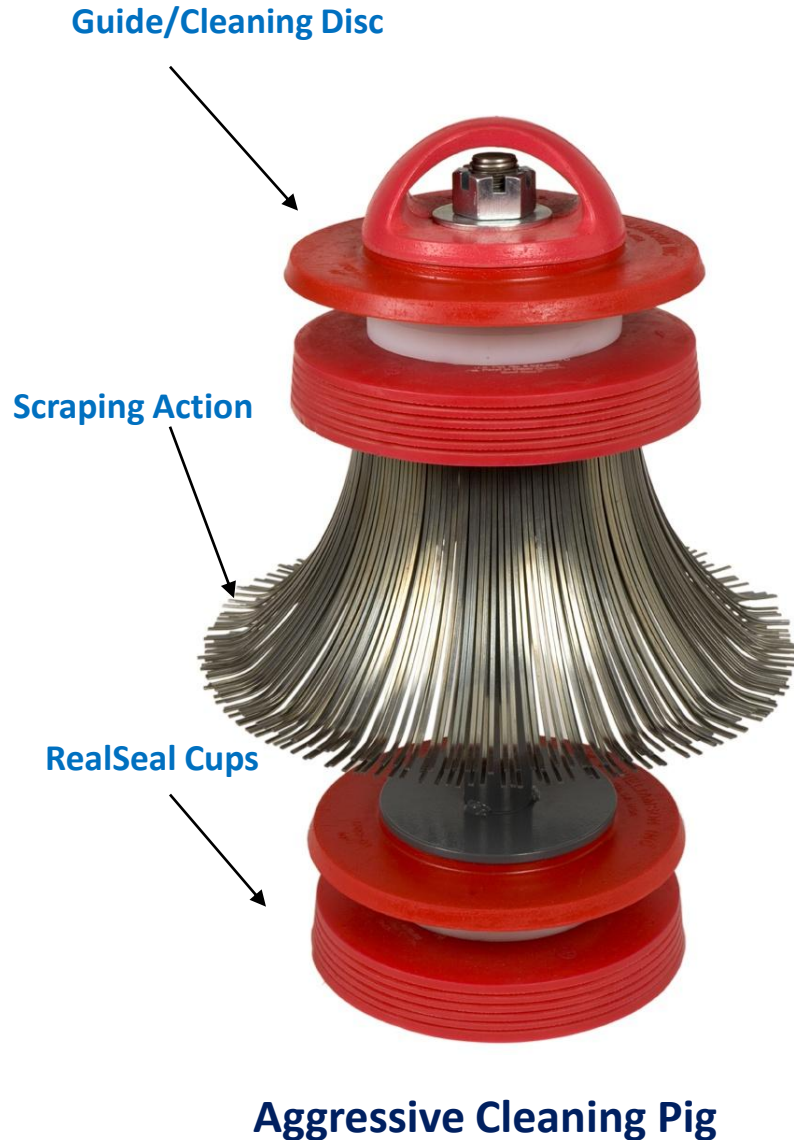


Disadvantages

- Size restrictions.
- Not effective in cleaning deep pits.
- Lever mounted pads are not Bi-Directional.



PitBoss™ Pig



- Available in sizes from 6" and larger.
- Is designed to remove deposits from internal pits while insuring excellent general purpose cleaning pig.
- Pit cleaning wire brushes are designed to improve effectiveness of corrosion inhibitors.
- Each wire scrapper acts independently as both a spring (forcing itself out and into the pit) and as a scraper.
- PitBoss is also available in dual diameter configuration.

Magnetic Cleaning Pig for Ferrous Materials

- Debris such as welding rods, bolts, tools, etc., is very difficult to remove with conventional pigs as the pigs typically push these objects for some distance and then ride over them.
- The removal of this type of debris is a must before attempting to run Corrosion Inspection Pigs.



Test Results

TDW recently performed four consecutive, 30-inch magnetic pig runs, which gives you a good idea of the success.

Run #1	320 welding rods and four steel plates removed
Run #2	165 welding rods and five steel plates removed
Run #3	50 welding rods and one steel plate removed
Run #4	12 welding rods and zero steel plates removed

Progressive Pigging

The more unknowns that exist in a pipeline segment, the less intrusive the initial pig run should be – start gently and use the following sequence. Use the following example:

- Foam Pig
- Foam Pig with Bristles
- Steel bodied Mandrel Pig With Brushes
- Steel bodied Mandrel Pig with Aggressive Brushes
- Gauging Pig
- Dummy Pig w/ Magnets
- Geometry Pig
- Metal Loss Pig

Sampling & Monitoring

- Pigging Samples
- Solids Sampling
- Liquids Sampling



Sampling & Monitoring

Examples



Tracking

- Pig Tracking Equipment
- Surveys
 - Centerline
 - Depth of Cover
 - AGM
 - Anomaly
- Defect Assessment

Tracking

- Reasons for Pig Tracking
 - Locate a Stuck Pig
 - Track a Nitrogen Purge
 - Monitor Progress of Cleaning or Batching Pigs
 - Track an Inspection Tool
 - Identify Pig Passage

Pig Tracking Equipment

Pig Sigs

■ Flag Indicator



■ Electrical Indicator



■ Flag/Electrical Indicator



Pig Tracking Equipment

Non-Intrusive Pig Sig

- Bands directly to the outside of a pipeline.
- No part of the unit enters the pipe (no need for seals or o-rings to contain pipeline pressure).
- No welding/tapping is required .
- Unit can be placed at nearly any location on a line and can be moved easily (no need for TOR).
- Bi-directional detection.



Pig Tracking Equipment



Pig Tracking Equipment



Pig Tracking Equipment



Pig Tracking Equipment

Receiver



Pig Tracking Equipment

Geophone



Pig Tracking Equipment

Tracking Techniques

- Leapfrogging - Tech A goes to first track point. Tech B is located at second track point. As pig passes Tech A he records time and notifies Tech B. Tech A then proceeds to third track point. Repeated until pig is received.



Centerline Survey

- Precise determination of the centerline of a pipeline is critical to identify its spatial position. Furthermore, a precisely obtained centerline is required for spatially based alignment of additional data collected on the right of way. Data corresponding to above ground surveys are all aligned through common spatial coordinates.

Centerline Survey

Latitude / Longitude / Elevation (GPS)

GPS readings shall be obtained at each flag location and reported in either of the following coordinate systems:

World Geodetic System 1984 (WGS84)

North American Datum 1983 (NAD83)

North American Datum 1927 (NAD27)



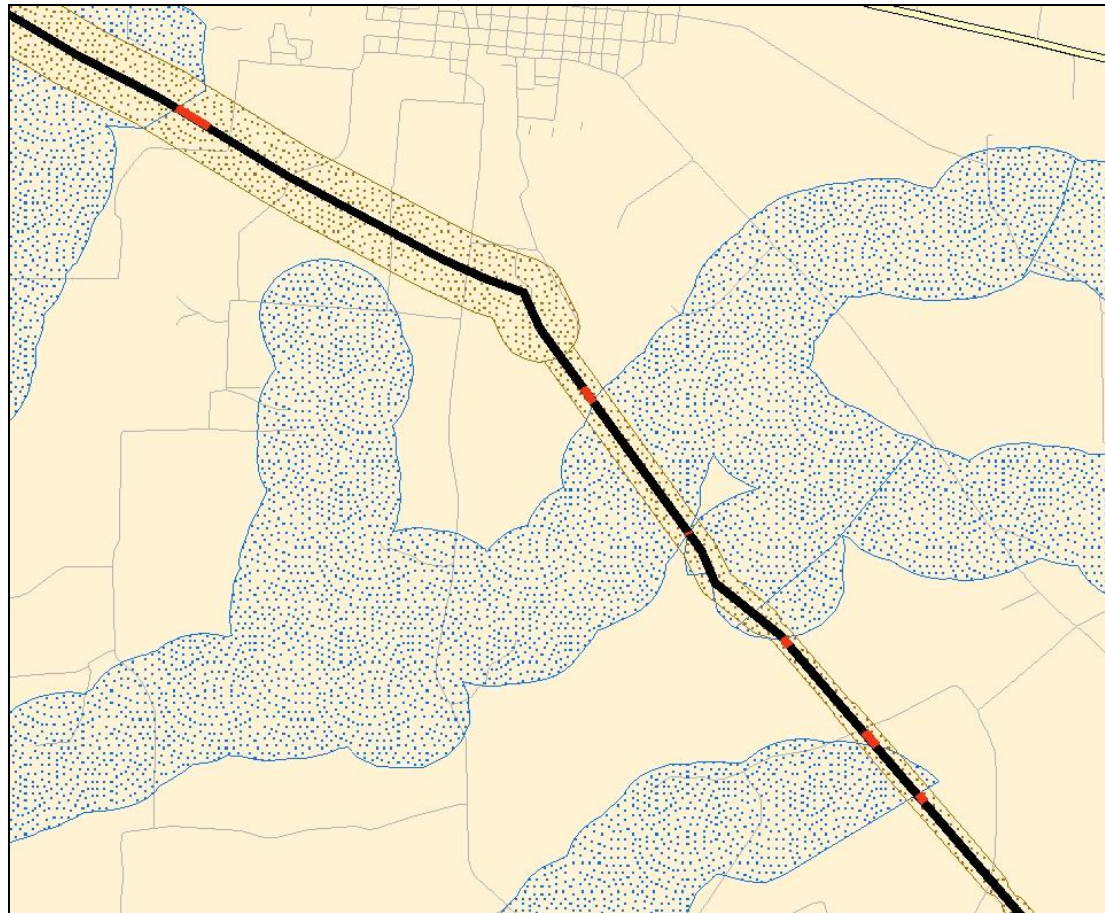
Centerline Survey

Flagging Point of Inflection



Centerline Survey

HCA Analysis



Depth of Cover Survey

The DOC is calculated by the following formula:

$$\text{DOC} = \text{Pipelinelocator depth} - \frac{D}{2} - b$$

Where,

DOC = Depth of cover

Pipeline locator depth = pipeline depth as measured by the pipe locator

D = diameter of the pipeline

b = separation between the ground and the lower end of the instrument

Above Ground Marker's

- A tool designed to be placed above the pipeline usually at a documented GPS location which records tool passage and communicates with satellites. Recognizes the magnetic field as the tool passes.
- Placement should be at points where GPS coordinates have been established & documented.
- Will store multiple passes.
- Tool and AGM are synchronized.
- Accuracies depend on the make of AGM.



Threats - Flammables

- Blow-Down
- Opening the Closure
- Static Electricity
- Equipment & Cathodic Protection Rectifiers
- Sources
 - Natural Gas
 - Condensate
 - Methanol
 - Pyrophoric Substances

Threats - Chemicals

- Blow-Down
- Opening the Closure
- Sources
 - Methanol
 - Corrosion Inhibitors

Threats - Toxicity

- Blow-Down
- Opening the Closure
- Sources
 - Odorants
 - Methanol
 - NORMS
 - PCB's

Summary

- Many pipelines can be made piggable with readily available components.
- System information is critical when preparing for In-Line Inspection or any other assessment method.
- Pipeline Cleanliness is a critical part of In-Line Inspection.
- Tools Have Strengths & Limitations. We need to apply the right tool for the right job.