WHY PIG A PIPELINE?

It is generally agreed that a pipeline should be pigged, but the reasons for doing so are not always fully appreciated. This may result in improper pigging programs and/or the use of the wrong type of pig and this could have an adverse effect on the pipeline's operating and maintenance costs. It is therefore important to clearly define the reasons at the very beginning and the following will provide some guidance in this respect.

SAFEGUARDING ASSETS & OPTIMIZING EFFICIENCY

Many operators only resort to pigging when a problem becomes apparent and they have no other choice. Often, this is too late. The damage has been done and a multi-million dollar investment is put at risk.

Use of the correct type of pig and a proper pigging program will help to maintain the integrity and optimum efficiency of the pipeline; safeguarding both the environment and the assets of the pipeline owner.

A pipeline is arguably the most efficient method yet devised for transporting fluids - whether gases or liquids. Its relative efficiency though, depends upon two fundamental requirements:

1. It must operate continuously.
2. The required throughput must be obtained with the least capital investment and the lowest operating costs.

Most pipelines are designed and constructed on these principles. Even so, the capital and operating costs are often very high, particularly for large diameter, long distance transport pipelines.

While many pipelines are constructed for purely financial reasons (they are simply the cheapest means of transporting a certain volume of fluid between certain points), others are built for strategic (often military), political, or international trading purposes.

Whatever the reason, it is certain that the decision to build a major pipeline has been taken at a very high (often the highest) level and that the decision is based on the two fundamental considerations mentioned above.

What is not always appreciated is that such decisions presuppose that these two fundamental requirements can be maintained during the life of the pipeline. It is not sufficient to simply design and construct the pipeline on the basis of continuous operation and optimum efficiency, it must be kept that way.

Pigs play a major role in both obtaining and maintaining the 'two fundamentals':

1. They help to maintain continuous operation by:
   - removing any substance which might damage the pipeline process systems
   - helping to prevent the formation of corrosion cells
   - providing timely information of any developing problems
   - providing data on any perceived problems to enable informed decisions to be made
   - providing an alternative to shutting down for statutory periodic testing.
2. They help to obtain and maintain maximum efficiency by:
   - removing any debris or foreign matter in the line
   - removing any deposits, either liquid or solid, which might otherwise build up and restrict the flow
   - by monitoring the operating and/or physical conditions of the line.

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THE PURPOSE OF PIGGING

In short, pipeline pigs help to ensure that the pipeline is constructed properly - and that it stays that way.

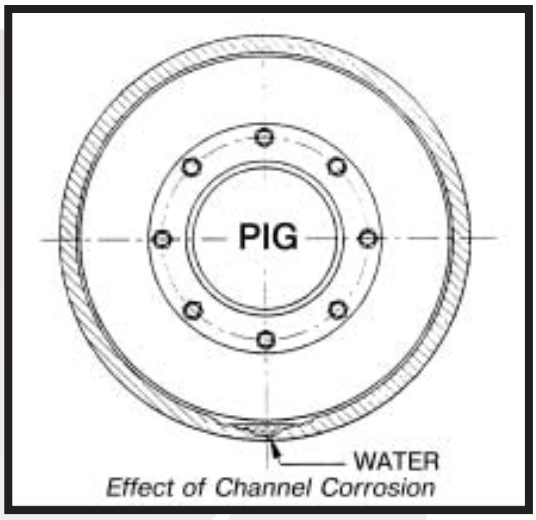
However, it must be remembered that the level of the contribution made to both the efficiency of the pipeline and to its protection will depend upon the pigging program and the effectiveness of the pigs which are used. Under any given set of circumstances there will be significant variations in the performance of different types of pig and even between different makes of the same type. However, the use of virtually any pig will be better than none at all.

Some elementary calculations will prove the point. Consider a simple short, straight section of a 12" (300 mm) water line. If the inside diameter is reduced by only 5% (15 mm) by a SMOOTH deposit, the loss of throughput at a given pressure would be over 10%. To bring the throughput back to its original level would require the pressure to be increased by almost 30%. However, if as is more likely, the deposit was uneven, the resulting turbulent flow may cause an effective reduction of 15%. In this case, throughput could be reduced by some 35%, while the pressure to overcome these losses would need to be increased by more than 140%.

Admittedly, this example is based on theoretical calculations but similarly dramatic effects have been noted in practice. Typical of these is the study made by Bern, Withers and Caim of British Petroleum on the Forties pipeline [paper EUR 206 - European Offshore Petroleum Conference] which showed that friction increased by 4.2% per day if the line was not pigged.

Perhaps one of the most common and yet costly mistakes is to rely totally on corrosion monitoring and automatic corrosion control systems to decide when to run a pig. The reliability of any monitoring system depends upon where the probes, coupons and/or sampling points are located - and this is difficult, if not impossible to achieve on subsea lines or to determine accurately on land lines, particularly on those which have any significant gradients.

Once corrosion, particularly pitting or channel corrosion has occurred, it is unlikely that a pig will be able to remove the water which will accumulate in these recesses. It is therefore advisable to include batch inhibition (running a slug of inhibitor between two pigs) as part of any corrosion control program.



Effect of Channel Corrosion

REGULATIONS, SAFETY & THE ENVIRONMENT

Legislation introduced by the United States in 1994, requires that most new hydrocarbon pipelines must be designed to enable them to be pigged. It also requires certain existing lines to be modified to facilitate pigging, It seems likely that future regulations will require certain types of pipeline to be inspected on a period basis. Elsewhere, there are no known regulations, but in some countries, licenses to construct and operate pipelines are dependent upon them being piggable.

PRACTICAL NEEDS

The earliest pigs were used simply to remove any large deposits of wax or dirt in order to maintain a flow through the pipeline. Today, pigging is required during each phase in the life of a pipeline - for many different reasons, typically:

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DURING CONSTRUCTION
- I) Removing construction debris from the line.
- II) Acceptance testing (water filling, dewatering, etc.)
- III) Commissioning

DURING OPERATION
- I) Pipe wall cleaning
- II) Condensate removal
- III) Product separation (batching)
- IV) Applying inhibitors

FOR INSPECTION
- I) To check for physical damage (geometry)
- II) To detect corrosion, laminations or cracking
- III) Leak detection
- IV) Sampling
- V) Line cover and spanning (subsea)

FOR GENERAL MAINTENANCE AND REPAIR
- I) Corrosion inhibition
- II) Pre-inspection cleaning
- III) Decommissioning
- IV) Isolation
- V) Recommissioning

DURING RENOVATION/REHABILITATION
- I) Gel pigging
- II) Applying in situ coatings
- III) Chemical cleaning
- IV) Scale removal
- V) Cleaning for product conversion

DECOMMISSIONING
- I) Product removal
- II) Pipe wall cleaning
- III) Inspecting/testing
- IV) Inerting

When considering any of the above applications, it should be remembered that each pipeline is different. They have different diameters, lengths, contents, geometry, operating pressures and temperatures, materials, wall thickness, locations, etc. They are also built by different contractors and have different owners, each of whom may have different philosophies and operating procedures. They will also have to be constructed and operated in accordance with different Codes and comply with requirements of different Authorities. Pig selection and the pigging program must therefore be tailored to suit the particular need as well as the characteristics of the individual pipeline and its operation.

PIGGING DURING PIPELINE CONSTRUCTION

GENERAL

Pigging during construction is frequently performed on sections of pipeline that are shorter than the entire pipeline, often using compressed air as the means of propulsion.

Pigs perform best if they are run at a near constant speed, therefore it is necessary to provide some means of speed control other than a constant input. If this control is not provided the pig may stop at a minor obstruction and the pressure behind the pig will increase until the pig moves. The pig then moves at a faster pace until equilibrium is reached and the pig again moves at a constant speed. This is often referred to as a ‘speed excursion’.

One means of providing better control is to close the downstream end of the pipe section, pressurize the entire section and then, by releasing pressure downstream as air is inserted upstream, it will be easier to maintain a constant differential pressure and therefore a near constant pig speed.

It must be remembered that the differential pressure required to keep a pig moving may be only 10% of that required to start it moving. Excessive and uncontrolled speed of a pig can be very dangerous.

It is always necessary to provide some means of restraining the pig at the receiving end of the pipe while releasing the pressure ahead the pig. If the restraining device is not provided, the pig can become a projectile propelled by the compressed air behind the pig similar to the action of an air rifle.

The catching devices can be as simple as a field made pig catcher or as sophisticated as a manufactured pig receiving trap. Often the receiving end of the pipeline is closed with a weld cap equipped with piping for controlling the release of the product and therefore the pig’s speed. Many contractors will build temporary pig launching and receiving devices that are reused during the construction of the pipeline.

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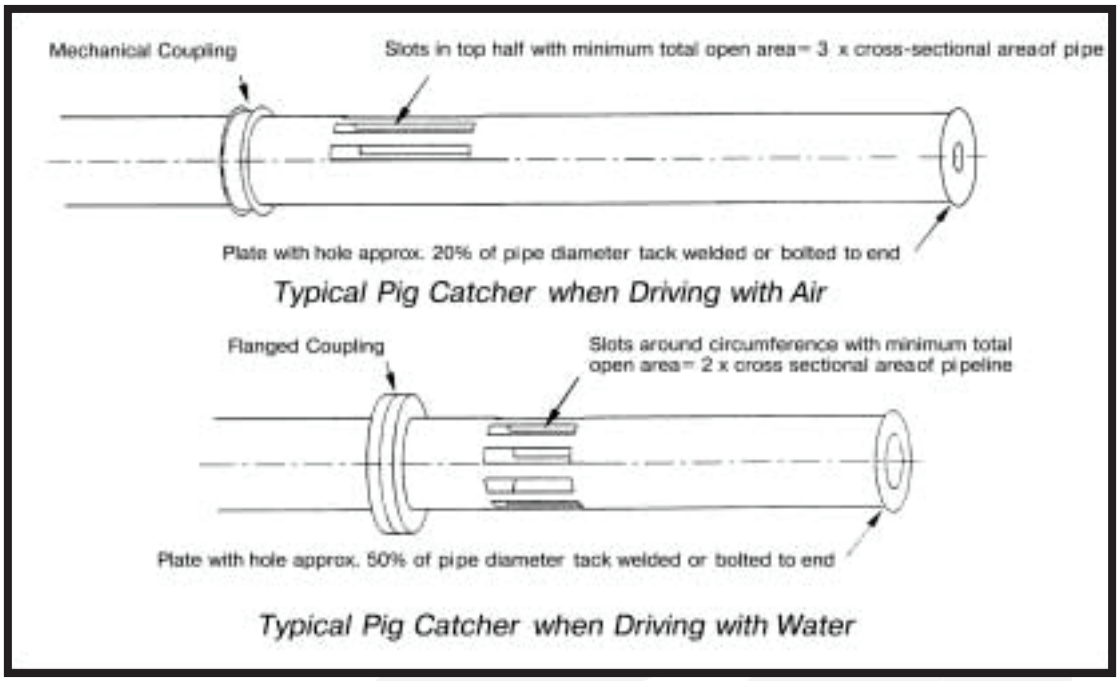
THE PURPOSE OF PIGGING



CLEANING

Pigging is an integral part of pipeline construction. Usually, the first application is when the contractor runs a cleaning pig to clean short sections of pipe to remove dirt and other construction debris that may be inside the pipe as the pipeline is being assembled. Apart from removing sand, stones, welding rods, rags, and other debris which will invariably be left inside the pipe, this procedure has been known to remove lunch buckets, construction skids, wild animals and other items which might be around the construction site.

As with many procedures on a pipeline, any steps that can be carried out before the pipeline is sealed will usually be easier than working with a closed system. A clean pipeline is required before a successful survey can be accomplished using either a gauging pig or an instrumented pig to ensure that the pipe has been laid properly.

The type of pig used will depend on various factors associated with the pipeline such as its diameter and length, the topography, whether it is onshore or offshore, sandy, rocky, etc. However, the arduous duty of a contractors cleaning pig usually requires it to be very strong and unless the line is internally coated it will usually be equipped with wire brushes. Even so, several pig runs may be necessary to remove all the debris.

Offshore, things are very different. Because offshore operations are much more costly, several steps may be combined. In spite of sometimes very strict specifications on cleanliness during construction. some debris will still accumulate.

Subsea pipelines are generally laid in very long sections which are capped and laid down on the sea bed. The ends are then tied in at some later stage. The “lay-down head” used at each end of the section on these lines is similar to the test end on a land line and is basically a very long pig trap. It may have to hold a large number of pigs, sometimes of different types, which need to be launched and received separately. To do this requires a manifold comprising numerous connections and very complex pigging procedures. These operations are therefore normally sub-contracted to a competent pigging service company.

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ACCEPTANCE TESTING

GAUGING

Pigging with a gauging pig during the construction process can be one of the most important inspection tools available to verify the pipeline is laid as specified since a pipeline is designed to deliver a certain throughput based on a minimum diameter, it is therefore necessary to be sure that the minimum diameter is not lost during the laying process.

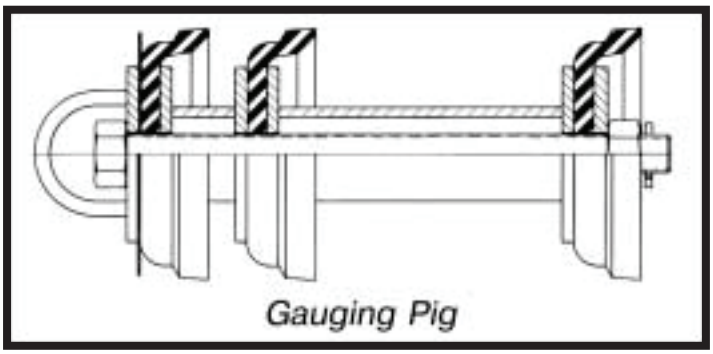
The oldest means of gauging this minimum diameter is by installing a plate on a pig. The diameter of the plate varies somewhat between pipeline companies but usually is between 90% and 95% of the pipe's normal inside diameter. This allows for some of the oval shape the pipe may have in the unpressurized condition as well as for any ovality caused by field bends.

In the early days of pipelining the gauging plates were made of steel and when gas welding was used the plates may have had hard surfacing applied to the outside diameter to shear welding icicles that intruded into the pipeline at the weld joint.

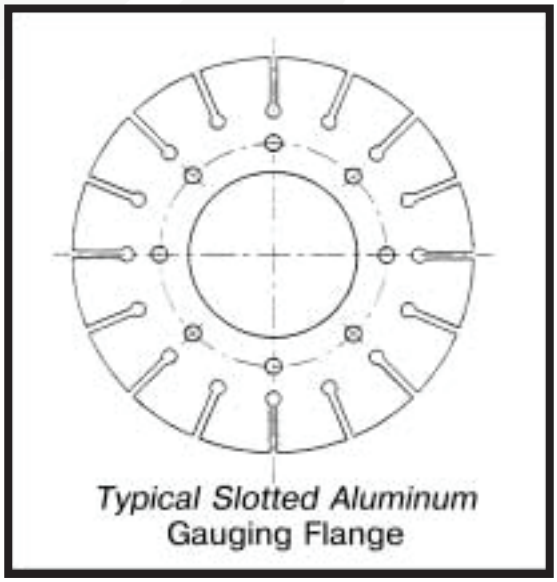
They also needed some device attached to the pig to make a noise so that the pig could be followed by walking to identify where it stopped if an obstruction was encountered. The noise maker might have been a dragging chain, or various types and shapes of rollers, gears or sprockets. This was a means for finding areas where the pipe had been damaged by material left in the bottom of the ditch or by material backfilled onto the pipe.

When steel gauging flanges were used they were almost always placed on the front of the pig so that the flange would push any construction debris out of the pipeline, or the pig would stop if it encountered an obstruction.

Most modern gauging flanges are made of aluminum so that contact with the pipe will not damage inside surfaces. The aluminum gauging plates are usually installed between the pig seals so that the gauging plate will be protected from any damage other than that caused by a reduction in diameter within the pipeline. If the aluminum plate traverses the pipe section without damage, it is evidence that the pipe does not have any reductions of concern. Some aluminum gauging plates are made of a soft aluminum to reduce spring back and some are cut into segments to help identify the shape of any restriction. It may be important to know whether the pipe is reduced in diameter in an oval shape or if the reduction is over a small area as may occur due to a dent caused by some external object. If the gauging plate is damaged, then it becomes necessary to find the obstruction and make a repair. These obstructions may have been located by the pipeline walkers following the pig, if for example at some point they noticed a hesitation in the pig speed.



Gauging Pig



Typical Slotted Aluminum Gauging Flange

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THE PURPOSE OF PIGGING

Once the obstructions have been removed it is then necessary to rerun the gauging pig to verify that all pipe diameter reductions have been removed from that section of the pipeline.

If the gauging flange is undamaged on the first run, this can be an economical means of inspection of the pipeline and it is a common means of gauging the pipe in the smaller sizes. It may also be used in larger size pipelines provided the wall thickness is sufficient for the pipe to stay in a near round shape while unpressurized, but after the pipe is covered.

When the pipeline is subsea the procedures for running and tracking a gauging pig must be modified. The pig may need to be bi-directional in case it contacts an obstruction that it cannot pass. It could then be pumped back to the point of origin. The location of such an obstruction may be estimated by monitoring the gas or liquid injected into the pipeline to propel the gauging pig. Electronic tracking devices may also be used.

However, whether a pipeline is onshore or offshore, using a gauging pig can be an extended operation if an obstruction is found. A bent gauging plate will indicate the worst reduction in the pipe but will not indicate how many similar or smaller reductions have been passed. The fault or faults must be repaired before the pigging run can be continued.

It must also be remembered that the gauging plate is deformed by contact with the pipe wall, so with the modern high tensile steel pipeline, it is desirable to have an alternate gauging system. This alternate is the instrumented pig designed to measure the inside diameter of the pipeline and identify the location of any nonconformity. These are known as ‘geometry’ or ‘caliper’ pigs. Some of these pigs can give a profile of the non-conformity to help with the decision making about corrective action.

Most geometry pigs can survey a pipeline without making any metallic contact with the pipe wall. The resulting report can be used to locate and make all the repairs needed. It is then rerun to provide a final report for the acceptance decision as well as a permanent record of the ‘as laid’ condition.

Unlike the gauging pig the geometry pig is designed to pass restrictions in the pipe without damage to the pig or the pipeline. Therefore it is necessary to clean the line first or the geometry pig may pass over any debris in the pipeline and record it as a reduction in diameter. Under careful control, these pigs can be driven through the line with compressed air but their accuracy may be affected by irregular speeds, so they are best run in a liquid. Unless there is an immediate problem to resolve, they are therefore often run during dewatering of the pipeline following hydrostatic testing and then periodically during the operational life of the pipeline.

HYDROSTATIC TESTING

After the pipeline section has been accepted as laid in good condition, it then becomes necessary to pressure test for leaks and to ensure it can be safely operated at the design pressure. The pressure test is almost universally a hydrostatic test with water and the pig again becomes an essential tool.

A pig is inserted in the pipe and the water fill is used to pump the pig forward and expel the air from the line. There are a number of reasons for having to ensure all the air is removed. One is to avoid pressure variations due to vapor locks and another is for safety in the event of failure since compressed air contains much more energy than water when under pressure. It is therefore essential to use a pig, otherwise it would be impossible to eliminate air from the higher elevations.

It is important to control the movement of the pig during the water fill. The forward movement will usually be controlled by the input of the water but a rebating air vent valve may also be installed at the receiver to enable the movement of the pig(s) to be controlled by the operator at the receiving end.

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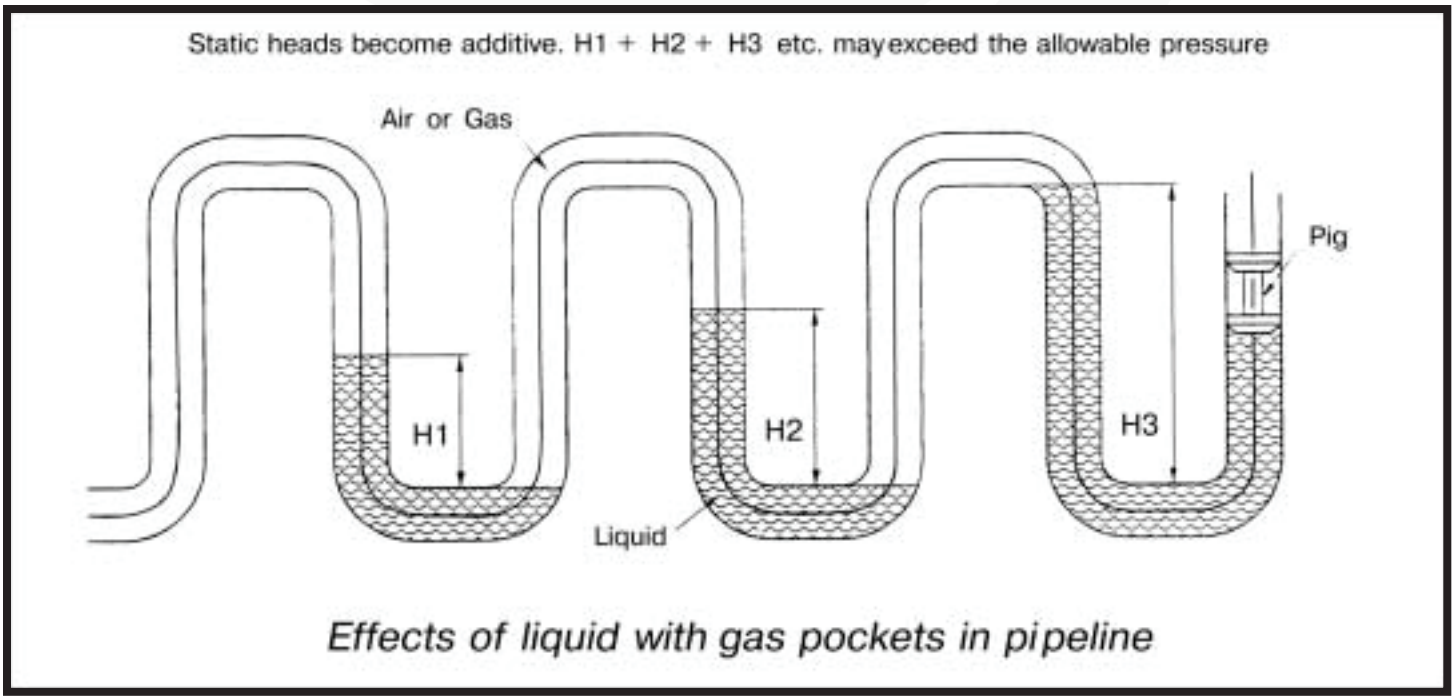
However when the pig starts a descent at an elevation change the weight of the water behind it may cause it to move faster than the water input. This can create a partial vacuum behind the pig, causing air to be sucked backwards into the liquid column. This creates a break in the line fill and eliminates the siphon effect, leaving the air at a high point. When there are significant variations in the elevation of the line, this causes the static heads of these now separate columns of liquid to become additive. The pressure then required to drive the pig may exceed the safe working pressure of the pipeline and perhaps the capacity of the available pressure pumps.

When this happens, it is usually necessary to install a vent at the high point to eliminate the air. The sections of the pipeline to be tested are therefore usually selected according to the elevation changes within the section.

There can be many reasons why it is not desirable to fill the entire pipeline for hydrotesting. The availability of a sufficient volume of test water being just one. In this event, the test water can be moved from one section to another as each section is hydrotested. This is done by preinstalling pigs in each section of the pipeline before welding on the test ends. Manifold piping is installed at each end of the test sections to allow the water to be transferred from one section to the next.

Typically, two pigs are installed in the test end and the first one is launched and pumped to the other end to complete the line fill of the first section. They both remain in the pipe during the pressure test.

After the first section is tested, compressed air (typically) is used behind the second pig to transfer the line fill to the next section for hydrostatic test, simultaneously driving the first of the two pigs pre-installed in that section to complete the line fill of the second section. This is repeated until the entire line has been tested.



Effects of liquid with gas pockets in pipeline

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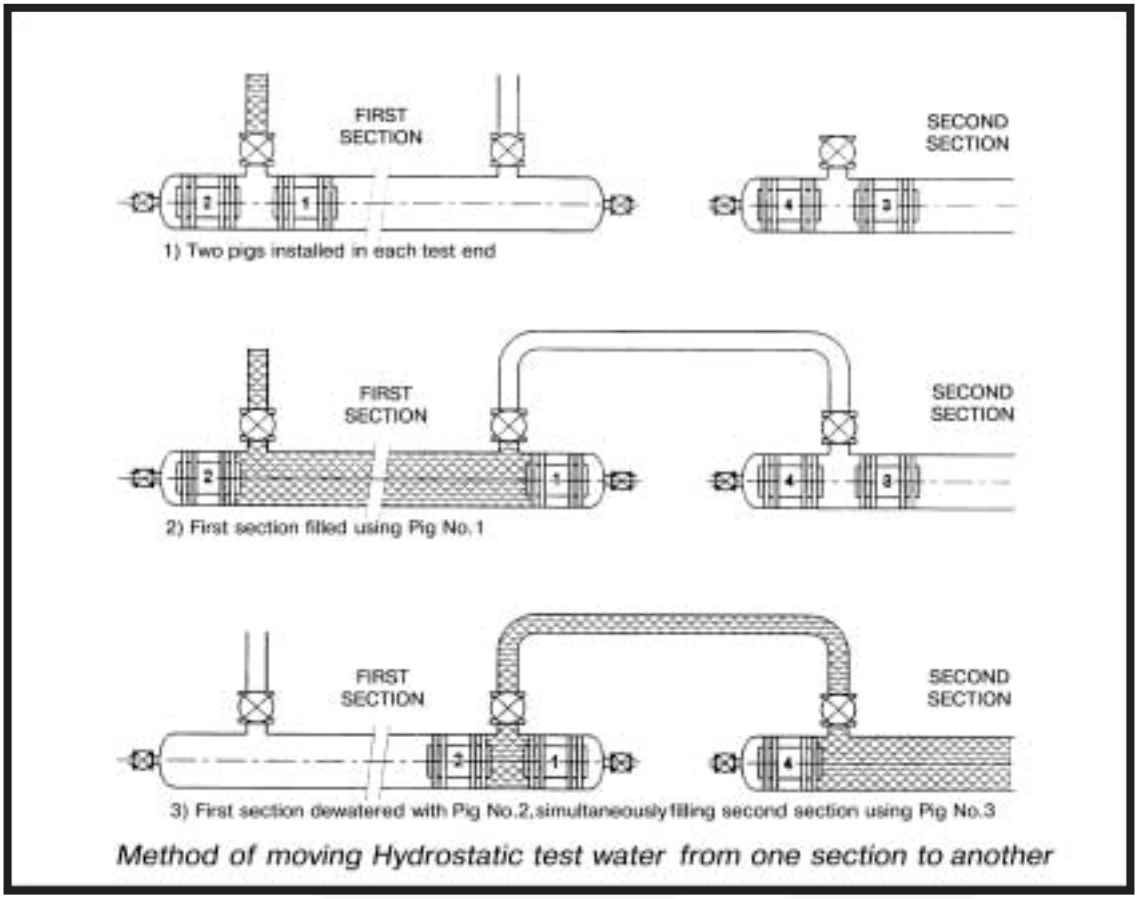

Method of moving Hydrostatic test water from one section to another

If the water must be returned to the watershed from which it came, the pigging process is reversed to return the water back through each section until it arrives at its original source. When this process is used the pigs must be bidirectional so that they are effective in each direction. However, in most other situations almost any pig designed for dewatering, batching or swabbing should be acceptable, except perhaps a foam pig. These pigs might be a sphere, mandrel pig or one piece batching type pig. Foam pigs are made of intercellular materials which allow fluids to permeate through them and so are not normally suitable for line fill prior to hydrostatic testing. Reference should be made to later sections in this manual for guidance in selecting the most suitable pig.

PRE-COMMISSIONING

After the acceptance testing is complete there are usually a number of other things which must be done before the pipeline can be brought into operation, or 'commissioned'. This stage is generally referred to as 'pre-commissioning'.

One thing which invariably needs to be done is to remove the test water. To determine what else needs to be done it is first necessary to know the details of the product(s) to be transported. For example, some products cannot tolerate water and therefore the pipeline must be made very dry before being filled.

Some products may be very susceptible to debris so the pipeline must first be thoroughly cleaned. If the new pipe is not internally coated, there may be rust and scale adhering to the pipe wall and even internally coated pipelines may have a coating of construction dust to be removed

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and it may require many pig runs to remove all the dirt. In some circumstances it may be acceptable to make these pig runs after the pipeline has been filled with product. However it will then usually be necessary to provide a means for filtering or placing the product in storage to allow the dirt to settle in order to have a clean marketable product.

Cleaning is generally relatively straight forward, but dewatering and drying require more careful consideration.

DEWATERING

Once the hydrostatic test is completed the water inside the pipe is removed by a series of pigs normally pushed through the pipeline by compressed air. The type of dewatering pig(s) used will be determined by such things as the length, diameter and configuration of the pipeline and the air compressor(s) should be capable of running the dewatering pig(s) at a speed of at least one mile per hour (1.6 kph) under these conditions.

The outlet end should be fitted with a valve to enable the pipeline to be completely shut off or to be throttled to rebate the rate of discharge to safe levels. Sudden surges may also be expected to occur as the pig approaches the receiving end if some compressed air has bypassed the pig. It should be noted that pigging with compressed air, or any other compressible fluid can be highly dangerous and should only be carried out by fully qualified personnel.

Once the dewatering pig(s) have been received it is common practice to run a series of foam pigs to swab up any residual water. However, if the product to be transported in the pipeline requires that all residual water must be removed (e.g. natural gas) then after dewatering, the line must be dried.

DRYING

Typical methods of drying a pipeline include blowing dry air through the line, usually in conjunction with foam pigs, the use of nitrogen, or to employ a technique known as “vacuum drying”.

The dry air and foam pig method is used mainly for onshore pipelines. The first step is to run low density polyurethane foam pigs with compressed air dried typically to a -90° F (-68° C) atmospheric dew point temperature. The pigs soak up the residual water while the dry air also absorbs water and carries it out of the pipeline. This process is continued until the pigs are received dry. On long pipelines, this may require several hundred runs.

The next step is generally to remove any rust and mill scale and any debris that may have settled out of the hydrostatic test water. This is typically achieved by running foam pigs equipped with fine steel wire brushes on a continuous basis until they are received without any material packed into the bristles.

If it is necessary to remove all loose material including the very fine dust which may remain, then more plain foam pigs may be run. Again, they would be run continuously until they are received in some previously specified condition or until some dew point has been attained.

Vacuum drying is particularly useful for offshore pipelines. It works on the principle that the boiling point of water is determined by the pressure. Reducing the line to below atmospheric pressure causes the residual water to boil. The water is then removed from the line in the form of steam. This drying process continues until some predetermined dew point value is reached. This method is invariably long and relatively expensive, but generally can be relied upon to achieve excellent results.

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COMMISSIONING

'Commissioning' is the stage when the completed pipeline is filled with the product and brought to the point where it is ready for operation. Because of the complexity, it is almost always entrusted to a qualified pigging service company.

Commissioning will almost always involve the use of pigs and may often require 'slugs' of other substances such as methanol, glycol, diesel, etc., to be pumped through ahead of the product. Slugs, if used, are contained between two or more pigs and are usually designed to avoid product contamination as, particularly with hydrocarbons, there may otherwise be a risk of explosion or perhaps serious blockages due to hydrate formation.

The technique finally used to commission the pipeline will almost always be determined by the product(s) to be transported.

WATER PIPELINES

Water pipelines are one of the few cases where there may be no need to dewater after the hydrostatic test. Indeed the line fill for hydrostatic testing may also serve to commission the line as the test water may in fact become the product of the pipeline.

If the pipeline is to transport potable water, then the test water will normally require special treatment before being used as the line fill, and especially so if that water is then to be used for consumption. In most countries there are strict regulations covering the procedures to be used for potable water pipelines as well as laws governing the quality of the water coming from the pipeline.

PRODUCTS PIPELINES

The method used to commission a products pipeline in particular will depend upon the type of product to be transported.

It is conceivable that for some products, large quantities of residual water would not present a problem. In this case it may be possible to combine the commissioning with the dewatering phase and simply pump the product in behind the dewatering pig to commission the line.

However, the vast majority of long distance products pipelines carry refined products so it is usually necessary to ensure that there is very little water remaining in the line prior to commissioning. Again, the procedure used for commissioning will depend upon the product, but as there will invariably be air left in the line, then for the more volatile products, the pigs must be able to separate the air from the product There must also be a method of separating the air from any other substance in the line which could create a hazard when exposed to air.

This may require running several pigs, perhaps in a 'train' with say methanol or other water absorbing chemicals in 'slugs' between the pigs and perhaps with slugs of an inert gas such as nitrogen interspersed between each different liquid or gas.

NATURAL GAS PIPELINES

If the pipeline product is to be natural gas, it again becomes necessary to ensure that the moisture content level within the pipeline is at a very low level primarily to prevent the formation of hydrates.

Hydrates are similar to crushed ice and form under certain conditions of pressure and temperature. They usually require either the application of heat or of a chemical such as methanol to disperse them. They can easily block a pipeline and once this occurs, methanol cannot be pumped down to disperse them and the application of heat is often impractical, especially on subsea pipelines. So once formed they are very difficult to remove.

It is therefore common to adopt a technique for commissioning natural gas pipelines similar to that described for transporting the more volatile products mentioned above.

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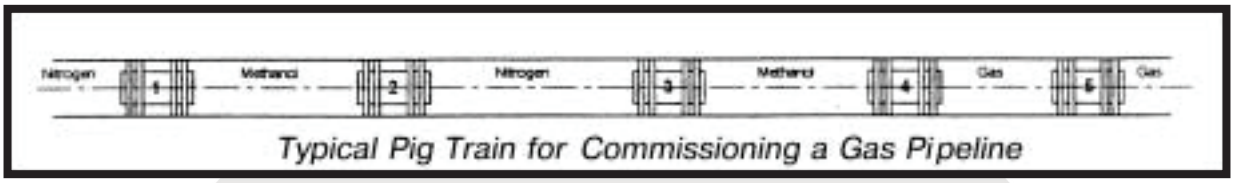
THE PURPOSE OF PIGGING



Typical Pig Train for Commissioning a Gas Pipeline

A typical procedure adopted by a major gas company when commissioning long distance gas transmission lines is to inject nitrogen equivalent to 10% of the volume of the pipeline at atmospheric pressure then insert the first pig. A slug of methanol is then injected equivalent to 7.5D gallons (US) per mile of pipeline (17.6D liters per kilometer) where D = the inside diameter of the pipe in inches, followed by pig No. 2. Next, nitrogen equivalent to a minimum of 0.5 miles (0.8 km) of line when compressed to commissioning pressure is injected and then pig No. 3. A second slug containing the same volume of methanol as the first one is then injected followed by pig No. 4. That normally completes the 'train' but a fifth pig may be run if it is considered necessary to remove any excess methanol.

For exceptionally long lines, particularly those offshore, the procedures may vary widely. Sometimes the methanol is injected in the form of a gel to provide a better seal as well as some lubrication and so minimize the risk of pig failure due to wear.

Commissioning a gas pipeline need not always be so complex. Under certain circumstances it may be possible to fill a pipeline with a gas while displacing the air in the line, without the use of pigs. However, in this case it will be necessary to monitor the downstream end of the line until a satisfactory product is received. This means that a lot of gas will have gone through the pipeline that is not suitable for use and is therefore wasted.

CRUDE OIL PIPELINES

The commissioning of crude oil pipelines may be similar to that used for many products pipelines. However, since many crude oils contain some water, separators are normally installed as standard equipment at the destination point. In this event, it is usually not necessary to dry the pipeline after the line has been dewatered.

OTHER PIPELINES

The commissioning procedures for some products require very special consideration. They may vary according to the material of the pipeline, the product to be carried, governing codes and even the internal company policies. For example, a hydrogen or helium pipeline may require leak testing in addition to the hydrostatic test because of the molecular size of the product. Hydrogen will also require very careful handling. LPG is another special case.

Therefore, it is the product, more than anything else, that will determine the procedures to be adopted. The aim is to commission the line safely and to transport the product thereafter in such a way as to meet the specifications required.

Having previously proven the integrity of the line by way of a pressure test, unless the product is toxic, the safety aspects during commissioning usually revolve around preventing fire or an explosion. So, as most combustible products need air in which to burn and a spark or compression to ignite the resulting mixture it is these two aspects which generally command most attention.

The air can usually be eliminated by using pig trains in conjunction with slugs of other liquids or gases and it is often vitally important to eliminate flammable mixtures of product and air since the sources of ignition are not so easy to eliminate. Compression is of course inherent in pigging but it must also be remembered that the metallic body of a pig might contact the pipe wall or the pig may pick up a stone or piece of metallic debris which could create a spark. Unless the product and the pipeline is very straightforward, it is strongly recommended that the commissioning of any pipeline be entrusted to a qualified pigging service company.

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BASE LINE SURVEYS

When the pipeline has been filled with the product and the line is at or near operating pressure, it is a good time to carry out an in line inspection using a geometry pig. This will provide a base line for comparison with all future surveys. The base line survey can help identify changes in the pipeline such as settling within the ditch or loss of support due to erosion (i.e. 'spanning') in subsea lines, which can expose the pipe to points of localized loading that could result in damage to the bottom of the pipe or buckling.

The base line survey can also be used for comparison and to locate damage that may have been caused by third parties operating over the pipeline but which did not create enough damage to cause a rupture at that time. They can provide vital evidence in the event of litigation and in any event they provide important data for monitoring the condition of the pipeline throughout the rest of its operating life.

When the pipeline is new and known to be in good condition, it also an ideal time to run other instrumented pigs to provide a base line survey for comparison with future runs. These surveys may include a metal loss (corrosion) pig and, if the pipeline has river crossings, is in earthquake areas, in areas of permafrost or in any other potentially unstable location it would be a good time to run a profile survey. Then future runs can be compared with the base survey for indications of movement and possible damage to the pipeline.

OPERATIONAL PIGGING

WATER PIPELINES

Water pipelines may need pigging to increase efficiency of the flow through the pipeline. The flow area may be restricted by either of two main conditions. There may be a soft sediment in the bottom of the pipeline consisting of solids that settled from the water stream or there may be a chemical deposit on the pipe wall, usually calcium based, which may be on the entire inside circumference. This chemical deposit may vary from being soft and therefore easily removed, to being rock hard and so requiring an entirely different and highly aggressive cleaning process to remove it.

Some of the soft sediment may be removed by simply increasing the flow rate by perhaps opening fire hydrants. Pigs are a better way to remove this sediment but many water pipelines do not have a provision for installing and removing pigs. Pigging services are available that can install foam pigs at or near fire hydrants and remove them at another hydrant further downstream. Most other pig designs are not adaptable to this type of pigging operation.

By contrast, the hard chemical deposit requires a different type of pigging program for its removal. This deposit may be several inches (centimeters) thick and therefore the effective inside diameter of the pipeline is much smaller than the inside diameter of the pipe. Whenever possible, this pigging is done onstream (i.e. while the pipeline is in operation) so it is critical that the flow is not blocked. In this case the first step is to get some type of a pig through the pipeline and then with repeated pigging runs increase the size and aggressiveness of the pig until the pipe is clean or acceptably improved. This procedure is often referred to as 'progressive pigging'.

To remove heavy, hard deposits in a water pipeline it is desirable to have pig traps for the installation and removal of the pigs since several pigging runs will be required. To help determine the severity of the deposit the first pig through can be a foam pig which will distort and pass obstructions that other types of pigs might not pass. The general procedure is to run a pig and monitor the amount of material received at the receiving trap. It is assumed that the maximum and minimum inside diameters are not known at this point so it is necessary to use a pig that will traverse the pipeline, and then to make gradual changes in the type and size of the pig as the cleaning process continues. The same pig or type of pig should be run as long at it is producing results as monitored at the downstream trap.

When a particular type and size of pig has ceased being effective, the next pig might be a larger foam pig or it may be time to use a mandrel type of pig. This could be a batching pig with flexible seals that would conform to the inside of the pipeline. Another choice could be to use a cleaning pig that is designed for dual sizes and therefore has the flexibility to pass the various inside diameters.

The first run with the mandrel cleaning pig should be made without cleaning elements to reduce the possibility of too much material being scraped from the pipe wall

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and creating a blockage. This pig should continue to be run until it ceases being effective as monitored at the downstream trap.

The next step would be to add all or perhaps only some of the cleaning elements to the pig and run again. Blade type cleaning devices will usually be more effective for the removal of the deposit than brushes. Brushes may be filled with the removed deposit and become ineffective while blades are self cleaning. Both elastomer and metallic blades are offered and the hardness of the deposit will determine which will be the most effective. When the dual size cleaning pig has become ineffective, the next step would be to run a pig designed for that particular pipe size. Only monitoring of the specific pipe conditions will determine whether blades or brushes will be most effective for the final cleaning.

After the pipeline is cleaned, it is important that a regularly scheduled cleaning program be conducted to prevent a recurrence of the problem that has just been resolved.

PRODUCTS PIPELINES CLEANING

Products pipelines need cleaning to remove fine solids that may have settled from the product as it traversed the pipeline. Also, some foreign material such as water may have separated from the product and be collected at low points in the pipeline. This water may reduce the efficiency of the pipeline but it may also cause corrosion at the point where it is collected, so it is important that it be removed. Any pig that seals in the pipe can be used to remove the water from the pipeline. A better pig for cleaning a products pipeline would be a pig with cleaning devices attached, and usually these would be brushes. These cleaning pigs may vary from a simple foam pig with strips of fine wire brushes bonded to the outside of its body to a purpose built cleaning pig designed for that specific size of pipe which can be fitted with various cleaning devices so they can be replaced as the components wear. Pigs should be selected for the specific application, such as the product and the type of cleaning needed, as well as taking into account the length and the other parameters of the pipeline.

PRODUCT SEPARATION

Pigs can be used between product batches to reduce the interface (the mixture of the two products being pumped) through the pipeline. These pigs can be referred to as batching pigs. swabs, foam pigs or spheres. Most batching pigs designed for this purpose will have four sealing elements. However, the number of seals can vary from one (sphere) to as many as six.

Some factors that must be considered when using pigs for batch separation are whether the interface must pass intermediate pump stations, whether the control systems are capable of placing the pig exactly at the interface and whether the control system can divide the stream exactly at the interface. Tests have shown that properly placed batching pigs can reduce the size of the interface, however a misplaced pig can actually create a greater interface.

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NATURAL GAS PIPELINES CLEANING

Natural gas pipelines sometimes need cleaning to remove dust particles that are often produced with the natural gas. This dust along with oil that may come from the compressors may create an internal coating that will reduce the efficiency of the gas flow.

The type of cleaning pig will be determined by the internal coating of the pipe. If the pipeline is internally coated, the cleaning pig should not be equipped with cleaning devices that could damage or remove the coating. When the pipe is internally coated the pig should be fitted with elastomer cleaning devices such as polyurethane blades to avoid damage to the coating. These elastomer blades clean the internal coating and with repeated runs also help to polish the surface.

If the pipeline is bare pipe, the cleaning pig may be equipped with brushes which will clean the inside of the pipe and with repeated runs will burnish the inside of the pipe wall and create a smoother surface, increasing the flow efficiency.

Some natural gas wells produce a pyrophoric dust. This will ignite spontaneously when exposed to air. However, in most cases, provided procedures are in place to damp the dust down prior to opening the receiving trap, this phenomena, although disconcerting, rarely causes any major problems.

Most natural gas transmission pipelines transmit gas that has been dried and therefore water is seldom a problem and condensate will only drop out under unusual conditions, typically a major drop of pressure.

SWABBING

Natural gas from the producing wells to the first processing plant will probably contain liquids. These liquids are referred to as NGL (Natural Gas Liquids) and may contain natural gasoline, butane, propane and other gases or liquids. Occasionally water may be also in the gas stream. These liquids must be removed from the gas pipeline and the NGL is therefore collected and processed for its own content. The water must also be removed to reduce contamination of the natural gas and possible corrosion damage to the pipe.

Liquids rarely threaten to block a line because as they settle out in the low spots and reduce the effective bore, this restriction causes the gas flow to increase locally and pick up the liquid once more. This situation is not acceptable however, because the turbulence will cause an increase in the pressure drop, thus reducing throughput, and the constant pick-up and dropout at the same point could conceivably give rise to problems of erosion.

Some natural gas wells produce considerable NGL and as the gas is produced and cools, in the winter especially, more NGL condenses from the gas and drops out into the pipeline. When a particular section of line becomes saturated, the liquids will be carried over to the next section, and so on until it arrives at the terminal. This is often unexpected, and could be in very large slugs. The slug catchers are sized to be able to handle the maximum likely volume and many of them are very large indeed. Even so, the slug which arrives, sometimes exceeds their capacity, and when it does, the liquids get into the processing plant and invariably cause both damage and a shutdown. These liquids need to be removed under controlled conditions. This is called ‘swabbing’ and it is performed using batching pigs, swabs, foam pigs or spheres. Spheres are commonly used for this purpose as pigging must be carried out on a regular basis and spheres are easier to launch and receive automatically. Some wells produce such quantities of NGL that it is necessary to run a sphere every few hours and therefore automation is essential.

There are several theories about the best size of the sphere for the removal of the condensate from the natural gas. One of the factors that affects this is the frequency of the pigging run. When a pig is run every few hours, wear becomes more of a factor than is the removal of absolutely all of the liquid.

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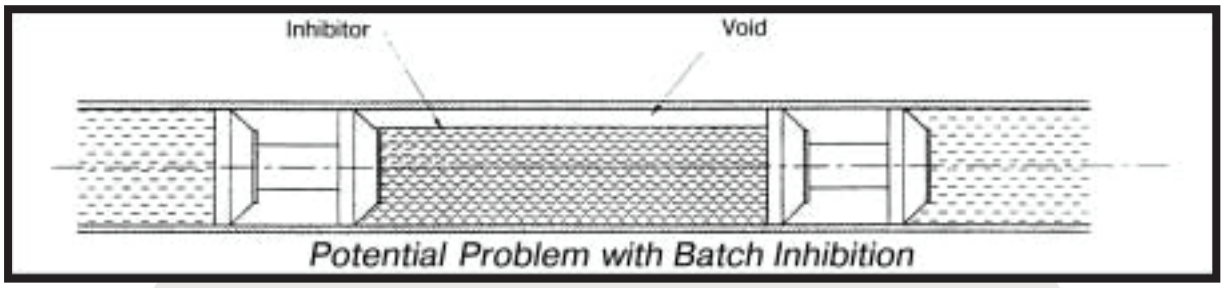

Potential Problem with Batch Inhibition

For batch separation or meter proving, the sphere may be pressurized to size it just slightly larger than the pipe inside diameter to give a good seal. When pigging for condensate removal however, it is common to size the sphere to equal the pipe inside diameter which will allow the sphere to roll and minimize the wear.

At one time spheres were produced with the outside diameter slightly smaller than the inside diameter of the pipeline. These spheres were hollow and had a hole in them to keep the pressure equalized inside and outside of the sphere and so they were not filled with liquid and were much easier to handle. The theory was that when spheres were run every few hours by automatic launchers, it was not necessary to remove all liquids with every pig run provided the majority of the condensate was removed. There is always a higher pressure behind a pig (or it would not move) and this reduces the leakage from front to back.

BATCH INHIBITION

Corrosion inhibitors are often added to the pipeline while it is in service but recent corrosion problems, particularly in Canada and the North Sea areas are pointing to the need for more effective inhibition to be carried out. In addition to the usual injection systems, pigs are now under development which actually spray the inhibitor onto the internal surfaces of the pipe wall while the pipeline remains in operation.

Running a batch of inhibitor between two pigs is theoretically one way to be sure that the whole of the internal surface of a pipeline is wetted, but there is no way of guaranteeing this - especially at the top center, or twelve o'clock position.

A pipe wall which has only partly been wetted by inhibitor may cause 'preferential corrosion'. This is a phenomena where the metal loss which would have occurred over the entire pipe surface is then concentrated on the small area which has not been wetted, thus making the situation worse, rather than better. It is arguable whether preferential corrosion is yet fully understood but it is almost certainly this which has caused batch inhibition to be only rarely used.

CRUDE OIL PIPELINES CLEANING

Crude Oil pipelines may need pigging to remove wax accumulations on the inside pipe wall but equally, if not more importantly, to remove any water. Water is often produced with crude oil and being of a higher specific gravity it will, if left, collect in the bottom of the pipe and cause pitting or channel corrosion. Regular pigging to remove the water is therefore essential because once this type of corrosion has formed, the pig seals will be unable to get into these crevices to sweep the water out and the corrosion rates will increase very rapidly.

Corrosion inhibitors will mitigate the problem but they are generally less reliable and more expensive than establishing a regular pigging program.

If pigs are not used to remove the surface debris such as dirt, sand, wax, corrosion products etc., then water will collect under it and it will prevent the inhibitors from properly treating the active corrosion area. The same situation will arise if there are bacterial corrosion problems caused, for example, by SRB's (Sulfate Reducing Bacteria).

For dewaxing, any type of pig will remove some of the wax, but unless the right type of cleaning pig is used, a lot of it will be left behind and simply smeared on the inside of the pipe wall. Elastomer blades work well for the removal of the wax from the inside surface and are self cleaning.

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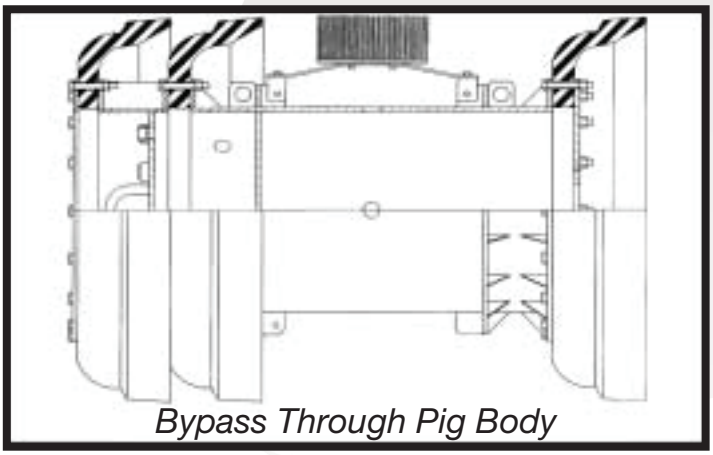
THE PURPOSE OF PIGGING

Most cleaning pigs have a means for product bypass through the pig. The provision for bypass may result in as much as 5% of the total product flow passing through the pig. When removing wax, the maximum acceptable bypass should be used. Many cleaning pigs have the bypass designed such that flow must enter the back of the pig, pass by the cleaning devices and then exit through the front of the pig.



Bypass Through Pig Body

This bypass also lets the pig slip slightly in the stream so that the wax that has been removed can be floated away in the faster flowing stream in front of the pig rather than be pushed into a solid mass. This will also avoid the potentially serious problems which could occur if the wax arrives as a solid plug at the receiving trap.

One of the authors witnessed a batching type pig being run in a 150 mile long crude oil line that was recognized for its heavy wax content. No bypass was provided through the pig and when it was received, the pig trap was full of wax that had to be removed with shovels before the pig could enter the trap. Even so, without changing any of the pumping parameters, the pipeline transported eleven percent more crude oil the day after this pig was run.

BATCHING

Crude oil pipelines may run batches when crude oil is not all derived from the same source and the batches may have different destinations or require different refining processes. Crude oil pipelines also may run batches of fuel to be used at intermediate pump stations on the pipeline. The interface mixing of the batches can be reduced by the use of batching pigs located at the interface.

The batching pigs must be placed at the interface of the two products to be effective. If there are intermediate pump stations, provision must be made for the pigs and the batch to pass the station without creating additional mixing of the two products.

PLANT PIPING SYSTEMS CLEANING

Pigging plant piping is similar to any other pigging operation, but some aspects need to be monitored in the plant that normally are not a consideration in a cross-country pipeline. In plant piping systems it is necessary to be sure that the elastomers on the pigs are compatible with the product in the pipeline.

Plant piping often contains factory produced elbows which excludes many pig designs. Most manufacturers produce pigs that will traverse long radius elbows (one and one-half pipe diameter as radius), some may traverse short radius elbows (one pipe diameter radius). It is imperative that the plant piping be carefully surveyed to be sure the correct pig is acquired for the intended purpose.

Many plant pipelines are relatively small and pigs may not be available with spring loaded cleaning elements similar to the larger pigs. These smaller cleaning pigs may use wheel type brushes that must be replaced as they wear. The cleaning procedures when using pigs, may also involve the use of cleaning or sterilizing fluids and this too will need careful consideration in both the design and operation of the overall system.

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SWABBING, SEPARATING, BATCHING

Swabbing, separating and batching are similar operations to those carried out on pipelines and are usually performed in a similar manner, although the reasons for the operation may differ.

A plant piping system may be used for many different products and the line fill has to be removed before each change of use. It is for this reason that in industrial or plant pigging, the operation is often referred to as 'clearing' rather than the pipeliner's terminology of swabbing, separating or batching. However, pigs may also be used in these systems to separate different products being transferred in the same pipeline in which case the term 'batching' would be more appropriate.

In some plants, the pipelines are loading lines and the direction of flow is reversed as applications change and the pipeline may be left filled with a non-contaminating product between changes in applications. Some pipelines may be used to transfer products whose specifications will deteriorate if left in the pipeline and therefore the product must be displaced between applications.

Food processing plants use batching pigs to remove product from the pipeline prior to cleaning. This may be required when the pipeline is being converted to another product, between runs of the same product or when the pipeline is to be shut down for some reason. The foods may be such that they would not meet specifications if allowed to remain in the pipeline for a period of time or the product may be of such a nature that it would solidify if left in the pipeline; chocolate being a typical example.

Pig manufacturers can provide pigs for virtually any purpose. They may require seals that are suitable for food products and the components may be made for easier cleaning. Pigs are used in milk chocolate, dough and other process food plants, for paints, pharmaceuticals indeed for almost every mass production system which uses piping to transport its products.

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