PLUGGING METHODS FOR IN-SERVICE PIPELINE SYSTEMS

Pipelines have been used as a safe, reliable way to transport a multitude of products for many decades. The reliance we place on pipelines as a transportation system, has also accentuated the uptime requirement for these pipeline systems.

But, like anything mechanical, there are times when even the most reliable machine had to be taken out of service for much needed, or even critical maintenance or repairs. The same applies with pipelines.

When a pipeline is taken out of service for any length of time, there are consumers and producers (sellers) who bear the financial impact and the inconvenience of it all.

Needless to say, then, plugging a section of pipeline, to isolate a very specific section, is a way to shorten the downtime of the overall pipeline being taken out of service and also the recommissioning time is shortened significantly. For this topic, we will disregard technology that will ensure continued flow in a pipeline, regardless of the work being done on it.

The most basic method is probably by simply turning the pipeline off, vent or drain the contents and then effect the required modification or repair, and after all this is done, re-commission and continue to use. The problem with this approach is that the downtime is long and expensive. This negates the whole argument of pipeline being a reliable form of transportation.

The second form I would look at, is freeze plugging. The basic premise that this technology is based on, is that the contents within a pipeline is frozen to form a plug or two plugs at a position upstream and downstream from a location that we plan to execute work on, be it a modification or repair. We will not delve too deep, but there are gel freezing plugs that can be used on gas pipeline systems.

This is a non-intrusive method to create a frozen plug inside the pipeline, stopping the flow of whatever product is in the line, with some, very important criteria; the contents must have the ability to freeze, the line must be full of that product and there must be zero flow through the pipeline.

Broadly speaking, a jacket or rather a cryogenic heat exchanger, is placed around the pipe location where the freeze plug is required. Liquid nitrogen is commonly used and is circulated within this jacket to cool the pipe and its contents down, sufficiently, in order to freeze the contents in the pipeline.

This technology has made advances throughout the years and it is not uncommon to see these freeze plugs being used in hydrotesting activities that may see freeze plugs withstand pressures beyond 3,000 psi.

It is also interesting to note that almost any type of pipe material can be subjected to this method of isolation, assuming certain parameters are adhered to and precautions taken.

The third method we will look at, is an inflatable bag that is inserted into the pipeline. We will focus on the method to insert an inflatable system into a pipeline under pressure. Many moons ago, Iris equipment allowed the installation of a bag together with a device, that, when deployed inside the pipeline through a tapped hole, would open up like a daisy and the bag would locate against this device, which would support the bag and prevent it from moving. Well, that was the theory anyway. Iris is no longer in use today, but there are some really effective systems available for this application. Basically, a hole needs to be tapped into the pipeline; the size of hole is generally determined by the size of the folded gas bag. The bag is sized according to the prevailing conditions inside the pipeline. The length is determined by considering the contact surface area required of an inflated bag, to overcome the force exerted by the column of water it is trying to hold back; in other words, the friction the bag exerts must overcome the force of the water column trying to push it down the line. The bags are limited in terms of pressure application but offer a very economical option for isolating pipelines; probably better suited to water and wastewater. The bags are made from a durable material outer, like ballistic nylon, with an inflatable inner bladder.

The bags (either one single bag or two bags in some cases) are contained in a housing and once a hot tap large enough has been completed, the bags can be placed in position with a simple mechanically operated cylinder. To help make the setting of these bags easier, some are fitted with a nosewheel that will contact the bottom of the pipe wall, causing it to deflect almost 90-degrees, to sit neatly inside the pipe, ready to be inflated and isolate the pipeline.

This system comes into its own on larger pipe diameters with pressures below 100 psi as a standard off the shelf option, but a more bespoke version would probably handle slightly higher pressures.

The next method for isolation, is also one of those simple yet effective ways that is impressive it its simplicity; valve insertion.

There are a few options to choose from; one type will require hot tapping the pipeline section through a bolted fitting and the other, milling a slot through the pipe wall for the gate to fit through.

Maximum application pressure is in the order of 250 psi and as far as I am aware of, hydrocarbon application of these valves is not recommended. These valves can be inserted onto any pipe material, uPVC, HPDP, DI, AC & CS and for sizes of 12" and below it takes one technician just under an hour to complete the installation, which is also one of the positive features of this technology.

The next option under the spotlight is line stopping. The technology was pioneered around 1956 and was referred to as a line stop or "Stopple" ® as it was termed by the pioneer, TD Williamson.

Even though "Stopple" ® or line stop refers to a method of isolating a pipeline section, it is indeed more of a system, encompassing a host of activities to arrive at the point where a pipeline can be isolated.

The activities being referred to are the following:

- Supply and install a special line stop fitting onto a pipeline section by welding this fitting during a period when the pipeline is in operation. This in itself is not only a critical activity but requires exact and precise consideration to be given to pipeline operating conditions (flow, pressure, temperature, wall thickness and a slew of other factors) to ensure successful and reliable weldment.
- The main differences between a normal hot tap fitting and a line stop fitting, lies in the following:
    - Type of flange on these fittings. This flange is fitted with segments recessed in the flange ID and the matching completion plug fits snugly inside the flange ID, seals with an o-ring and has a matching slot for these segments to engage and keep the plug intact under pressure. This allows the user to recover the expensive low-profile valve used in plugging operations.
    - Line stop fittings would be a size on size fitting, with the exception of a folding plugging head, which is a derivative of the line stop plugging option.
- Once the fitting is welded to the pipeline, NDT and pressure tests completed, a low-profile valve (sandwich type valve) installed onto the flange, then a hot tapping machine is installed and a hole is tapped into the pipeline, equal to the pipe ID.
- By manipulation of the low-profile valve, the equipment is installed and removed during the process to allow for access to the pipeline under pressure.
- The tapping machine is removed, and the plugging actuator fitted with a plugging adaptor and pivot plugging head is installed.
- The pivot plugging head consists of control bar head with attaching bolts to fix the plugging head to the hydraulic actuator, yoke and yoke pin that forms the pivot between the yoke and control bar head and lastly the nose piece where the sealing element is attached.
- The sealing element is a disc type cup made from a rubber compound that is bolted onto the nosepiece. This is what will provide a seal when the pivot head is lowered into and set in the pipeline. The sealing elements are correctly sized for each pipeline diameter, wall thickness and service application. The quality of seal is dependent on pipe roundness, internal pipe condition and internal cleanliness, but a workable seal is achieved in most cases.
- Traditionally a secondary barrier is created by inserting an inflatable gas bag downstream of the plugging position and any leak is vented through a fitting installed in between the gas bag and plugging head. Now it is safe to proceed to cut and perform remedial work.
- There are permutations to the type of isolation carried out:

    - Single position: One fitting and one plugging assembly (consisting of actuator, plugging adaptor, pivot head and sandwich valve). This is done in zero flow condition and isolates the pipeline completely.
    - Double position: Two fittings and two plugging assemblies (consisting of actuator, plugging adaptor, pivot head and sandwich valve). This is done in conditions where there is minimal to zero flow and isolates the pipeline completely.
    - Double position with bypass: Two fittings and two plugging assemblies (consisting of actuator, plugging adaptor, pivot head and sandwich valve). This is done in conditions where there is minimal to zero flow and isolates the pipeline completely but does not disrupt the flow through the pipeline whilst work is being carried out.
    - There are other options, but that is the subject for a more technical discussion on pipeline isolation.
- So, at this point the pipe section has been isolated and repair or remedial work has been completed.
- The first order of business is to create a pressure differential of zero across the sealing elements to allow us to remove the line stop actuators.
- Once removed, we will attach the completion plug onto the hot tap machine boring bar.
- The tapping machine with the plug is installed onto the sandwich type valve and the plug is carefully lowered into position with the com,pletion flange so that the recess and segments in the flange line up. This is only possible when time was spent before commencing with the hot tap to take careful measurements of all aspects of the assembly (fittings, machine, sandwich valves and a host of other)
- Once the plug has been set, the equipment can be removed, and a blind flange installed on the line stop fitting and the isolation is done.

Admittedly, this is a very onerous process, but considering the pipeline pressures and temperatures that this technology can be used on, it is understandable that the safety of this method also lies in the proven processes that has to be followed.

It is also important to note that there have been some interesting advances made in the line stop offering. Double block and bleed systems, high temperature applications or even very high-pressure applications, previously viewed in the same light as the unicorn, a mythical fable indeed.

Lastly, and the most advanced option under discussion, is the use of an untethered, remote operated isolation pig. Such systems have been successfully used on offshore pipelines for decades and more recently they are being used successfully on onshore pipeline as well.

Typical attributes and functions of an isolation pig are:

- it can be launched and received using normal pipeline launchers and receivers that can handle smart pigs
- it is pigged to location with either product or other medium in the pipeline, it does not self-propel
- it is tracked using normal pig tracking methods, but typically also has on-board built in pig tracking transmitters
- some models can create bubble tight seals in gas or liquids
- some models can negotiate 3D or even 1.5D bends
- they are commanded to set and form a seal by receiving coded signals from a transmitter located above ground, outside of the pipe
- their operating condition can be monitored remotely via their onboard communications systems
- some models can perform multiple sets and unsets on a single pig run allow for multiple isolations
- once the seal or isolation is no longer needed, they are pigged out of the pipeline and are received in a pig receiver (or launcher acting as a receiver)

To help explain the benefits of an untethered isolation pig let us look at the steps for a basic application - isolating a pipeline in order to repair or change out a launcher valve.

- insert the isolation pig into the launcher
- launch the isolation pig in to the pipeline and move the pig with nitrogen to position it just downstream of the subject valve. A precise setting location of the isolation pig is not needed so long as it is downstream of the valve
- stop the flow in this section of pipeline.
- remotely set the isolation pig
- Note that if piping permits the pipeline downstream can start operating again downstream of the isolation pig
- excess nitrogen pressure is relieved, either at the launcher or at the valve
- work is performed on the valve
- when the work on the valve is completed, equalize the pressure across the isolation pig and unset it
- push the isolation pig back into the “launcher” (which is now being used as a receiver) and remove it from the launcher

As you can see using an isolation pig does not require the use of external fittings nor does it require the use of tapping or welding on an in-service pipeline. The added benefit is that there are no fittings, extra valves or blind flanges left on the pipeline once the project has been completed.

For as long as we have operating pipelines conveying everything from water to oil, gas and fuel, a need will remain to safely isolate pipelines.

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