PIPELINE REPAIR METHODOLOGIES

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ABSTRACT
Pipelines are subjected to risks that can cause damage to them. These risks are such as internal corrosion due to corrosive fluids, erosion caused by the presence of the solid particles in the flowing fluid, external corrosion, and vandalism of pipes to the external surface of the pipe. In a case of damage and leakage in the pipeline, in addition to the large loss in the product and significant economic loss, it also causes environmental pollution. Therefore, identifying pipeline repair methods and knowing the condition in which each one is applicable is important. From the first day of using pipelines until now, many methods have been used for repairing pipeline defects. While all kinds of defects were always the same, repair methods have been continuously improving to reduce the time, cost and increasing safety and operational certainty. The impact rate of each of these varies according to the parameters such as type of damage, working environment (land and sea), working pressure and temperature, pipe length, fluid, etc. In this project the various methods of detecting pipeline defects, types of pipeline repair and required equipment have been reviewed.

Keywords: Repair, Pipeline, Corrosion, Vandalism.
1.0 INTRODUCTION

When people think of pipelines, they often associate them with the oil and gas industry. But pipelines have broader use than just for this industry, and the technology is not new. In fact, there is a long history of societies using pipelines to provide transportation to fill a variety of important needs.

A pipeline in the oil and gas industry is a channel made of pipes used to convey gas or petroleum products. The word Repair simply means to restore or fix a damaged condition. Now Pipeline repair methods are the different methods or ways used to fix a damaged or faulty pipe.

Early references to pipelines span a large part of the globe: clay sewer pipes used by Babylonian settlements in 4,000 BC; Greek and Roman installations for water supply, sewer and storm sewer systems; Mayan civilizations with indoor plumbing using pressurized water; and Han Dynasty installations of stoneware pipelines supplying water to the Imperial Palaces in China in 189 AD. It is interesting how many of these pipeline applications were developed independently by different cultures with large geographical distances between them.

The pipeline network is a transportation system used to move goods and materials. Pipelines transport a variety of products such as sewage and water. However, the most common products transported are for energy purposes, which include natural gas, biofuels, and liquid petroleum. Pipelines exist throughout the country, and they vary by the goods transported the size of the pipes, and the material used to make pipes.

While some pipelines are built above ground, others are located inside water bodies some are also buried underground.

There are two main categories of pipelines used to transport energy products:

Petroleum pipelines: transports crude oil and there are three main types of petroleum pipelines involved in this process: gathering systems, crude oil pipeline systems, and refined products pipelines systems.

Natural gas pipelines: transport natural gas from stationary facilities such as gas wells or import/export facilities, and deliver to a variety of locations, such as homes or directly to other export facilities.
It is dangerous for habitation to thrive in places that oil and gas pipeline networks are located and since they are well concealed from the public, most individuals are unaware of their existence. Therefore, legal rights called *Right of Way* is granted to pipeline companies that prevent habitation in such areas.

1.1 TYPES OF PIPELINE REPAIR

1.1.1 TEMPORARY

Temporary repairs are used when the operator plans to complete a more comprehensive repair or replacement at a later time and its duration is commonly specified by the pipeline Engineer.

1.1.2 PERMANENT REPAIRS

A permanent repair is typically intended to restore the pipeline to service for a period greater than five years without a requirement for re-evaluation.

1.2 REASONS FOR PIPE REPLACEMENT

There could be varieties of reasons why pipes are needed to be replaced ranging from the weather to damages, to wear and tear, to vandalism, to re-channelling. Amongst all these mentioned above, it could depend on majorly on locations and weather, as these mentioned reasons could vary with location. For example, in a country like Nigeria, we are quite familiar with the challenge of oil bunkering and pipeline vandalization which poses a threat to human life.

For pipe replacement, the pipe life varies between 30 – 50 years life span of which requires replacement.

For every replacement that is to be done, there’s a unique approach of either total or partial technique that’s used.
1.3 CONSIDERATIONS FOR DETERMINING THE MOST APPROPRIATE METHOD OF REPAIR

After it has been determined that a repair is required, the next question that must be answered is: “How are we going to repair it?” The answer to this question varies and is based on many different elements. There are many acceptable repair methods recognized by the industry, however not all repair methods are applicable in all situations and some repair methods require special procedures to be in place in order to ensure they are properly completed. Timing, material availability, or the additional procedures that may have to be in place, all can have an impact on the method selected to repair a pipeline.

It is important to consider the limitations of each repair method in order to determine whether the repair method is valid, per industry codes, standards and best practices, and whether it is feasible with respect to the specific situation.

Below are some considerations prior to implementing repair methods:

- Does the defect or damage affect a seam or girth weld?
- Is the defect, damage, or anomaly leaking?
- Can the pipeline be shut down or diverted?
- What is the size of the targeted repair?
- Schedule/availability of materials: How soon is the repair required to be completed?
- Are all required procedures and qualified personnel available to perform the repair?
After all the considerations are been made and a method chosen the next thing is to execute it.

1.4 OIL AND GAS PIPELINE TESTING METHODS

Federal minimum pipeline safety regulations that establish minimum requirements for liquid pipeline safety integrity management allow four approaches to assess pipeline integrity:

- Inline inspection or “ILI,” often called smart pigging,
- Magnetic flux tools
- Ultrasonic tools
- Hydrotesting
- Direct assessment for external corrosion
- An equivalent other technology that must be noticed and demonstrated to PHMSA before it is used for a particular threat on a pipeline segment.

Federal regulation establishes a maximum reassessment period of no longer than 5 years, not to exceed 68 months. The federal regulations are mute as to the various strengths and weaknesses of the four allowed above assessment approaches, but place the obligation on the company to know and select which inspection method(s) best matches the threats on a specific pipeline segment, and the need for more frequency reassessments using these permitted assessment methods. The following is a brief perspective of the above assessment methods:

1.4.1 IN-LINE INSPECTION TECHNOLOGY

There are different categories of in-line inspection technology:

1.4.1.1 SMART PIGGING
Smart Pigging is the practice of using devices known as ILItools or smart pigs to perform various periodic maintenance inspections usually on a flowing or operating pipeline. Smart pigs are often long, multi-ton, complex devices consisting of at least four main parts:

1) A sensor section designed to possibly identify specific threats the pig is intended to identify such as corrosion,
2) A battery power source
3) Data gathering/storage segment
4) A driver segment, usually using the flowing pipeline fluid to move the pig along the main pipeline.

1.4.1.2 MAGNETIC FLUX TOOLS:

There are two types of tools commonly used for inspections of hazardous liquid pipelines based on magnetic flux measurements.

A) A Magnetic Flux Leakage (MFL) tool
Magnetic flux leakage (MFL) tool is a magnetic method of non-destructive testing that is used to detect corrosion, pitting and wall loss in steel structures through the use of a temporarily applied magnetic field in the axial or direction of pipeline flow.

![Magnetic Flux tool](image)

**Fig 3:** A Magnetic Flux tool

B) A Transverse MFL/Transverse Flux Inspection tool (TFI)

This identifies and measures metal loss through the use of a temporarily applied magnetic field that is oriented circumferentially, wrapping completely around the circumference of the pipe. It uses the same principle as other MFL tools except that the orientation of the magnetic field is different (turned 90 degrees) and this different magnetic field alignment creates some highly complex challenges to reliably detect and identification of such imperfections.

1.4.1.3 ULTRASONIC TOOLS

![Ultrasonic inspection tool](image)

**Fig 4:** An Ultrasonic inspection tool

There are two types of tools commonly used for inspections of hazardous liquid pipelines based on ultrasonic measurements.

A) Compression Wave Ultrasonic Testing (UT) tools
This measures pipe wall thickness and metal loss. The first commercial application of UT technology in ILI tools used compression waves. These tools are equipped with transducers that emit ultrasonic signals perpendicular to the surface of the pipe. An echo is received from both the internal and external surfaces of the pipe and, by timing these return signals and comparing them to the speed of ultrasound in pipe steel, the wall thickness as well as whether the corrosion is external and/or internal can be directly determined.

B) Shear Wave Ultrasonic Testing (also known as Circumferential Ultrasonic Testing, or C-UT)

This is the nondestructive examination technique that more reliably detects longitudinal cracks, longitudinal weld defects, and crack-like defects (such as stress corrosion cracking). Because most crack-like defects are perpendicular to the main stress component (i.e., the hoop stress), UT pulses are injected in a circumferential direction at an angle to obtain a maximum acoustic response. Shear Wave UT is categorized as a liquid coupled tool. It uses shear waves generated in the pipe wall by the angular transmission of UT pulses through a liquid coupling medium (oil, water, etc.).

1.4.2 HYDROSTATIC TESTING

Hydrostatic pressure testing is generally used for the post-construction testing of hazardous liquid pipelines and higher stress natural gas pipelines. In a pressure test, a test medium (water) inside the pipeline is pressurized by the use of specialized pumps to raise the test pressure with water to a level that is greater than the maximum operating pressure of the pipeline. This test pressure is held for a number of hours to ensure there are no leaks in the pipeline.
Any indication of leakage requires the identification and repair of the leak. The pipeline is then re-pressurized and the test is repeated. The operational integrity at the time of the hydro test of field welds and more importantly of the pipe itself is assured if the pressure test is successfully completed.

Hydrostatic testing is also widely used to periodically reassess the integrity of hazardous liquid and gas transmission pipelines (particularly when the use of "smart pigs" is not feasible nor appropriate given the state of developing ILI technology). If a pipeline successfully passes a hydrostatic pressure test, it can be assumed that no hazardous defects are present in the tested pipe at the time of the hydro test.

1.4.3 DIRECT ASSESSMENT FOR EXTERNAL CORROSION

In limited instances where only external corrosion is a threat to pipeline integrity on a pipeline segment, a process called "direct assessment”—an inferential method of evaluating the integrity of a pipeline may be used in such limited situations. In Direct Assessment, various indirect measurement tools are used to determine locations on the pipeline that may require, in the judgment of the pipeline Engineer performs a direct examination to verify pipeline integrity. These locations are then excavated and examined to verify that the pipe is in good condition or to make necessary repairs. The weakness of Direct Assessment is that not all parts or a pipeline segment are actually evaluated. (And accurate data are not gotten making the accuracy level not always acceptable)
1.4.4 OTHER TECHNOLOGIES

In order to encourage the advancement of assessment technologies federal pipeline safety regulations to permit pipeline companies to propose Other Technologies to assess pipelines insensitive high consequence areas. The pipeline Engineer must, however, demonstrate to PHMSA before the use of such Other Technologies that “the Engineer demonstrates can provide an equivalent understanding of the condition of the line pipe.” The burden of proof is on the pipeline engineer before they choose to try to utilize such Other Technologies in the field. (There are a series of required steps required to demonstrate this other approach to the regulatory agency. This is very important).

2.0 PIPELINE REPAIR METHOD

There are varieties of repair methods applicable to either oil or gas pipelines or for both, these methods include;

- Mechanical Sleeves (Sleeving)
- Hot tapping
  - Mechanical bolt-on clamps (structural clamp)
  - Weld overlay / Direct weld deposit
  - The cut out and replace method (Sectional Replacement)
  - The grinding method

2.1 MECHANICAL SLEEVES

This mainly consists of the following two types:

2.1.1 STEEL REINFORCING SLEEVES (TYPE A)

Type A sleeves are particularly attractive because they can be installed on a pipeline without welding to the carrier pipe. Such sleeves provide reinforcement for the defective area. They cannot contain the pressure and are used only for nonleaking defects. To protect the repair crew from a defect that may be on the verge of failure, they should be installed at a pressure level below that at which the defect might be expected to fail (e.g., 20% less than that the pressure that was present at the time the defect was discovered). A typical configuration and weld details for a Type A sleeve are shown in Figures 2 and 3 below, respectively.
The sleeve consists of two halves of a cylinder of pipe or two appropriately curved pieces of plate that are placed around the carrier pipe at the damaged area and after positioning, are joined by welding the longitudinal side seams. As shown in Figure 2, the seams may be single-V butt welds or overlapping steel strips fillet welded to both halves. If the side seams are to be butt welded and the sleeve halves are to be made from the same diameter pipe as the carrier pipe, then each half should actually be more than half of the circumference of the piece of pipe (Figure 3). Otherwise, the gap to be filled by butt welding will be too large.

With the overlapping strip concept, it is not essential that each half actually be more than half of the circumference because the gaps can be easily bridged by the side strips. One major advantage of Type A sleeves over other types of repairs is that for relatively short flaws they can function effectively without necessarily being a high-integrity structural member. Relatively short flaws are those for which the length\((L)\) is 20Dtp, where \(D\) is pipe diameter, \(t\) is the pipe wall thickness, and all dimensions are inconsistent units. This is the length beyond which hoop stress can no longer distribute itself around the flaw. For such flaws, the role of the sleeve is limited to restraining bulging of the defective area. As a result, they can be fabricated simply and require no rigorous non-destructive inspection to ensure their
effectiveness. Also, because Type A sleeves do not carry much hoop stress in the case of short flaws, they can fulfil their restraining role without necessarily being as thick as the carrier pipe. As a rule of thumb, the thickness of Type A sleeves should not be less than two-thirds of the thickness of the carrier pipe when used to repair short flaws (as already discussed), assuming that the sleeve is at least as strong as the carrier pipe. When designing a Type A sleeve, it is common to simply match the grade and wall thickness of the carrier pipe. With flaws longer than 20Dtp.

![Image](image)

**Fig 4:** Sleeve fabrication from pipe material.

The sleeve thickness should be at least as great as that of the carrier pipe, again assuming that the sleeve is at least as strong as the carrier pipe. Since hoop stress cannot redistribute itself around these longer areas, they may plastically yield transferring some of the hoop stress to the sleeve. It is acceptable to use sleeves thinner than the carrier pipe if their strength is increased by an amount sufficient to compensate for their thickness being less than that of the carrier pipe. In a similar fashion, the sleeve could be of an acceptable material with lower strength than that of the carrier pipe if its thickness is increased to compensate for the difference in strength. To assure that adequate reinforcement exists and that the sleeve will indeed prevent a rupture, the sleeve should be extended beyond the ends of the defect (i.e., onto sound, full-thickness pipe material) at least 50mm (2in.).
2.1.2 TYPE B SLEEVES (PRESSURE CONTAINING)

The other type of steel sleeve used to make pipeline repairs is known as a Type B sleeve. The ends of Type B sleeves are fillet welded to the carrier pipe. The installation of a Type B sleeve is shown in Figure 5.

![Type B repair sleeve](Image)

Fig 5: Type B repair sleeve

As with Type A sleeves, the primary purpose of tight-fitting Type B sleeves is structural reinforcement (i.e., to prevent a defect from bulging). Since their ends are attached to the carrier pipe, Type B sleeves can be used to repair leaks and to strengthen circumferentially oriented defects. In fact, Type B sleeves have been used in place of girth welds to make tie-ins on a pipeline. Because Type B sleeves may contain the pressure and/or carry substantial longitudinal stress imposed on the pipeline by lateral loads, they should be designed to carry the full pressure of the carrier pipe. Additionally, they should be carefully fabricated and inspected to ensure integrity.

The typical configuration of a Type B sleeve is illustrated in Figure 6. It consists of two halves of a cylinder or pipe or two appropriately curved plates fabricated and positioned in the same manner as those of a Type A sleeve. Since the Type B sleeve is designed to contain full operating pressure, the ends are welded to the
carrier pipe, and butt-welded seams are required. For sleeves that will be or may become pressurized, the overlapping strip concept is not acceptable because fillet welds are inherently weaker than sound full-thickness butt welds. Type B sleeves should be designed to the same standard as the carrier pipe. This usually means that the wall thickness of the sleeve will be equal to that of the carrier pipe and that the grade of the sleeve material also will be equal to that of the carrier pipe. It is acceptable to use a sleeve that is thicker or thinner than the carrier pipe and is of lesser or greater yield strength than the carrier pipe as long as the pressure-carrying capacity of the sleeve is at least equal to that of the carrier pipe. Many companies simply match the wall thickness and grade of the pipe material. For tight-fitting sleeves, the outside diameter of the sleeve is slightly greater than the outside diameter of the carrier pipe. Usually, this point is ignored in the sleeve design even though it causes the sleeve to be slightly under-designed when it’s made from the same material as the carrier pipe. If material is removed from the sleeve for a groove to accommodate the carrier pipe seam weld or a backing strip for the sleeve side seam welds, the thickness of the sleeve should be greater than that of carrier pipe by an amount that compensates for the material that is to be removed.

Sleeve Length While it should be long enough to extend beyond both ends of the defect by at least 50mm (2in.), there is no inherent upper limit to the length of a Type B sleeve. However, practical considerations are likely to impose some limits on sleeve length. If the sleeve length is limited, two requirements should be satisfied. First, as mentioned previously, the sleeve should extend at least 50mm (2in.) beyond both ends of the defect. Second, the fillet-welded end of one sleeve should not be any closer than one-half of the carrier pipe diameter to the corresponding end of another sleeve. This latter requirement is needed to avoid a notch-like condition between the two sleeves. If two sleeves should be placed closer than one-half pipe
diameter apart, the inboard ends of the sleeves should not be welded to the carrier pipe. Instead, a bridging sleeve-on-sleeve should be used or the sleeve ends should be joined using a full penetration butt weld (Figure 7).

![Fig 7: Methods of joining the ends of adjacent sleeves](image)

Another important factor that should be considered when installing long sleeves is the weight that is being added to the pipeline in conjunction with how it is being supported during the sleeve installation process. When the sleeve length exceeds four pipe diameters or when two or more sleeves whose total length exceeds four pipe diameters are to be installed within a single excavation, the pipeline Engineer's written procedures should contain guidelines for support spacing, methods of temporary support (e.g., airbags, sandbags, skids), and soil conditions under the pipeline upon backfilling. One use for Type B sleeves is to repair leaking defects. Type B sleeves installed over leaking defects become a pressure-carrying component and should meet the same integrity requirements as any other pressure-carrying component in the system. These include the appropriateness of the design (i.e., wall thickness, material grade) and the integrity of the side seams and end fillet welds.

Type B sleeves are installed over leaks in a variety of ways;

1. Elastomer seal between the carrier pipe and sleeve; Chains and hydraulic jacks are then used to force the sleeve halves against the carrier pipe.
2. A small branch pipe with a valve over a hole in one of the sleeve halves. The hole and branch are located over the leak and a doughnut-shaped elastomer seal is placed between the carrier pipe and sleeve. Chains and hydraulic jacks are then used to compress the seal that forces the fluid to enter the branch. The fluid then can be released at a safe location and welding of the sleeve can be completed safely. Upon completion of sleeve fabrication, the branch valve is closed and capped. A variation of the same technique uses a plug to seal the branch through the valve, which allows the valve to be recovered.

2.2 HOT TAPPING

Hot tapping, also known as pressure tapping, is a method of connecting (either by drilling or cutting) to a pressurized system, such as a pipeline or pressure vessel, without removing the pipe or tank from service. This prevents costly and potentially dangerous environmental hazards while allowing for continued operation.

Hot tapping strictly refers to the installation of connections to pipelines while they remain in service. In the welding context, it is commonly used for any welding onto in-service equipment. Hot tapping is frequently used in order to repair areas that have undergone mechanical damage or corrosion or to add branches for system modifications. There are distinct economic and environmental advantages to performing this welding without removing a pipe from service.

Problems can occur with hot tapping when the risk of burn-through, unstable decomposition of the flowing product and the risk of hydrogen cracking is not considered adequately.

Burn-through occurs when welding onto a pressurized pipe if the unmelted area beneath the weld pool is not strong enough to contain the internal pressure of the pipe. The greater the wall thickness of the pipe, the less the risk of burn-through. Unstable decomposition of the flowing product can cause violent reactions when heated under pressure; this is prevented by taking special precautions to prevent the internal wall temperature from exceeding a critical temperature. This critical temperature is dependent on the nature of the flowing product.
The risk of hydrogen cracking is increased for hot tapping in comparison to other welding situations, due to the flowing product increasing the rate of heat flow from the weld region. This leads to shorter cooling times, with an associated increased risk of forming hard microstructures and thus greater susceptibility to hydrogen cracking.

The cracking risk can be reduced by the use of low-hydrogen electrodes, and through careful selection of heat input. Preheat control is sometimes possible, but the cooling capacity of the flowing contents can make this an inefficient approach. Temper bead deposition sequences can be used to control hardness.

**2.2.1 THE HOT TAPPING PROCESS CONSIST OF TWO PHASES**

1. The welding process in which the nozzle part has to be fixed online.
2. The mechanical cutting of the hole onto the pipe/equipment.
2.2.3 PROCEDURE FOR HOT TAPPING SAFETY

1. Hot tapping work shall be carried out by a specialized contractor.
2. The risk assessment shall be carried out by specialized consultants who are having the required expertise and knowledge.
3. The contractor shall obtain approval from the company for a specialized contractor/consultant for hot tapping.
4. Once work has started, it should proceed without interruption until the hot tap has been completed and the valve closed.
5. Determination of metal thickness- the area to be hot tapped shall be visually and physically identified. An ultrasonic thickness test measurement of the metal must be made, within 48 hours before work, at the exact location(s) of the proposed hot tap.
6. Prepare all the materials as the approved specification for tie-in.
7. Bench test on all valves prior to the installation shall be carried out. It is nothing but a hydro test of the valve body and steam in presence of PD.
8. QC approval shall be taken prior to fitting.
9. Hot tapping is not applicable for stress relief pipelines.
10. Flow in Lines- such as flare line it is necessary to continuously purge or flood the line with steam, inert gas, hydrocarbon gas to ensure the line does not have gas pockets of the flammable mixture during the welding process.
11. At any time during Hot tapping operation pressure of fluid inside the pipe shall not exceed 7000kpa and hot tapping shall not be carried out on subatmospheric pressure.
12. Hot tapping shall not be carried out on pipes that contain:
   i. Hydrogen.
   ii. Vapour/ air or oxygen/vapour mixture.
   iii. Chemicals such as acid and chlorides.
   iv. Caustic and amines.
   v. Unsaturated hydrocarbon such as ethylene.
   vi. Oxygen enriched atmosphere or chlorine.
   vii. Compressed air.
   viii. Equipment and piping under vacuum.
   ix. Sulphuric acid.
   x. H2S above toxic level.
13. Welding shall be qualified and expert in butt welding joints and pass muck up test.

14. Parameter, operating techniques, electrode shall be detailed in procedure and must be strictly followed.

2.3 MECHANICAL BOLT-ON CLAMPS (Structural clamp)

They are designed to encapsulate damaged or leaking pipes and restore pressure integrity through mechanical seals or locks engaging on the sound parent pipeline section.

It consists of housing comprised of two half-shells, with two end gasket rings tightened against the pipe outer diameter by bolting. Clamps are usually employed for emergency pipe repair work. They provide the sealing of damaged pipes without shut down or disruption to critical service.

The clamp halves are joined by bolts to form a high integrity pressure vessel around the damaged or leaking pipe. Sealing is provided by elastomer seals of the highest quality selected for compatibility with the pipeline fluid and operating temperature. Certain clamps may be welded to the pipe in which case the clamp may be pressure tested and the welds examined for a permanent repair.

This versatile mechanical joint fitting is built to meet the specific requirement of special applications. It is applied where strength, weight and continued service are critical.

2.3.1 APPLICATIONS OF CLAMPS

- They are used to repair cracks
- Used in the repair of longitudinal and circumferential breaks
2.4 WELD OVERLAY/DIRECT WELD DEPOSIT

This is a welding process where one or more metals with specific characteristics are applied to a base metal to improve desirable properties or to restore the original dimensions of the component. It is also referred to as cladding.

Instead of general welding which is the process of joining two material pieces together, weld overlay applies a corrosive resistant or hard facing layer to the parent metal.

2.4.1 USES OF WELD OVERLAY

- It is used for corrosion resistance.
- It is used to restore the original dimensions of components.

2.4.2 CONSIDERATIONS FOR WELD OVERLAY

It consists of depositing weld reinforcements on the pipe surface. Several considerations apply:

- Compatibility of the weld.
- The sequence of the weld bead deposition.
- The number of passes.
- The necessity to minimize residual stress
2.5  THE CUT OUT AND REPLACE METHOD

This outlines the procedure for cutting out a section of the pipeline when it is damaged and needs repair. The method used is cold cut which is a standard rule to use if the pipe is operational. Cold cuts are performed on the pipeline in order to remove a section of pipe for new installations of piping or equipment, rerouting the pipeline or replace defective pipe sections. No electrical or hot equipment is used. Before cold cutting can be done, the pipeline section must be shut down, isolated and drained or purged of the product. Once the pipeline has been cut open, any trapped product must be drained and removed and the atmosphere tested safe, you can continue with the next portion of the work using power equipment and/or torches. Cold cutting on the pipeline will usually be only one part of a larger scope of work. This procedure, along with procedures covering the other aspects of the scope of work, such as work area protection and coordination of multiple crews will have to be considered when doing a risk assessment and developing a written plan for the job.

![Fig10: Cold cutting method carried out on a pipe.](image)

2.5.1  COLD CUTTING EQUIPMENT

The Cold Cutting equipment used to cut pipelines is a much larger version of the simple tool used by plumbers to cut copper pipe. An appointed, authorized or designated person who has knowledge and understanding, through experience and training on how to use the cold cutting equipment on the pipe does the job.
2.5.2 HAZARDS AND PRECAUTIONS

A Safety Supervisor (Safety Watch) is required during a Pipeline Cut-out. This is to make sure that they won't be any problems encountered during the procedure. Some springing from misalignment, especially in pipeline risers, should be expected. Care should be taken to prevent sparks from mechanical ditching if the soil is contaminated with oil, particularly if it contains high levels of light ends.

If the pipeline is damaged, whenever possible, the damage should be repaired temporarily with a sleeve, or equivalent and the lines should be purged of fluid.

2.5.3 SITE PREPARATION

The job coordinator will:

- Specify the location at which the cut out is being performed
- Arrange for the required section of pipeline to be exposed
- Schedule downtime through the Products Movement department
- Arrange for isolation of section of line with four nearest block valves (two each upstream and downstream)
- Arrange for purging of the line or drain down as appropriate.
- Prepare a Job Specific written plan and complete a Risk Assessment as required.
- Prepare work site and arrange for equipment to be on-site in advance of the cutout date.
- Review procedures and job-specific execution plan and tour site(s) to understand specific job requirements.
- Excavate if required and fence the site if it is to be left unguarded.
• Ensure excavation is wide, deep and long enough for adequate work access.
• At the cutout points, ensure there is adequate clearance below the pipeline for the cutter to work.
• Take into consideration water accumulation and removal when excavating, prepare excavation accordingly.

2.5.4 SUGGESTED TOOLS & SAFETY EQUIPMENT

• Pipe cutters and handle (as appropriate for the size of the pipe)
• Extra cutting wheels
• Bonding clamps and length of bonding cable
• Knives and files
• Drip tubs and tarps and absorbent
• Fire extinguishers
• Gas atmosphere monitors

2.6 PIPE GRINDING AND RECOATING

Pipe grinding is used when base metal or welds contain fabrication or service-induced defects (weld flaws, arc burns, gouges or cracks). It produces smooth surfaces and removes harmful stress concentration, defects and micro-cracks. Repair of mechanical damage by grinding has historically been allowed by several standards. Ground surfaces are examined by liquid penetrants or magnetic particles to confirm that the defect has been removed. The ground area may be left as it is without weld deposit, provided the remaining wall thickness exceeds the minimum requirement by code.

Minor damages, welding anomalies, or line pipe metallurgical discontinuities can be removed through grinding, thus eliminating the possibility of crack initiation. Additionally, grinding is used to remove stress concentrations due to the presence of extremely hard or relatively softer metal in completed pipelines.

Codes/standards do not provide any limitation on the length of grinding span when it is used to remove metal that is < 10% of designed pipe wall thickness. Grinding should not be used to remove metal more than 40% of the designed pipe wall thickness. The die penetrant
method of magnetic flux can be used to check for soundness of repair. If required (when the remaining pipe wall thickness is less than minimum allowable wall thickness), the metal loss can be re-deposited through a welded patch, or a composite wrap can reinforce that portion.

Certain restrictive conditions are also commonly applied for grinding, which includes:

• The operating pressure should be reduced to 80 percent during the repair process.

• If the crack or the affected material near the defect is not entirely removed by grinding, an alternative repair technique must be applied.

• The removal of all cracks must be verified by non-destructive NDT testing after grinding.

• Removal by grinding of more than 40 percent of the wall thickness is not accepted.

In pipeline construction, weld quality is paramount. Every weld is X-rayed — so any weld defect costs time and money to repair. Properly preparing and cleaning the base material is the first step toward ensuring quality welds and minimizing defects in the demanding pipeline environment.

Consider the various options for preparing and cleaning pipeline materials and welds, along with best practices for each solution.

The first step is to prepare the bevel. A pipe is generally delivered to the job site with a bevel already created. However, it will require cleaning and shoring up the land, which is the flat portion at the end of the bevel, using a grinding wheel. This flat area allows for proper
spacing between the two pipe ends so they can be aligned and tacked together for welding. A notching wheel or 1/4-inch grinding wheel work well for this task.

When using a grinding wheel, don’t dwell too long in any one spot, as this can gouge the material. Instead, keep the wheel in motion and travel the circumference around the land, while keeping the wheel as flat as possible.

Once the land has been created, the bevel and interior diameter of the pipe opening should be cleaned for welding. The right tool for cleaning the bevel depends on how much rust is on the pipe. Operator preference also plays a role. The most common way to clean a bevel is with a wire wheel, but it depends on the condition of the pipe.

Base material conditions can vary greatly when pipes arrive on the job site. There is typically some rust on the pipe — how much depends on the length of time since manufacturing and the pipe storage conditions. The more time that passes between the manufacturing of the pipe and preparing it for welding, the greater the chances more rust has accumulated.

If the pipe has only light surface rust, it requires a different conditioning product than if it has heavier rust.

Wire Brushes and Wheels: Light surface rust can typically be removed with a hand wire brush or wheel. Wire brushes efficiently remove loose material on the surface of the pipe without changing the base metal.

Product options in this category include hand wire brushes for small-diameter pipe or power wire wheels, such as stringer bead wheels, and wire cup brushes for larger-diameter pipe and faster cleaning. Wire wheels can be used to clean the pipe surface prior to welding and for cleaning the welds between passes. Cup brushes tend to clean more surface area and often clean faster, but they also tend to create a kickback if the cup hits the wrong part of the pipe. Both products clean effectively. While the choice often comes down to operator preference, wire wheel brushes are most commonly used.

Note, wire products also work well to remove any burrs that may have formed while creating the land.

Because wire wheels and brushes are designed to let the wire tips do the work, it’s important to orient the tool so only the wire tips hit the work surface. This promotes the most effective
cleaning action, reducing the urge for the operator to push harder. It also helps extend product life and reduce the risk of wire breakage. With a wire brush, apply light pressure — just slightly more than the weight of the grinder — to let the wire tips do the work.

Flap Discs: If the base material has more than light surface rust — perhaps even pits in the steel — it requires a more aggressive product to clean the metal. The bevel must always be completely cleaned and any rust or pits removed from the material.

Flap discs are a good option in this situation — especially a 60-grit flap disc — to efficiently grind out any rust, pits, and imperfections on the pipe, while also minimizing the potential for gouging that can occur with a grinding wheel.

Flap discs are available in many different material types. A disc with an aluminium backing is more rigid, which is ideal for maintaining the edge of the bevel without rounding the material. Rounding the edges of the bevel during cleaning can be detrimental to properly fill the weld.

Following the root pass, it is necessary to grind the weld to ensure proper penetration for the next pass or hot pass. This can be done using a 1/8-inch grinding wheel along the root pass, which helps create a flat or u-shape at the bottom of the weld.

With subsequent welds laid down after the hot pass, use a wire brush to clean away any imperfections or slag. This prepares the metal for each weld layer. A narrow-faced wire wheel works well for this. If the v-groove of the weld joint is wider, such as filler passes with larger-diameter pipes, choose a brush with a wider face that is designed to clean larger areas.

When two welders work on opposite sides of the pipe on larger-diameter pipes, the starting and stopping points for each welder are typically at the 12 o’clock and 6 o’clock positions. The point where the welds join and overlap is called the button. While this area can be more difficult to clean, avoid banging the wire wheel on the button, as this will damage the wires. Use normal pressure and allow the brush more dwell time to clean this area.

The same wire wheel used for interpass cleaning can also be used to clean the weld and remove any slag from the cap pass.

Some wire wheels use a dual-hex nut design that simplifies periodic flipping of the wheel to help promote the self-sharpening ability of the wire tips. Choosing a wheel with this design helps deliver maximum cleaning action, long life, and safer use.
An encapsulated stringer bead wheel is another option for cleaning between weld passes. Only the wire tips are exposed from the encapsulation. These brushes offer several advantages, including longer product life and aggressive cleaning action. And because there are no long wires outside of the encapsulation, long wire breakage is eliminated.

Be aware that the operator has less flexibility with an encapsulated wire brush because of the short trim length of the wires. When choosing this option, look for an encapsulated wheel that uses a heat-stabilized encapsulation that gradually wears away to expose a consistent short trim. This makes it suitable for cleaning hot welds without overheating.

**Pipe Grinding**

Pipe grinding is used when base metal or welds contain fabrication or service-induced defects (weld flaws, arc burns, gouges or cracks). It produces smooth surfaces and removes harmful stress concentration, defects and micro-cracks. Repair of mechanical damage by grinding has historically been allowed by several standards. Ground surfaces are examined by liquid penetrants or magnetic particles to confirm that the defect has been removed. The ground area may be left as it is without weld deposit, provided the remaining wall thickness exceeds the minimum requirement by code. The ASME B31.8 permits repair by grinding to a depth of 10 percent of the pipe wall thickness during the installation of new pipes and provides certain criteria for grinding of dents with gouges for in-service pipelines. The ASME B31G provides limits on the allowable extent of damage and the remaining strength of corroded pipelines.

Certain restrictive conditions are also commonly applied for grinding, which includes:

- The operating pressure should be reduced to 80 percent during the repair process.
- If the crack or the affected material near the defect is not entirely removed by grinding, an alternative repair technique must be applied.
- The removal of all cracks must be verified by non-destructive NDT testing after grinding.
- Removal by grinding of more than 40 percent of the wall thickness is not accepted.
2.6.3 KEY SAFETY PRACTICES

Following proper safety procedures can help maximize product performance and efficiency, while also contributing to a safer environment for operators and nearby workers.

No matter which product is in use, operators should always use a tool guard to improve safety and wear proper safety gear such as face and eye protection and gloves. Most manufacturers’ tool and accessory instructions include specifications about the recommended safety gear.

Also, be sure the rpm rating of the wheel or disc meets or exceeds the recommended rpm rating of the grinder for safest use. Just because a product fits a specific tool does not mean it was designed to be safely used with it.

Grinding wheels with a harder bond tend to load, which refers to base material accumulating on the wheel due to the heat of the grinding process. Some operators form chips or notches around the edge of a grinding wheel to clean a wheel that loads, but this is a dangerous practice that can result in flying debris. Instead, look for a wheel with the appropriate bond strength for pipeline welding.

At the end of the day, quality and productivity are important — but safety is critical. Choosing the right product to prepare and clean the base material for welding — and following some key best practices — helps prolong product life, improve operator efficiency and benefit safety on the pipeline job site.

3.0 CONCLUSION

Oil and gas transmission pipelines have a good safety record due to a combination of good design, materials and operating practices. However, just like any other engineering structure, pipelines do occasionally fail. The most common causes of damage and failures in onshore and offshore oil and gas transmission pipelines are external interference and corrosion. Assessment methods are needed to determine the severity of defects after which suitable repair methods are used to restore the original integrity of the pipeline.
4.0 REFERENCES


Hot Tapping Safety.. https://www.safetynotes.in/hot-tapping-safety/