

Sudan University of Science and Technology



College of Engineering
Mechanical Engineering
Production Department



Oil Pipeline Defects Maintenance and Repair

*A Research Submitted in partial Fulfillment for the Requirement
of the Degree of B-Tech (Honors) in Mechanical Engineering*

Prepared by:

1. Ibrahim Osman Adam Baraka
2. Ahmed Mohammed Elamin Hassan
3. AbdelrahimAbdelaziz Osman

Supervisor:

Dr. AlsawiYahia

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الآية

قال تعالى :

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

﴿ وَقُلْ اَعْمَلُوا فِیْ سَبِیْلِ اللّٰهِ عَمَلًا مَّوَدِعًا لَكُمْ وَرَسُولُهُ

وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ اِلَىٰ عَالَمِ الْغِیْبِ وَالشَّهَادَةِ

فَیُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ ﴾

صدق الله العظيم

سورة التوبة الآية (105)

DEDICATION

I would like to give my deepest thanks to my father and my mother for their understanding and unlimited patience. Without their support this work would have not been possible.

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At the beginning and finally all the thanks for Allah, and to my guide and light, my supervisor **Dr. AlsawiYahia**, Who lead us with patience, I express all gratitude and respect for his great help, guidance, and valuable advice.

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- my beloved family
- the staff of School of mechanical Engineering
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CHAPTER ONE

1.1 Introduction:

Most pipeline companies have complex maintenance and repair system .good maintenance allows companies to catch small problem before they becomes large and cost.

it also means that equipment runs more efficiency .operators are not responsible for maintenance or repair ,however operator need to be able to communicate with maintenance and repair personal ,because what that do may affect operator work

this module cores basic techniques and methods of maintenance and repair .it also describes how these actives affect line operation the important of proper inspection of pipeline cannot be over emphasized ,the lack of preventive maintenance and repair program may result in sever consequences many lives have been lost because operators have not understood the element of preventive maintenance program the impact of repair on line operation should also understood .this module discusses:

the inspection of pipelines the element of preventive maintenance program pigging

1.2 Problem Statement

The pipeline defects and maintenance repair

1.3 OBJECTIVE

The objective of this Technical is to provide guidance for pipeline defect assessment and repair methods according to recognized and generally accepted engineering practices and standards to:

- pipe line without defect
- Pipeline with effective performance.

CHAPTER TWO

2.1 Introduction

The procedure for repairing pipelines this module present inspection on the following goals .

It describes the types of inspection that occur on pipelines.

It examines the main elements of the preventive maintenance program.

It discusses the procedure for repairing pipelines .

This section examines the fulla pipeline that belong to petro energy (26 inch -api51 x65),the important of inspection in the proper maintenance of pipeline cannot be stressed enough .the goal of inspection is to gather information to prevent major problem from occurring in the pipeline or on the pipeline rate .

2.2 definitions of defects

2.2.1 Corrosion:

Corrosion is the natural deterioration of a substance as a result of its environment.

If you leave your axe outside and unprotected for a few days, for example, it is likely that the air and moisture will cause the iron in the steel to oxidize.

The subsequent rust formation is corrosion on the axe head. The same thing happens to a pipeline, but for different reasons. In a pipeline system, corrosion occurs both internally and externally This results in the weakening and eventual rupture of the pipe.

2.2.2 Shielded Metal Arc Welding (SMAW):

Shielded Metal Arc Welding uses the heat of an electric arc between a covered metal electrode and the work (pipe, plate, etc). Shielding comes from the decomposition of the electrode flux coating. Filler is supplied by the electrode core wire and covering (iron powder and alloys).

This process is usually done manually. The basic equipment is a power source, an electrode holder, a work clamp and the electrode. Electrodes operate variously on alternating current, direct current electrode positive (reverse polarity) or direct current electrode negative (straight polarity).

2.2.3 (SMAW) electrode identification system :

E X XXX

(XX) =strength

(X) =position

(X) = coating /operating characteristics

Strength- Tensile strength (I.E. 70, or 60) 70,000 psi / 60,000 psi Position:
1= all positions. 2= flat and horizontal fillet position only Example: E-7018,
E-6010

2.2.6 Non-destructive testing (NDT)

is an integral part of the weld inspection process on both ferrous and non-ferrous structures/components as it ensures that welds are free from sub-surface and surface breaking defects that may not be readily apparent.

We have a network of qualified Weld Inspectors who are located throughout the country, with each being able to provide a comprehensive

range of NDT disciplines both at fabricators and on sites. NDT weld inspection disciplines that we can offer are:

Visual Inspection of completed welds

Ultrasonic Testing (UT) of welds

Magnetic Particle Inspection (MPI)

Dye Penetrate Testing (DPI) of welds

Eddy Current Testing of welds

Should any flaws or cracks be detected by our Weld Inspectors our team of Engineers and Consultants can assist in determining the cause of the failures and assist in the development of remedial actions .

2.2.5 Welding Defects

a discontinuity of sufficient size, length, type that will render that particular object unsuitable for intended service base on a criteria in an applicable code

Listed below are some of the more common welding processes used:

SMAW Shielded Metal Arc Welding (STICK)

GMAW Gas Metal Arc Welding (MIG)

GTAW Gas Tungsten Arc Welding (TIG)

SAW Submerged Arc Welding

2.3 Measure of External Corrosion

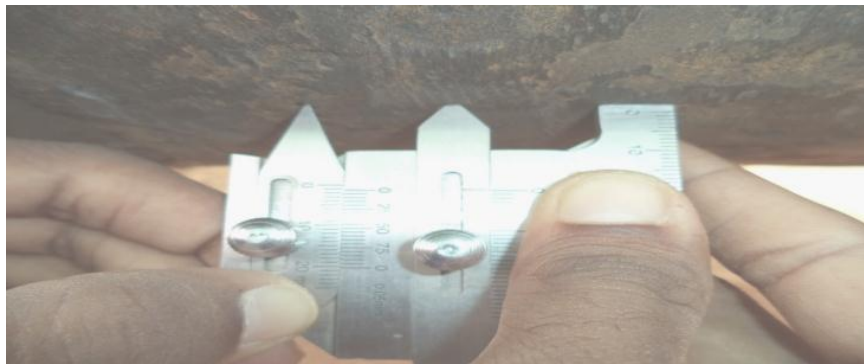


Fig. (2. 1) inspection Pipe Corrosion

2.6 Measure of Internal Corrosion

The Internal Corrosion for Pipelines – Basic course introduces the fundamentals of implementing, monitoring, and maintaining an internal corrosion control program as part of an overall Pipeline integrity management program. It is an introductory level course focusing on internal corrosion of liquid and natural gas pipelines used for transmissions, storage, and gathering systems.



Fig. (2. 2) IP Inspection for HC Pipeline

CHAPTER THREE

3.1 Types of Pipeline Pigs

Although first used simply to clear the line, the purpose of pipeline pigging has evolved with the development of technologies. Utility pigs are inserted into the pipeline to remove unwanted materials, such as wax, from the line. Inline inspection pigs can also be used to examine the pipeline from the inside, and specialty pigs are used to plug the line or isolate certain areas of the line. Lastly, gel pigs are a liquid chemical pigging system.



Fig. (3. 1) Debris after pigging

Similar to cleaning your plumbing line, utility pigs are used to clean the pipeline of debris or seal the line. Debris can accumulate during construction, and the pipeline is pigged before production commences. Also, debris can build up on the pipeline, and the utility pig is used to scrape it away. Additionally, sealing pigs are used to remove liquids from the pipeline, as well as serve as an interface between two different products within a pipeline. Types of utility pigs include mandrel pigs, foam pigs, solid cast pigs and spherical pigs.



Fig.(3. 2) Pipeline pig.

Inspection pigs, also referred to as in-line inspection pigs or smart pigs, gather information about the pipeline from within. The type of information gathered by smart pigs includes the pipeline diameter, curvature, bends, temperature and pressure, as well as corrosion or metal loss. Inspection pigs utilize two methods to gather information about the interior condition of the pipeline: magnetic flux leakage (MFL) and ultrasonic (UT). MFL inspects the pipeline by sending magnetic flux into the walls of the pipe, detecting leakage, corrosion, or flaws in the pipeline. Ultrasonic inspection directly measures the thickness of the pipe wall by using ultrasonic sounds to measure the amount of time it takes an echo to return to the sensor

Specialty pigs, such as plugs, are used to isolate a section of the pipeline for maintenance work to be performed. The pig plug keeps the pipeline pressure in the line by stopping up the pipeline on either side of where the remedial work is being done.

A combination of gelled liquids, gel pigs can be used in conjunction with conventional pigs or by themselves. Pumped through the pipeline, there are a number of uses for gel pigs, including product separation, debris

removal, hydro testing, dewatering and condensate removal, as well as removing a stuck .

Because there now exist multi-diameter pipelines, dual and multi-diameter pigs have been developed, as well.

3.2 Internal Corrosion

Internal corrosion in a pipeline is caused by the build-up of wax, sludge and salt deposits on the walls of the pipe. Some products may be corrosive due to their sculpture content. Internal corrosion is controlled:

- Chemically, by inhibitors, and physically, by scraper pigs.

3.3 External Corrosion.

In comparison, most of external corrosion happened in joint area where the heat shrink field joint coating has experienced extensive coating failure and has lost its adhesion. when water penetrate between the coating and the pipe, the corrosion occurred.

Inhibitors (control corrosion)

Are substances added to the liquid in the pipeline they lessen the build-up of corrosive material in the pipe.

Are cleaning tools that are armed with brushes or urethane blades. As they move down the line, they remove scale and loosen gummy deposits from the pipe wall. When steel pipe is buried underground, there is usually a difference in electrical potential between the soil and the steel that can cause an electrical current to flow between them. Corrosion is the result of an electro-chemical reaction involving electron movement from the pipe (anode – a positive electrode)

into the soil (cathode – a negative electrode). Corrosion can be prevented by the application of:

- Cathode protection or

- Coating and wrapping.

Both methods are used, in varying degrees, to achieve the best protection.

3.6 Corrosion

Corrosion is the natural deterioration of a substance as a result of its environment. If you leave your axe outside and unprotected for a few days, for example, it is likely that the air and moisture will cause the iron in the steel to oxidize. The subsequent rust formation is corrosion on the axe head. The same thing happens to a pipeline, but for different reasons. In a pipeline system, corrosion occurs both internally and externally. This results in the weakening and eventual rupture of the pipe.

3.6 Corrosion Control

3.6.1 Cathodes protection:

Essentially involves setting up a current around the pipeline to reverse the flow of electrons and thus inhibit corrosion. The design of the system depends on:

- The resistivity of the soil
- The Potential Difference between The Soil And The Pipeline
- The Line Current Measurement in A Test Section of the Pipe, And
- The type of coating on the pipe.

Two common types of cathode protection systems are rectifier-ground bed systems and magnesium-anode systems.

3.5 Corrosion & corrosion prevention

Pipeline External Inspection Technology Content:

3.5.1 Definition and terminology

3.5.2 Inspection technology (CIS, ACVG, DCVG)

Definition Holiday:

A discontinuity in a protective coating that exposes unprotected surface to the environment

Corrosion Activity:

A state in which corrosion is active and ongoing at a rate that is sufficient to reduce the pressure-carrying capacity of a pipe during the pipeline design life.

Terminology

Alternating Current Voltage Gradient (ACVG): A method of measuring the change in leakage current

in the soil along and around a pipeline to locate coating holidays and characterize corrosion activity.

Direct Current Voltage Gradient (DCVG):

A method of measuring the change in electrical voltage

Gradient in the soil along and around a pipeline to locate coating holidays and characterize corrosion activity.

Close-Interval Survey (CIS):

A method of measuring the potential between the pipe and earth at regular intervals along the pipeline.

CIS/CIPS

Its detection principle is:

A reference electrode is placed on the ground and connected to the voltmeter. The other end of the voltmeter is connected to the test pile of the pipeline to read the pipe-earth potential.

When the anticorrosive coating exists a holiday at a certain point, the current density will increase at the holiday, the IR drop around this point would be greater than other places, the protection potential will drift to the positive direction.

What's IR drop?

V_m = measured potential drop

V_{IR} = Pressure drop (IR drop)

V_p = polarization potential

$V_m = V_{IR} + V_p$

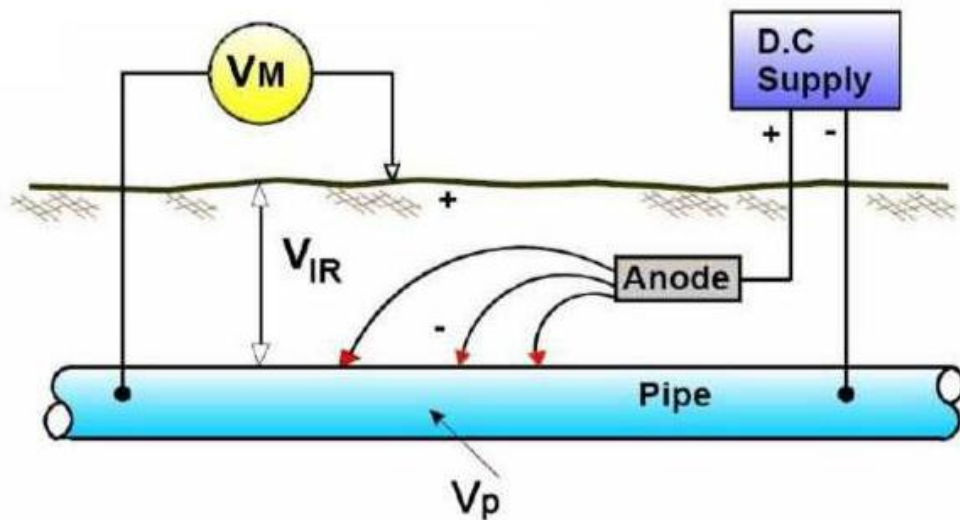


Fig. (3. 3) Cathode Process

Close-Interval Survey (CIS):

Close Interval Potential Survey (CIPS)

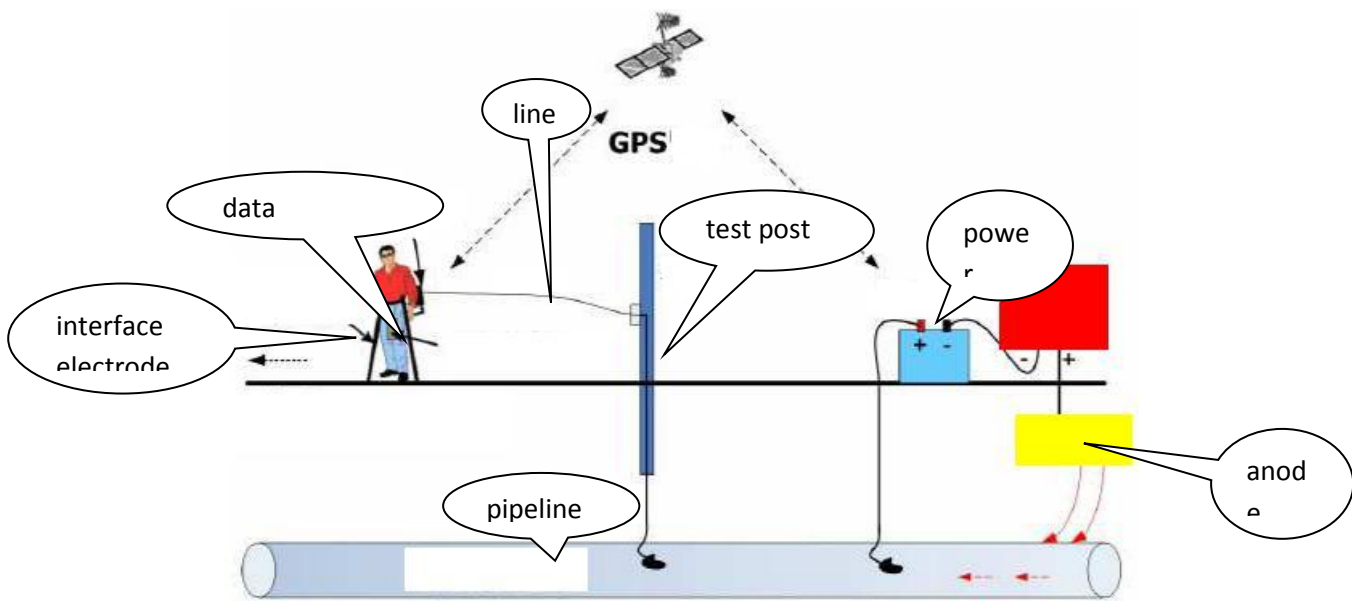


Fig. (3. 4) Scada System

Four basic NDT methods

Magnetic particle inspection (MT)

Dye penetrate inspection (PT)

Radiographic inspection (RT)

Ultrasonic inspection (UT)

Surface Testing

Dye Penetrated Inspection Magnetic Particle Inspection

Volumetric Inspection

Ultrasonic Inspection Radiographic Inspection

Penetrated Testing

Surface breaking defects only detected

This test method uses the forces of capillary action to detect surface breaking defects

The only limitation on the material type is the material cannot be porous

Penetrates are available in many different types:

Water washable contrast

Solvent removable contrast

Water washable fluorescent

Solvent removable fluorescent



Fig. (3. 5) Penetrated Inspection

Dye Penetrated Inspection (DPI)

Penetrated Flaw Detection (PFD)

Penetrated Testing (PT)

Surface inspection method Applicable to all non-porous, non-absorbing materials

Penetrate Inspection

Step 1: Pre-Cleaning

Ensure surface is very Clean normally with the use of a solvent

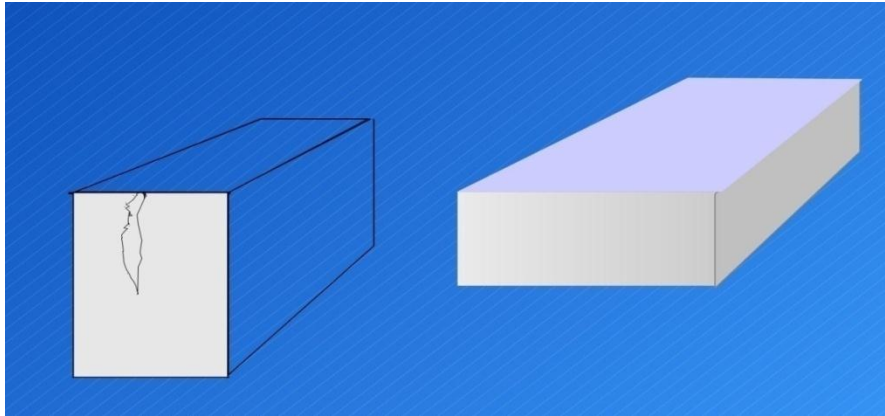


Fig. (3. 6) Apply penetrate

After the application of the penetrant the penetrant is normally left on the components surface for approximately 15 minutes (dwell the time)penetrant. Enters any defects that may be present by capillary action

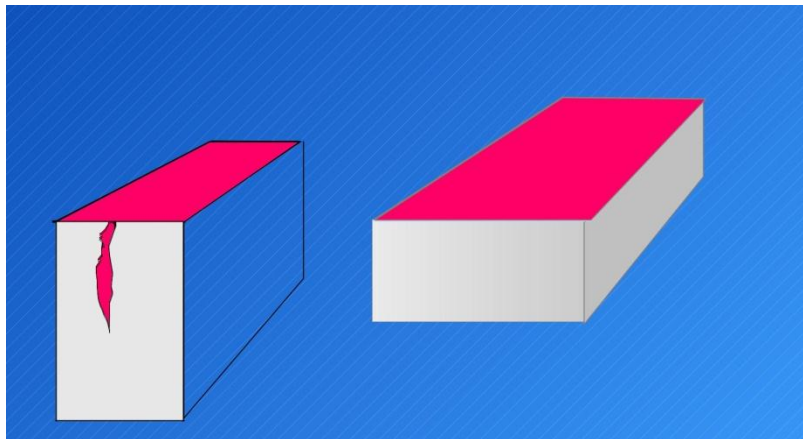


Fig. (3. 7) Clean off penetrant

Step 3. Clean off penetrant

After sufficient penetration time (dwell time) has been given the penetrant is removed, care must be taken not to wash any penetrant out of any defects present.

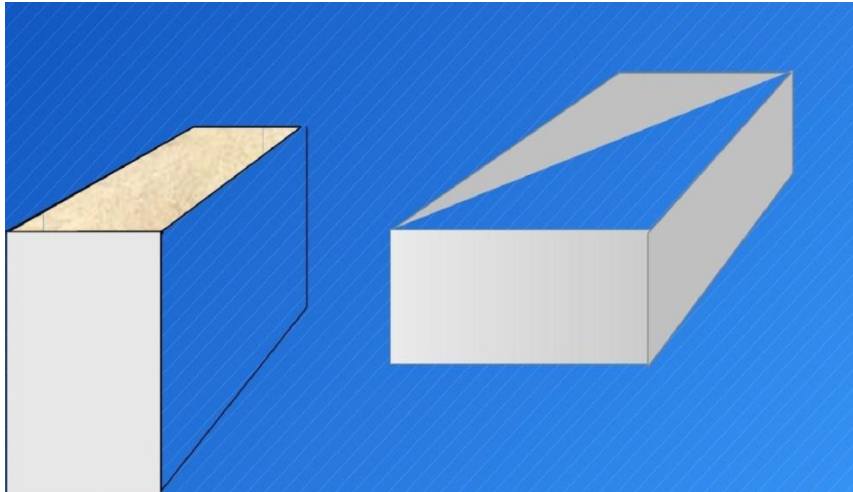


Fig. (3. 8) Penetrant inspection

ULTRASONIC INSPECTION

Principle waveforms in ultrasonic:

There are two Principle waveforms used in ultrasonic inspections:

- Compression
- Shear

Ultrasonic inspection equipment



Fig. (3. 9) Shear waves

Vibration at right angles to direction of propagation

Travel in solids only

Velocity $\propto \sqrt{1/2}$ compression (same material)

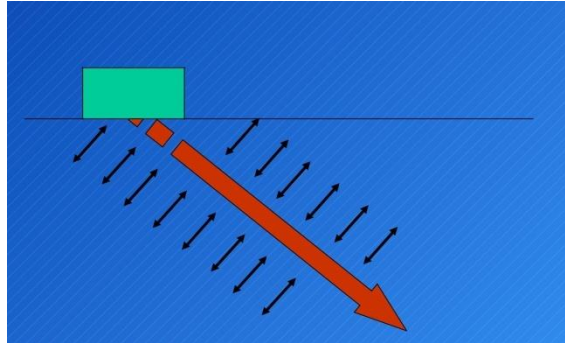


Fig. (3. 10) Particle vibration Propagation

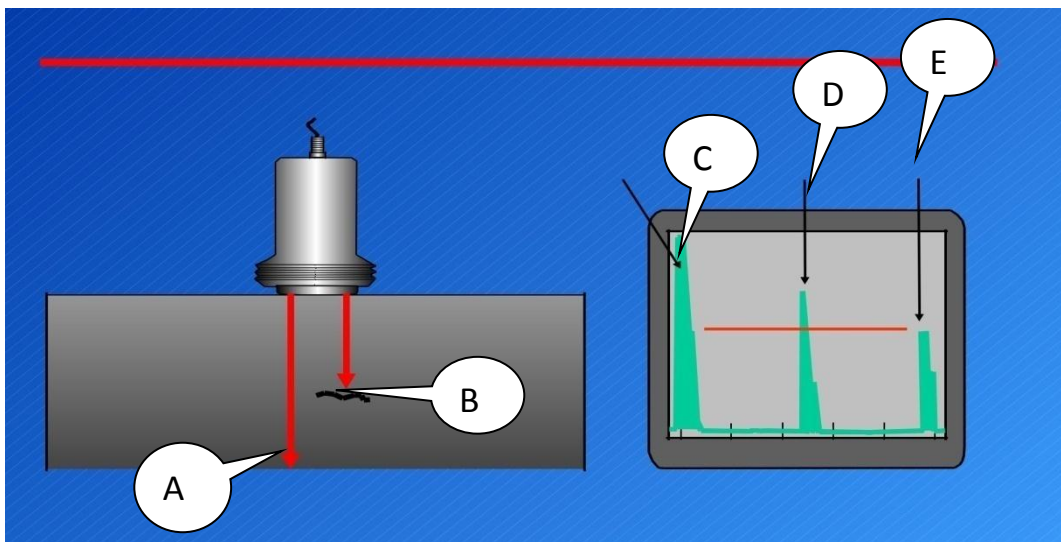


Fig. (3. 11) Ultrasonic Inspection

A: length Area	C:initial pulse
B : defect	D:defect echo
	E:Back wall echo

CHAPTER FOUR

6.1 Pipeline Repair Methods

Defects in pipelines may be repaired by a variety of methods those that have been commonly used by pipeline operators include:

- Removal of a section of pipe and replacement with new pipe
- Grinding an anomaly to significantly reduce its effect as stress concentrator or site for crack initiation
- Reinforcing a defective piece of pipe with an encircling sleeve
- Placing a sealed pressure containment device (clamp or sleeve) over a defect, including one that is leaking
- Applying a composite wrap over corrosion and blunt wall-loss defects
- Applying deposited weld metal in a defect to fill it with new material
- Placing a patch or sole (partial encirclement reinforcement device) over a defect
- Hot tapping to remove a defect

Descriptions of these methods are provided in this manual for the benefit of those who may not be familiar with one or more of them. Throughout this manual, we refer to temporary repairs. For our purposes, a temporary repair is a repair that will be re-evaluated within a period specified by the pipeline operator's written procedures. Any repair that is left in service for a period greater than five years, without being re-examined, should be considered to be permanent.

6.2 Removal and Replacement of a Defective Segment

Sometimes it is both possible and desirable to remove a defective section of pipe and replace it with new pipe rather than to attempt some other type of repair. Removal necessitates shutdown or isolation and depressurization of the affected pipeline segment. The defective section within the segment is then cut out as a cylinder. This removed section is in turn normally replaced with a pre-tested section of sound pipe, the tie-in welds are inspected, and the pipeline is returned to normal service. When pre-tested pipe is not used, the pipeline must be hydrostatically tested, as required by code, before the line is returned to service. In the remainder of this manual a removal and replacement repair is referred to simply as a removal repair.

6.2.1 Hot Tie-In or Hot Repair

Hot tie-in or hot repair, which is described in detail elsewhere,(16) refers to the method of repairing a gas pipeline by removal under controlled conditions with a burning gaseous atmosphere present. Rather than purging the pipeline with an inert gas, the repair or cutting operation is carried out with the product still in line. This is achieved by performing welding and cutting operations with a low positive pressure of gaseous product in the pipeline. The pressure is high enough to prevent ingress of air in to the pipeline, which would result in the creation of an explosive mixture, but it is low enough to ensure that the resulting ignition of escaping product does not produce excessively large flames that would place the personnel and equipment involved in the repair in danger.

Appropriate weld procedures need to be established, as there will be arc interference and metallurgical changes in the weld metal. Because this

technique involves the release of gas, properly trained personnel together with well planned procedures are necessary. Some safety considerations for a hot tie-in or hot repair procedure include the following:

- All personnel involved have appropriate training and clear instructions of the task.
- The potential for an explosive atmosphere, due to air ingress requires detailed investigation and planning prior to undertaking the repair.
- Monitoring for explosive mixture is recommended. Particular attention should be given to elevation differences along the repair section as this could have a bearing on the ability to control air ingress.
- In order to carry out this procedure on pipelines containing liquids, i.e. gathering lines, condensate and oil may be present. The line should be pigged prior to the hot cut to remove the liquid.
- Effective communications via 2-way radio is essential at the work-site, mainline valves and the communication centre.
- This repair method relies on the presence of a flame during the cutting and welding operations, therefore, suitable flame retardant safety wear should be adopted.

The gas purge required for a hot tie-in or hot repair procedure must maintain a positive pressure throughout the operation. This may be achieved by a regulator system or via the bypass on the mainline valves. Caution must be exercised if gas is regulated through a ball valve, as a high differential pressure exists.

6.2.2 Type A Sleeves (Reinforcing)

The Type A sleeve is particularly attractive because it can be installed on a pipeline without welding it to the carrier pipe. Such a sleeve provides reinforcement for the defective area. It cannot contain pressure and is used only for nonteaching defects. It should be installed at a pressure level below that at which the area of the line pipe with the defect might be expected to fail.

A typical configuration and weld details for a Type A sleeve are shown in Figures 1 and 2, 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 side seams. As shown in Figure 2, the seams may be single-V butt welds or overlapping steel strips fillet welded to both halves may join the sleeve 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. 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 gap can be easily bridged.

6.2.3 Assuring Effective Reinforcement

To be effective, the Type A sleeve should reinforce the defective area, restraining it from bulging radically as much as possible. First and foremost, the sleeve should be installed with a minimal gap between the sleeve and the carrier pipe in the area of the anomaly. Forming and/or positioning the sleeve so that it firmly contacts the carrier pipe, especially at the area of the defect, can assure that the gap is minimized. One or more of the following

actions (discussed separately in this sub-section) can further enhance the effectiveness of a Type A sleeve:

- Reduce pressure in the carrier pipe during sleeve installation.
- Externally load the sleeve to force it to fit tightly against the carrier pipe.
- Use a semi-liquid material that will fill and harden in any gaps in the annular space between the sleeve and the carrier pipe.
- Apply special fit-up procedures for seam welds.
- Use special epoxy-filled shells.

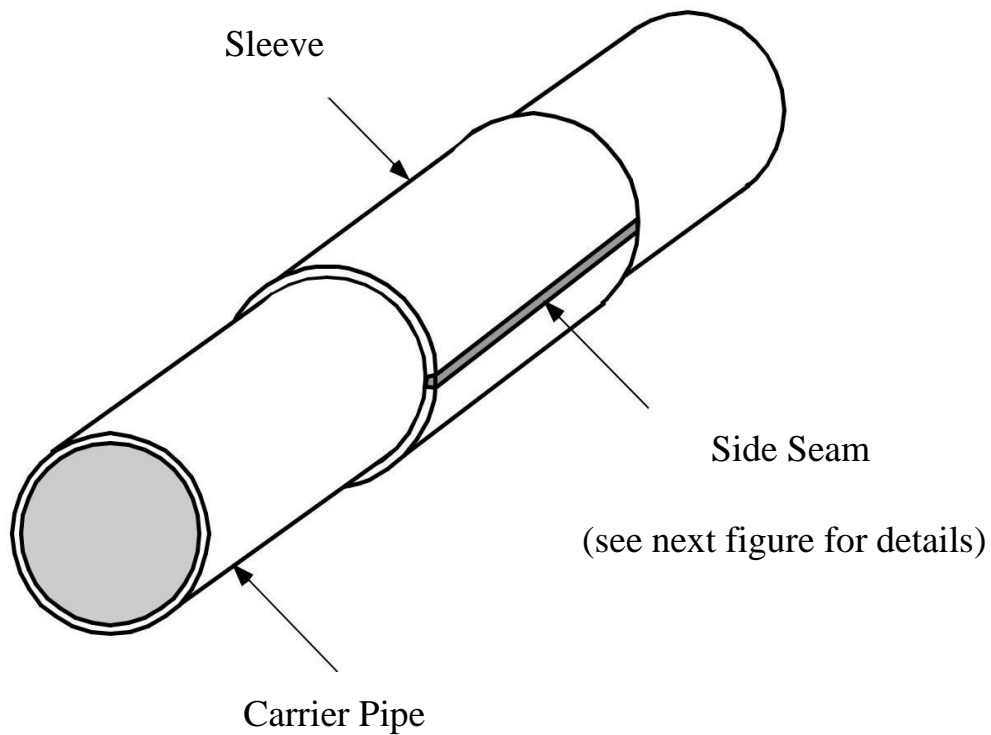


Fig. (6. 1) Illustration of Type A (reinforcing) sleeve.

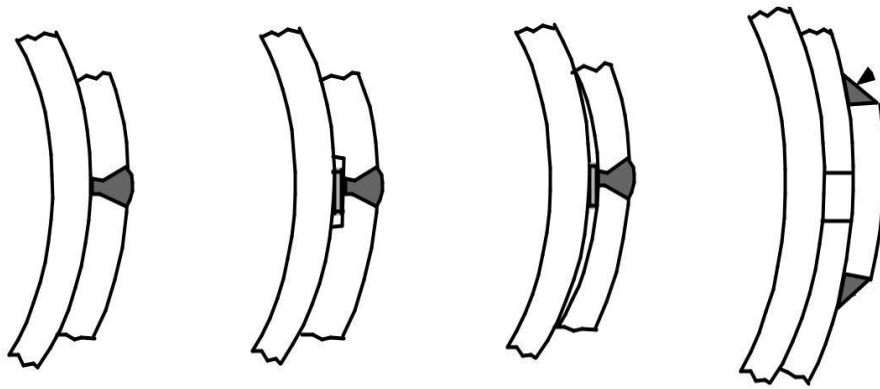


Fig. (6. 2) Weld details for Type A sleeve

6.2.6 Mechanical Loading

The two halves of a sleeve can be forced to conform to the carrier pipe and their sides can be drawn together appropriately for welding by mechanical means such as those shown in Figure 5. These can consist of chains and jacks (Figure 5b) or special preloading devices (Figure 5c). Lugs can be pre-installed on each half (Figure 5a). At the option of the installer, the lugs can be cut off after installation or left in place. Cutting them off facilitates coating the sleeve, an important consideration. A third option is the special chain-clamp device shown in Figure 5c. The hydraulic actuator that accompanies this latter device can be used to produce a significant preload in the sleeve. A significant preload can enhance the effectiveness of a Type A sleeve in the same manner as a pressure reduction in the carrier pipe. However, preload should not be substituted for pressure reduction in cases where a reduction of pressure is necessary for safety prior to the start of repair operations.

6.2.5 Hard enable Fillers

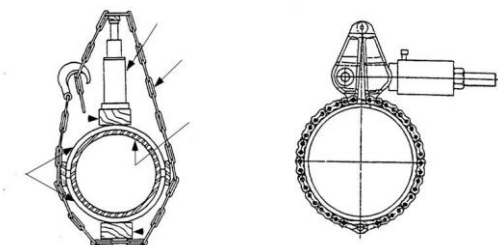
Hard enable fillers, such as epoxy or polyester compounds, are frequently used to ensure that no gaps exist between the sleeve and the carrier pipe. These compounds are typically mixed and trowel led into depressions in the carrier pipe, such as dents and pits. After the mixture hardens, the filler is shaped using files or other similar tools until the outside diameter of the pipe is restored. Another alternative is described below.

Before the mixture hardens, the sleeve halves are placed around the pipe, and mechanical means, such as those described above, are used to squeeze the excess filler material. By the time the side seams of the sleeve have been welded, the filler mixture has usually solidified and load transfer between the sleeve and the carrier pipe is assured at all defect locations.

Tests performed on pipe sections with filled gouges and dents showed that such fillers are very effective.



Fig. (6. 3) a Lug and Bolt Method



(Drawing provided courtesy of Midwest Pipeline Supply, Inc.)

Fig. (6. 4) Mechanical methods for assuring tight-fitting Type A sleeves.

6.3 Fit-Up on Submerged-Arc-Welded and Flash Welded Line Pipe

One concern with respect to applying Type A sleeves is the presence of a crown or reinforcement on the seam weld of submerged-arc-welded (SAW) carrier pipe or the flash on flash-welded carrier pipe. To assure a tight-fitting sleeve, three options are available. The first option is to remove the weld crown or flash by grinding it flush to the surface of the carrier pipe. This option is acceptable if the pressure has been reduced as suggested. The second option is to grind a compensating groove in one of the sleeve halves. If this second option is selected, it may be desirable or necessary (in the case of long defects) to use a sleeve that is thicker than the carrier pipe by an amount that compensates for the thickness of material removed, including any compensation needed for differences in material strength. The third option is to force the unmodified sleeve over the weld reinforcement after sufficient filler material has been deposited to fill the expected gaps. This third option is acceptable if the resulting fit-up of the sleeve halves is adequate for side-seam fabrication. With the standard method of application shown in Figure 5b, there is no risk of damaging the weld. This third option should not be used with relatively high-force methods, such as lug and bolt (Figure 5) or chain clamp (Figure 5), as local bending adjacent to the seam weld reinforcement may result.

6.3.1 Epoxy-Filled Shells

British Gas developed a variation of the filled-sleeve concept in the form of their epoxy-filled shell repair method.⁽²⁵⁾ In this case, the shell is a sleeve with a standoff distance of several millimeters from the carrier pipe.

The shell is placed on the defective pipe, and bolts are used to center it. The side seams are then welded, and the gaps at the ends are sealed with toweled filler. After these seals have hardened, epoxy is pumped into the annular space until it comes out an overflow hole at the top of the sleeve.

Once the epoxy filler has hardened, the radial bulging tendency of the defect is restrained by the epoxy in the same manner as a conventional Type A sleeve would have if it were directly in contact with the sleeve. Data have been presented that show that the epoxy-filled shell also can be used to repair weakened, but not leaking, girth welds. Bonding between the epoxy and the sleeve and the epoxy and the pipe permits the transfer of longitudinal stress. If the sleeves are used for an under-water repair, an epoxy that cures properly in water should be used.

6.3.2 Steel Compression Sleeves

Steel compression sleeves are a special class of Type A sleeves. They are designed, fabricated, and applied so that the repaired section of the carrier pipe is maintained under compressive hoop stress during subsequent operation. This approach is attractive for repairing longitudinally oriented crack-like defects because without a tensile hoop stress there is no driving force for crack growth. This type of sleeve is not suitable for the repair of circumferential cracks or for defects in field bends. CSA Z662 (addresses the use of steel compression sleeves

Steel compression sleeves involve installing two sleeve halves over the defect area and drawing them together using clamps, jacks and chains, or lugs and bolts. The sleeve halves are then welded together using conventional welding techniques. Pressure reduction during installation is normally used to induce compression in the carrier pipe. Thermal contraction of the longitudinal seam welds also promotes compression in the

carrier pipe. Epoxy filler is used between the carrier pipe and sleeve to achieve the transfer of stresses. As pointed out previously, pressure reduction alone will only transfer a portion of the hoop stress from the carrier pipe to the sleeve.

Petro Sleeve™ is a commercial product that was developed to combine pressure reduction with thermal shrinkage of the sleeve for achieving full compression in the carrier pipe. Figure 6 illustrates the installation process for Petro Sleeve™. Two steel sleeve halves with sidebars are installed over the defect; the sleeve halves are heated, and are initially held in place with chain clamps or hydraulic jacks. The halves are then welded together using two longitudinal sidebars. During installation, an epoxy layer is applied between the sleeve and the carrier pipe. The epoxy is used as a lubricant when the halves are placed on the carrier pipe and later acts as a filler to evenly transfer the load between the sleeve and the pipe. As with other versions of Type A sleeves, no welds are made to the carrier pipe. Thermal shrinkage of the sleeve upon cooling helps induce a compressive stress into the carrier pipe. A completed Petro Sleeve installation is shown in Figure 7.

Several factors influence the degree of stress reduction in the carrier pipe. These include the fit of the sleeve, the pipe wall thickness and diameter, the sleeve wall thickness, the internal pressure during installation, and the installation temperature. Specially developed software can be used to determine the target sleeve installation temperature and to help confirm that the desired amount of sleeve compression has been achieved.

Quality control procedures for Petro Sleeve™ involve monitoring sleeve temperature during the heating process and verification of the achieved carrier pipe compression by measuring how far the two sleeve

halves advance towards each other using caliper measurements. Three sets of measurements on each side of the sleeve are typically made. Nondestructive inspection of the completed welds is conducted after cooling.

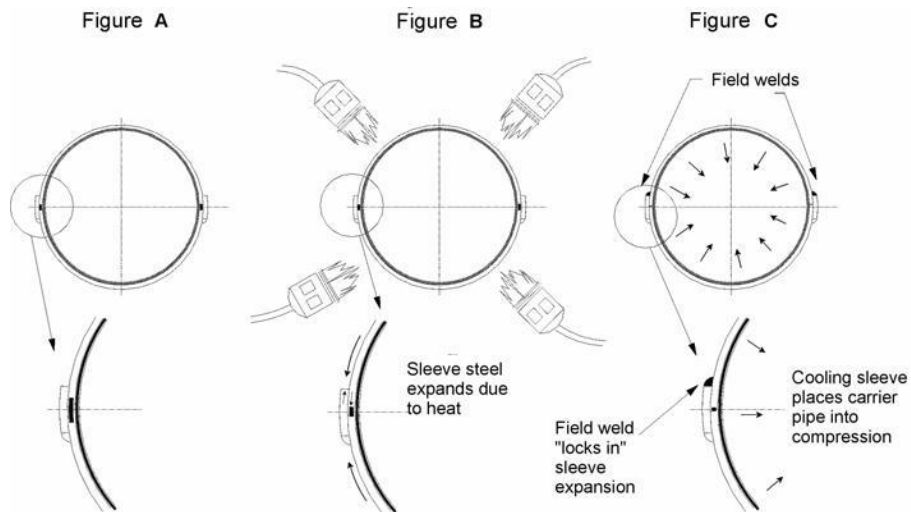


Fig. (6. 5) Installation steps for the steel compression sleeve: (A) place half-sleeves on carrier pipe, (B) heat sleeve to expand sleeve, and (C) place field welds and cool assembly to achieve compression (drawing Courtesy of Petro-Line, Inc.).



Fig. (6. 6) Example of installed and sandblasted steel compression sleeve (photograph Courtesy of Petro-Line, Inc.).

Type B Sleeves: Pressure Containing or Capable of Containing Pressure

The other type of steel sleeve used to make pipeline repairs is known as a Type B sleeve. The ends of a Type B sleeve are fillet welded to the carrier pipe. The installation of a Type B sleeve is shown in Figures 8. Detailed discussions of the issues related to welding on an in-service pipeline are presented in Appendix A. Since its ends are attached to the carrier pipe, a Type B sleeve can be used to repair leaks and to strengthen circumferentially oriented defects. In fact, a Type B sleeve has been used in place of a girth weld to make a tie-in on a pipeline. Because a Type B sleeve may contain pressure and/or carry a substantial longitudinal stress imposed on the pipeline by lateral loads, it should be designed to carry the full pressure of the carrier pipe. Additionally, it should be carefully fabricated and inspected to ensure its integrity.



Fig. (6. 7) Installation of a Type B repair sleeve

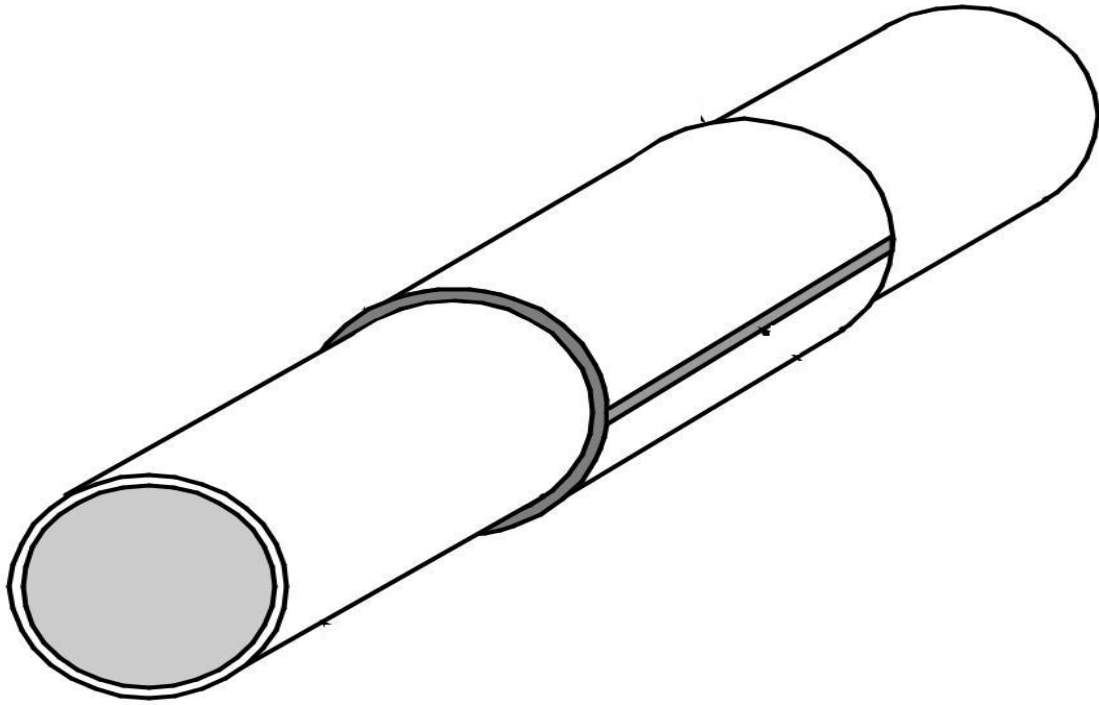


Fig. (6. 8) Illustration of a Type B sleeve

6.3.3 Sleeve Length

While it should be long enough to extend beyond both ends of the defect by at least 50 mm (2 inches), 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 50 mm (2 inches) 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

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 operator's written procedures should contain guidelines for support spacing, methods of temporary support (e.g., air bags, sand bags, skids), and soil conditions under the pipeline upon backfilling.

6.3.6 Leaking Defects

One use for a Type B sleeve is to repair a leaking defect. A Type B sleeve installed over a leak becomes 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. One common method is to place 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. Chains and hydraulic jacks are then used to force the sleeve halves against the carrier pipe. In some cases, a neoprene ring is placed so that it is compressed by this process to form a seal around the leak and force 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.

6.3.5 No leaking Defects

Type B sleeves are sometimes used to repair no leaking defects. In the past, some pipeline operators used Type B sleeves exclusively because they preferred to have the ends sealed by fillet welds even when no leak existed. Other operators have installed Type B sleeves over no leaking defects and then hot-tapped through the sleeve and pipe to pressurize the sleeve and relieve hoop stress from the defective area. With the advent of new repair methods, such as steel compression sleeves and composite sleeves and concerns for possible cracking and failures at the end fillet welds, some operators have reduced their use of Type B sleeves in recent years.

Even though a Type B sleeve may not be pressurized, any sleeve with ends welded to the carrier pipe should be designed and fabricated to be capable of sustaining the pressure in the pipeline, since there is a chance that

it could later become pressurized. This is necessary because the sleeve may become pressurized at a later time. For example, if a Type B sleeve is used to repair internal corrosion and the internal corrosion continues, a leak could develop in the carrier pipe and pressurize the sleeve.

6.3.6 Inspection Requirements

The installation or fabrication of any repair requiring welding on an in-service carrier pipe should be preceded by ultrasonic inspection to determine the remaining wall thickness of the carrier pipe in the regions where welding is to be performed. For the case of fillet welds around the ends of a Type B sleeve, it is reasonable to measure the wall thickness at 50-mm (2-inch) intervals along the circumferential path where the weld is to be located. If welding is to be performed on external pits, the pit depth should be determined by measuring from the original external pipe surface if possible. If the remaining wall thickness cannot be adequately determined, welding should not be attempted with the carrier pipe in service.

Repair sleeve welds (sleeve-half butt welds and sleeve fillet welds) should be inspected after welding to help assure weld integrity. Weld joints are usually inspected by means of magnetic-particle inspection (MPI), liquid-penetrant inspection (LPI), or ultrasonic shear wave inspection. Automated and advanced ultrasonic inspection techniques are sometimes applied to assure the integrity of critical welds. Whatever method or combination of methods is employed, operator skill, training, and experience are critical to achieving a successful inspection. MPI or LPI is expected to reveal surface-connected indications, with MPI typically being more sensitive than LPI. Grinding the toe smooth facilitates the inspection of fillet welds. The best assurance of a quality repair is the use of a proven qualified procedure and a highly trained and qualified repair specialist.

6.3.7 Special Sleeve Configurations

The special-purpose sleeve configurations described in the following sub-sections may be useful for certain applications.

6.3.8 Sleeves to Repair Girth Welds

The typical configuration of a sleeve used to repair a defective or leaking girth weld is shown in Figure 10. The hump in the sleeve is designed to accommodate the crown of the girth weld. The ends are welded to the carrier pipe so that the sleeve can share the longitudinal stress. This type of sleeve is expected to contain a leak and does reinforce the girth weld to some extent.

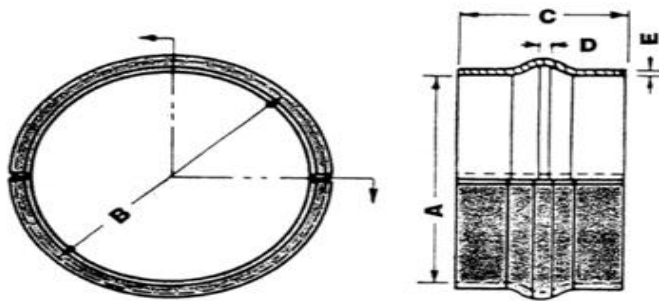


Fig. (4. 9) Typical sleeve configuration for repair of girth welds (drawing courtesy of Allan Edwards Companies)

6.3.9 Sleeves to Repair Couplings

Many older pipelines have joints that were made using couplings. For small diameter pipes, these may be threaded couplings. For large-diameter pipelines, as well as for some small-diameter ones, mechanical compression-type couplings were used. Typically, these couplings rely on longitudinally oriented bolts and collars that are used to compress packing or gaskets to seal against the pipe. These types of couplings provide negligible longitudinal stress transfer along the pipeline. As a result, they are prone to pullout incidents when the pipeline is subject to unusual longitudinal loads. To overcome both the pullout problem and the perennial leakage problem with this type of coupling, many pipeline operators have resorted to the repair sleeve configuration shown in Figure 11. This type of sleeve, often called a pumpkin or balloon sleeve, is typically welded to the pipes on both ends. The side seams are also welded so that the sleeve can contain pressure. Because the mechanical couplings tend to transfer little or no longitudinal stress along the pipeline, the fillet welds at the ends of this type of sleeve become the primary means of longitudinal stress transfer. Therefore, the quality of the fillet welds for such a sleeve is even more critical than that of the welds at the ends of a conventional Type B sleeve.

A pumpkin sleeve may be used to repair buckles, oval ties, and wrinkle bends because of its ability to fit over such anomalies.

6.6 Sleeve-On-Sleeve Repair

Experience with cracking at the toes of fillet welds around the ends of conventional Type B sleeves led to the development of the sleeve-on-sleeve configuration shown in Figure 12. This configuration consists of two rings installed outboard to the ends of the defective sleeve. Each ring is fillet

welded to the carrier pipe on the end facing the end of the defective sleeve. If a toe crack forms at one or both of the rings, it will be contained within the space between the ring and the sleeve. The final step consists of installing two outer sleeves to bridge the gaps between the rings and the defective sleeve. These outer sleeves are fillet welded to both the rings and the defective sleeve to make a leak-tight repair in case the toe crack grows through the wall of the carrier pipe. A test program (30) showed that this configuration is expected to adequately protect an existing toe crack from causing the pipeline to fail.

6.6.1 Sleeve Configurations for Curved (Field-Bent) Pipe

It is possible to install a conventional Type A or Type B sleeve on a curved piece of pipe. The shorter the sleeve, the better the fit will be on a curved section of pipe. For a Type A sleeve, the annular space created by the curvature could be filled with a hard enable material to provide contact with the carrier pipe. A relatively short Type B sleeve could be installed effectively, but beyond some length that depends on the pipe size and amount of curvature, a straight Type B sleeve will not fit well enough to a curved pipe to permit a satisfactory installation.

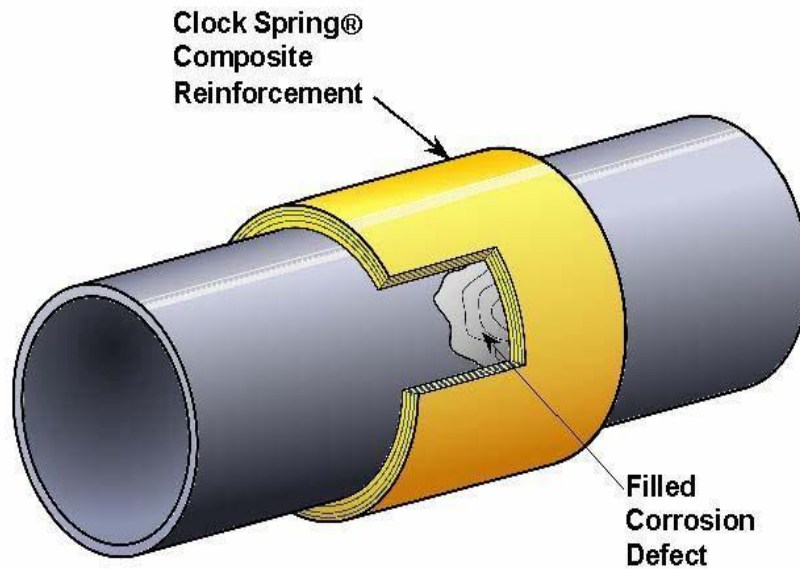


Fig. (6. 10) Components of the Clock Spring repair system

(1) Composite wrap,

(2) polymer adhesive, and

(3) Filler compound (courtesy of Clock Spring Company, L.P.)

6.5 Coatings and Coating Processes

Coating fundamentals makes reference to a multitude of concepts and properties. A critical property of antifouling paint is, for example, the inhibition of living organism growth on the coating.

A fire-resistant coating, on the other hand, should resist or retard the burning of the substrate. From a corrosion point of view a coating is rated on the resistance it provides against corrosion in a specific environment, and because there are many variations in environment corrosively, there is also a great variety of corrosion protective coatings. These can be broadly divided into metallic, inorganic, and organic coatings. A general description of how the main elements are used in metallic and inorganic coatings

6.5.1 Metallic coatings

Metallic coatings provide a layer that changes the surface properties of the work piece to those of the metal being applied.

The work piece becomes a composite material exhibiting properties generally not achievable by either material if used alone. The coatings provide a durable, corrosion-resistant layer, and the core material provides the load-bearing capability.

CHAPTER FIVE

5.1 Pigging Report

Table (5. 1) Pigging Report

Station	Launch	Receive	Date	Time	Press. <MPa >	Temp · <°C>	Distance <km>	Estimated arrival time to next station
KT#06		√	June.10.2015	16:25	0.28	36.1	267.62	
Operators		Ibrahim osmanbarka						

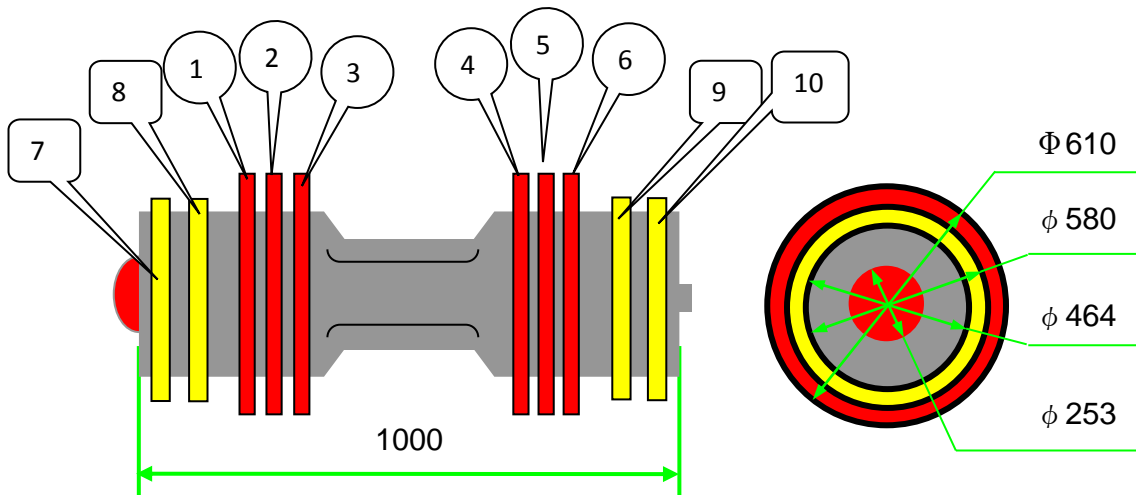


Fig. (5. 11) Section of Pig

Table (5. 2) Pigging Details:

Item	Spare	N	P	M	S	Accumulative running Distance <km>	Comments
	parts						
Sealing Disc	1				√	267.62	Before φ=610, After Per=582
	2				√	267.62	Before φ=610, After Per=damage
	3				√	267.62	Before φ=610, After Per=576
	6				√	267.62	Before φ=610, After Per=damage
	5				√	267.62	Before φ=610, After Per=586
	6				√	267.62	Before φ=610, After Per=582
Guiding Disc	7				√	267.62	Before φ=580, After Per=575
	8				√	267.62	Before φ=580, After Per=576
	9				√	267.62	Before φ=580, After Per=579
	10			√		267.62	Before φ=580, After Per=580
Skeleton			√			267.62	
Location sys.							Received in KT#06
Other							

Note:

- N-new: new spare part:
- P-perfect: not worth service and can be used without any change or replacement
- M-medium: only need to change position without replace with new
- S-severely: need to replace with new one

CHAPTER SIX

6.1 Conclusions and Recommendation

6.1.1 Main Line Inspection

Flyover line walking, public surveillance, hydrostatic testing and the use of smart pigs.

- Flyovers use aircraft to check large sections of the pipeline for Major signs of trouble such as crude oil leaks and withered Vegetation around the pipeline route.
- Line walking consists of company personnel patrolling the pipeline Route and checking for any problems.
- With public surveillance, the general public is asked and encouraged to advise the pipeline company of any problems or Unusual situations.
- Hydrostatic testing is done to test the integrity of a new pipe, or an old pipe that may have to operate at higher pressures.
- Smart pigs are used to check the inner surfaces of a pipeline for corrosion, pitting, or other damage.
- Preventive maintenance is done to avert high repair bills and increase efficiency.

6.1.2 Pipe line Preventive Maintenance

- Preventive maintenance consists of corrosion control, equipment inspection, equipment tune-ups, and instrument calibration.
- Corrosion can be both internal and external. Internal corrosion is controlled by the use of scrap
- per pigs and chemical inhibitors.

External corrosion is controlled by cathode protection and coating and wrapping the pipe.

- Cathodes protection sets up an electrical current around the pipeline to inhibit external corrosion. Stray current corrosion, a type of external corrosion, can be caused by direct current. Direct current railroads, streetcars, or catholically protected foreign pipelines canal cause stray current external corrosion. This type of corrosion can be controlled by changing the environment around the pipeline.
- Equipment should be inspected regularly to prevent unnecessary stress on equipment, rate loss, and/or unnecessary callouts.

Equipment tune-ups and instrument calibration are an integral part of equipment maintenance. For example, valves and meters require regular calibration to prevent problems like false alarms or incorrect readings.

6.1.3 Pipe line Pigging

Pigging is an important part of the pipeline maintenance program.

Pigs are used for maintenance and inspection.

- Scraper pigs clean the inside of the pipeline. They prevent the build up of deposits on the inside of the pipe that could slow down product flow rates.
- Smart pigs can be gauging, sonar, magnetic flux, or ultrasonic. Gauging pigs check the geometry of the pipe wall to ensure it does not have any dents, buckles, or flat spots. Shifting and settling can affect the curvature of the pipeline; sonar pigs are used to detect these effects. Magnetic flux or ultrasonic pigs detect metal loss in the pipe wall. They can also record the specifics of the loss.
- Pigging requires a great deal of planning and communication between maintenance and operating personnel. A thorough study of the line to be pigged must be done before the pig is run.

6.1.6 Pipeline Repair Overview

- The five main steps in repairing any pipeline are isolation and draining, nitrogen purging, repair/replacement of equipment, testing, and restarting.
- The first step in isolating a pipeline is to use a special flange and sandwich valves to isolate the pipe section. A tapping machine cuts a hole in the pipe wall and a by-pass pipe is installed. Mud plugs, and downse pigs can also isolate pipelines.
- Nitrogen purging is another procedure used to evacuate sections offline for repair. Nitrogen purging is efficient and safe.

6.2 Detailed Selection Criteria

This section provides and discusses general guidelines for selecting a repair method for a particular type of defect or situation. These are not necessarily unique because each operator may modify them to fit their own situation or may develop its own flow chart. They illustrate typical selection criteria for the following ten categories of defects and/or other situations that may require in-service pipeline repair:

External corrosion Figure 26

Internal corrosion Figure 27

Uses of the selection criteria illustrated in Figures 26 through 35 are described in the following subsections.

6.2.1 – External Corrosion

External corrosion can usually be readily inspected and characterized as to its effect on pipeline integrity. The exceptions are selective corrosion of an ERW or flash-welded seam and corrosion with extensive circumferential extent in conjunction with unusually high axial stress in the pipeline. One should not attempt to repair selective seam corrosion using the external corrosion repair criteria. Selective seam corrosion should be addressed using the longitudinal crack repair criteria. Cases with large circumferential extent and high axial stress can be addressed using the girth weld defects criteria

Repairs to external corrosion can be selected using the guidelines in Figure 26. For use of these criteria, as well as the others covered Sections 6.2.2 through 6.2.10, it is strongly recommended that the pressure be reduced to a level that would be expected to prevent a near-failure defect from failing during the repair process. For this purpose, the following two pressure levels are defined:

P_d = pressure at the time the defect is discovered.

P_h = historical high pressure known to have occurred during the past year.

Pressure reduction is recommended for safety. The operator should consider when and how much pressure reduction is needed to provide an acceptable safety margin during excavation, inspection, and repair. Reducing the pressure to $0.8P_d$ or $0.8P_h$ is recommended prior to examination and repair of a region of external corrosion. It is possible to make an exception if the results of an in-line inspection (ILI) within the past year indicate that the failure pressure is at least 1.25 times the current pressure. A thorough cleaning of the pipe by blasting with sand,

walnut shells, water, etc. or by power wire brushing should be completed prior to examining the corroded area.

Prior to repairing an area of external corrosion, one should verify the nominal (uncorroded) wall thickness of the pipe by ultrasonic testing and measure the pipe diameter. The axial length, circumferential extent, and maximum depth of penetration should be measured, also. Detailed measurements of the depths of wall loss are needed if a RSTRENG (6) calculation is to be performed.

The criterion for repairs of external corrosion (see Figure 26) begins by considering the maximum depth of pitting. If the depth is greater than 80% of the nominal wall thickness, and if the pipe is not leaking at the defect, the appropriate repair choices are a Type B sleeve, a mechanical sleeve, hot tapping (if it can remove the entire anomaly), or a patch (subject to code and regulatory restrictions). If the defect is leaking, the appropriate repair choices are a Type B sleeve, a mechanical sleeve, hot tapping (if it can remove the entire anomaly), a leak clamp (if the anomaly is an isolated pit), or a patch (subject to code and regulatory restrictions).

For regions of external corrosion where the deepest penetration is less than 80% of the wall thickness, an ASME B31G(3) or RSTRENG(6) evaluation of acceptable defect length (L) can be conducted. The acceptable circumferential extent (c) of the defect should be evaluated using Figure 36, which is Figure 5-7 of API RP 579,(6) where t is the nominal pipe wall thickness, d is the maximum defect depth, and D is the nominal pipe diameter. Pipe that is not severely corroded enough to fail either of the criteria for acceptable defect length and the criterion for acceptable defect circumferential extent requires no repair except recoating and backfilling.

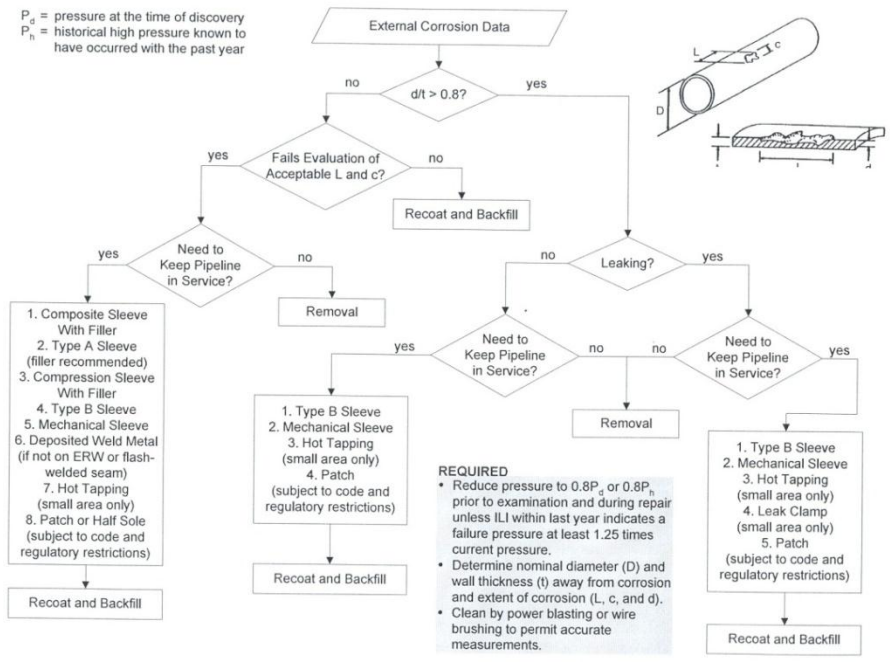


Fig. (6. 12) Repairs for external corrosion.

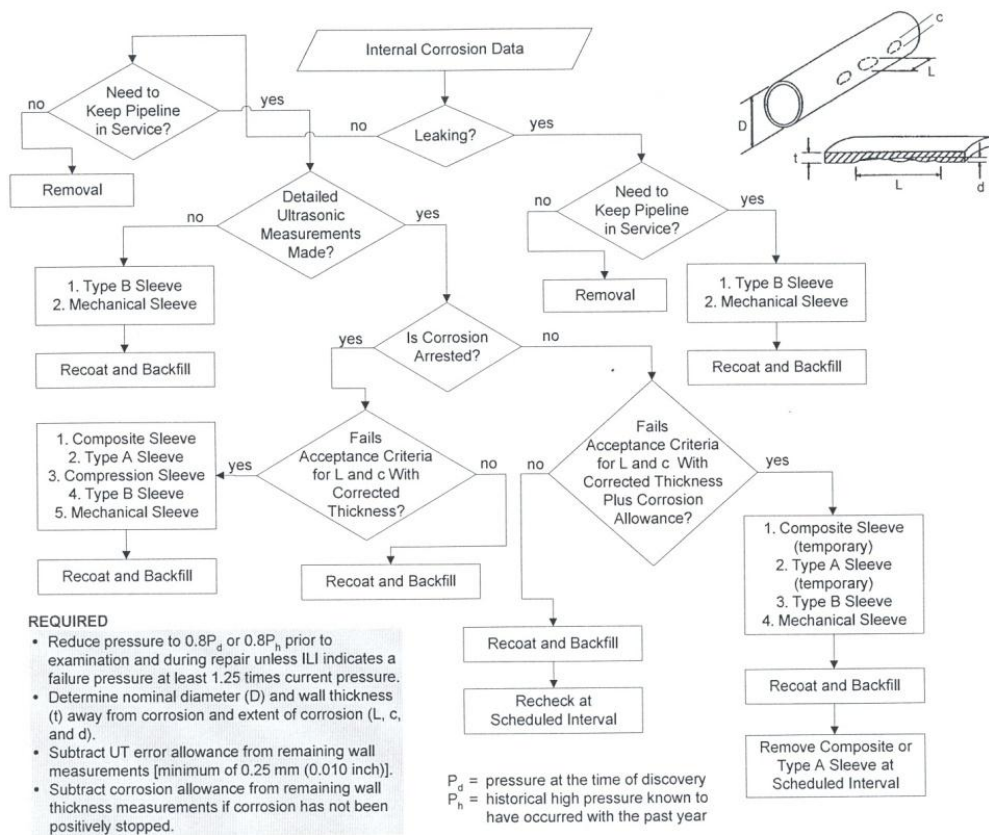


Fig. (6. 13) Repairs for internal corrosion.

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