Rehabilitation Of Pipeline Using Liner

A thesis submitted in partial fulfillment of the requirements for the Degree of

Master of Technology

(Pipeline Engineering)

By

Anish S R

R160208004

Prof. P.K.BAHL

Pipeline Engineering

UPES, Dehradun

Mr.P.SREEKUMAR

Senior Manager,

Pipeline

Headquarterss,Assam

College of Engineering

University of Petroleum & Energy Studies

Dehradun, May, 2010

Rehabilitation Of Pipeline Using Liner

A thesis submitted in partial fulfilment of the requirements for the Degree of

Master of Technology

(Pipeline Engineering)

By

Anish S R

R160208004

Under the guidance of

....

Prof. P.K.BAHL

Approved

....

Dean

College of Engineering

University of Petroleum & Energy Studies

Dehradun

April, 2010

ऑयल इंडिया लिमिटेड
OIL INDIA LIMITED

Oil India Corporation Limited
Pipeline Headquarters
Oil India Limited, Udayan Vihar
Narengi, Guwahati, Assam – 781171
INDIA
Phone : + 91-361-2643685/2641144
Fax + 91-361-2643686
Email: oilat@sancharnet.in.

, INDIA / PL/GW Dated : 21.04.2010

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Sh. Anish** S.R., final year M.Tech student at University of Petroleum and Energy Studies, Dehradun (UPES), has successfully undergone 3-weeks Project in Oil india Pipelines from 25.03.2010 to 22.04.2010.

During the course of training, he had an exposure to operations & maintenance activities of Oil india Pipelines and visited Rehabilitation sites of Oil India Pipelines.

We found him enthusiastic and eager to learn during the period of Project.

(P. Sreekumar)
Senior Pipeline Engineer

Sreekumar
Sr. Manager
Oil India
Pipeline Division

Acknoledgement

It has been an immense pleasure and truly enriching experience doing my project at the **Pipeline Division,** Assam of **Oil India.(OIL).** We take this opportunity to thank all those people who have made this experience a memorable one. Firstly, We would like to thank my guide **Mr. P. Sreekumar, Senior Manager, Pipeline Headquarterss,Assam , Mr. Rajib Goswami, Chief Engineer ,Business development** who has been instrumental and a guiding force behind the completion of this project. He has been constantly eliciting insights and viewpoints on the subject matter.

I would also like to thank the complete Team who were there throughout my stint at OIL, for any help we needed. I also indebted to to **Mr. Vipinachandran Senior Construction Manager , IOCL,** for giving me an opportunity to get the project work in the OIL.

We also thank **Prof. Sreehari, Dean, Collage of Engineering ,Prof. P.K.BAHL, Mr. Adersh Arya, Course co-ordinator,** for his encouragement and for permitting us to do this project and for providing us all the facilities with their valuable suggestions

Our sincere thanks to each and everyone who are all connected with my internship at OIL, Assam and UPES.

(Anish S R)

Contents

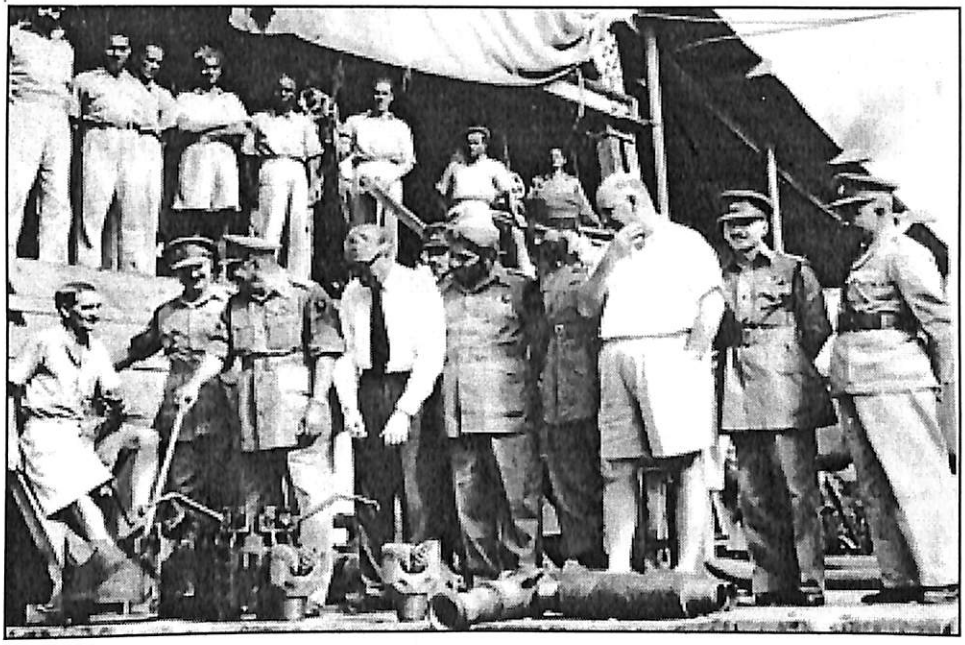
1.0.Abstract

Most of the pipelines in the world have been used beyond their design life and they are still being used. The main reason for the reduction in strength or deterioration is external and internal corrosion. The main problem of decommissioning or rehabilitation is that most of pipeline ROW, is through densely populated area require immediate care for leak and accidents . The replacement of existing with new pipeline is not economic. Thus , this problem is overcome by trenchless rehabilitation techniques.

In this paper , mainly discuss with the design of CIIP (Cured – In- Place thermosetting Pipe) for the Oil India crude pipeline, from Dikom to Dibrugarh (Assam). This design methods is used as per the code ASTM F 1216. This paper summarizes the initial phase of this work with respect to the renovation of deteriorated pipe by lining. This paper consider only the pressure pipe situation.

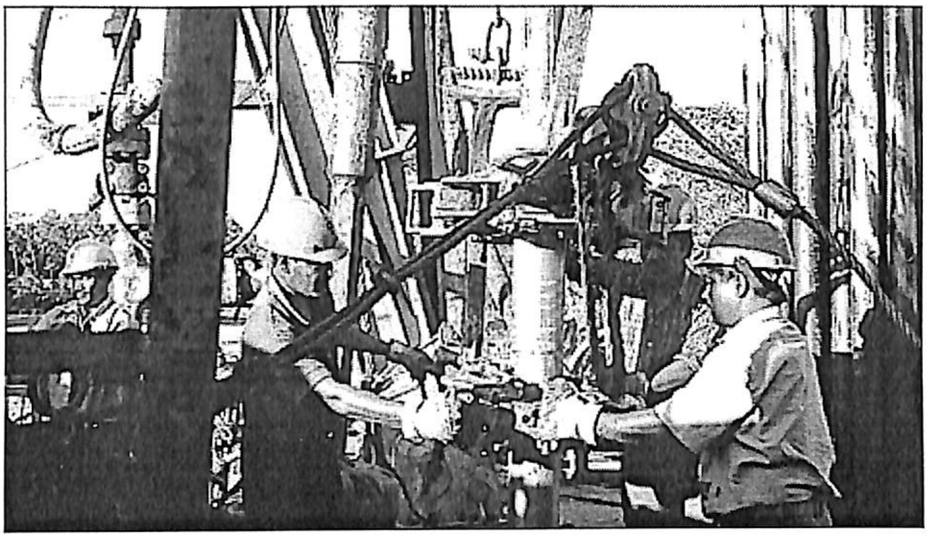
2.0About Company

Oil India is one of the oldest oil sector company in India. The story of oil India begins from before independence. The story Oil India ltd showcase the development and growth of Indian petroleum sector or petroleum industry. The flag ship of Oil India ltd starts from the discovery of crude oil in the far east of India at Digboi, Assam in 1889.The present situation is fully integrated upstream company dealing with exploration and production. During the period of time OIL has achieved lot of milestones.



The company flag Ship Company has come under Indian constitution have under gone expansion on February 18, 1959, due to the discovery of oil fields of Naharkatiya and Moran in the Indian North east. In 1961, it has became a joint venture company between Indian Government and Burmah Oil Company Ltd, Uk.

In 1981, OIL has become part of a fully-owned Government of India enterprise. Today, OIL is one of the premiers Indian National Oil Company engaged in the business of exploration, development and production of crude oil and natural gas, transportation of crude oil and production of LPG. OIL has also providing various Exploration and Production related services for the various oil sector company and the company is holding 26% equity in Numaligarh Refinery Limited.



The Authorized capital share of the Company is around Rs. 500 Crores. The Issued, Subscribed and Paid share capital of the company is Rs. 240.45 Crores. At present, the Government of India, the Promoter of the Company is holding 78.43% of the total Issued & Paid-up Capital of the Company. The balance 21.57% of the Equity capital is held by others.

OIL has over 1 lakh sq km of PEL/ML areas for its exploration and production activities, most of it in the Indian North East, which accounts for its entire crude oil production and majority of gas production. Rajasthan is the other producing area of OIL, contributing 10 % of its total gas production. Additionally, the exploration activities are spreads over onshore areas of Ganga Valley and Mahanadi. OIL is also participating in the NELP exploration blocks Mahanadi offshore, Mumbai Deepwater, Krishna Godavari Deepwater, .. etc, as well as various overseas projects in Libya, Gabon, Iran, Nigeria and Sudan. In a recent survey held by CRISIL- India Today , OIL was pronounce as one of the five best major PSU's and one of the three best energy sector PSU's in India.

OIL, is the pioneer in crude oil transportation in south-east Asia, owns and operates 1,432 km of cross-country crude oil pipelines. Commissioned in 1962, OIL's crude oil pipeline traverses 79 river crossings, including the mighty Brahmaputra River rushing through paddy fields, tropical rain forests and the world's greatest watershed zone - the Teesta Area. The state-of-the-art pipeline can transport over 8.0 MTPA of crude oil, feeding 4 Public Sector Refineries in North-east India. OIL has owned 10 crude oil pumping station and seventeen repeater stations spread across the eastern India states of Assam, West Bengal and Bihar.

Department Profile of the company

- Pipeline Maintenance.
- Mechanical Maintenance.
- Oil Movement.
- Telecommunication.
- Electrical and Cathodic.
- Pipeline Business Development.
- Projects

Technical Services

- Construction of Cross country petroleum pipeline.
- Design, detailed and residual engineering studies for pipelines, tank farms, pump stations and terminal.
- BOOT contracts for cross- country pipelines and terminals for natural gas and CNG pipelines.
- Development and design of fully dedicated telecommunication infrastructure including Optical Fibre Communication (OFC), Telemetry and SCADA that are usefull for the online inspection and monitoring of the pipeline system.
- Design and Development of temporary and permanent Cathodic Protection System that very necessary for the prevention of corrosion of the under ground structure like pipelines..
- Fire fighting facilities with fire hydrant network for all the pipelines, tank farms,..etc..
- Preparation of Disaster Management Plan for onsite and offsite.
- Specialized pipeline services like; hot tapping, pipe cutting and shearing off, etc.
- Services providing for existing pipelines such as; revamping, augmentation of pipeline for increasing throughput, de-bottlenecking.

- Supervisory service and provide guidance for construction of hydrocarbon transportation system, such as pipelines, pump stations, compressor stations, terminals, cathodic protection and telecommunication systems.

Specialize Services Provided By OIL

i. **Hot tapping:**

Oil has hold its own state-of-the –art TD Williamson hot tapping machine, capable of carry out work from 50mm to 406 mm diameter at a rating of 100 kg/cm^2.OIL are also providing end to end hot tapping services like split tees and saddles at commercially reasonable rates on turnkey basis. The hot tapping services was used to implement turnkey projects for Indian Public Sector companies like IOCL,BRPL,NRL, etc.

ii. **Stoppling**

OIL have possession of a sophisticated stoppling machine from TD Willamson. This stoppling machine is used for the activity like line plugging operations. The company make available integrated stoppling services including sandwich valves, split tees and saddles at commercially economical rates.

iii. **Pipe Cutting and Shearing off**

The company has acquired pipe saw machine which is capable of producing double bevel cuts on pipe sizes upto 559 mm diameter with wall thickness upto 12 mm,in highly hazardous and inflammable conditions.

Operation and Maintenance

- Cross-country crude oil, gas and multi-product pipeline.
- Trunk Telecommunication system on UHF/ OFC, Including radio communication, telemetry, SCADA and instrumentation.
- Cathodic Protection System of single and multiple pipelines in the same ROW and associated facilities.

- Specialized machinery and Heavy equipment.
- Rotating equipment, pumps and engines, and ancillary equipment used in the pipeline transportation system.
- Maintenance of ROW, like avoid or removal of encroachment, planting big tree, spotlight repair (exposure repair), river training and bank protection works, lowering of pipelines, pipeline tracking with instrumented pig, maintenance of pipeline in river bridges, submerged crossings and suspension crossings.

Business and Service on offer

1. **Pipeline Construction:**

   OIL has been bid for a number of gas pipelines, and it has endeavor into the construction of product pipelines in consortium with IOTL for the Numaligarh – Siliguri product pipeline pipeline in the sector of Assam.

2. **Project highlights:**
   - Environmental clearance.
   - Micro-tunneling for river crossing across seven major rivers has been conceded out for the very first time in India.
   - Dewaxing of the pipeline to switch over from crude to product pipeline.

3. **Cathodic Protection:**

   Cathodic protection is very important for the protection of the buried pipeline from corrosion. The company has cross the threshold into a joint venture with ICSA India to provide intelligent cathodic protection services in India and Abroad.

4. **Telecommunication:**

   OIL has completed the design, installation and commissioning of almost 1200 km of optical fiber cable network of STM-16 capacity from duliajan in Assam to the Barauni in Bihar. Above that OIL's row trunk line communication is also incorporated. The telecom department of OIL has dominating the national long distance license for leasing of telecom bandwidth, and has formerly obtained Infrastructure Provider Category - 1 license for leasing out spare dark fiber and associated telecom infrastructural facility as a part of business venture.

5. **Leasing of right of way:**

   The company has diplomacy to discriminating lease out available segment of the 1157 km long ROW for laying oil and gas pipelines as part of business venture.

6. **HDD (Horizontal Directional drilling):**

   OIL is in the course of action of carrying out horizontal directional drilling for pipeline crossings for various agencies and Public sector undertakings. Online inspection of 756 km long 14 " (355 mm) diameter main line from Gowhati to Barauni is currently underway.

Research and Development

OIL has conceded research and the field trials in development of intelligent cathodic protection system(ICP), which will help in acquisition and monitoring of real time PSP(pipe to soil) data and control of impressed current voltage, besides mitigating abnormal conditions, to keep the pipeline and associated systems under protection at all times in all conditions. This will help to make the cathodic system more effectively. The main advantage of ICP is that it will provide all the real time data and it can easily available on the control room or it has to be integrated into the package of pipe studio along with SCADA and other monitoring parameter. This provide lot of money too, through the cut-off of field data collection.

3.0.Introduction and Scope

3.1. Introduction

Buried , high – pressure pipelines are subjected to loads and environmental effects that may cause the pipeline (metal structure) become degraded with the passage of time. The main reason for metal degradation is corrosion. The corrosion means reaction of metal with its environment , some times non – metal are also corroded. The corrosion or degradation of metal is also put into the design stage.The corrosion cannot be completely eliminated , but can minimized to some extent by providing proper techniques (mitigated) like;. coatings, cathodic protection , material selection, chemical inhibitor and environmental change. The other impacts that damage the pipeline like; environmental hazards , soil erosion, third party damage and improper maintenance. In most of the case corrosion allowance is also provided and it is added to the minimum wall thickness.

To control the corrosion well monitoring of the system is required. All pipeline operators are well aware of this, and the operators have active programs to mitigate deterioration and to remediate defective pipe. The efficiency of the pipeline mitigation is mainly done by resolving and identify the problem in time. The identification of problem is done by routine ROW (Right of Way) petrol this is done by line walker report. The monitoring of cathodic protection potentials and rectifier current and PSP reading also provide better identification of defects.If the reading obtained in the PSP reading has to be in the range of -0.85 to 1.15 mv. If the reading falls above or below the limit then we assumed that defect is present.

The problems or defect associated with the pipeline are identified in routine monitoring as well as we will go for intelligent pigging and hydrostatic testing to revalidate the pipeline. The condition for the assessment will be due to some special circumstances may be the existence of excessive amounts of low pipe-to-soil potential readings,the occurrence of leaks or ruptures, or just an intuitive feeling that it is time to check the condition of a pipeline.

After getting the intelligent pigging report we reduce the pressure of the pipeline. After that the risk assessment is carried out if the risk of pipeline is found high the we will go for rehabilitation.

In this paper mainly deal with trenchless rehabilitation of Dikom to Dibrugarh tank firm pipeline by using rhabilitation liner.

3.2.1.The scope of the project report is most of the pipeline being used are beyond their design life, or the strength of aged pipe is less due to deterioration .This may be fully or partially this paper discuss the way to improve the strength by adding or provide liners.

3.2.2. This practice describes the procedures for the reconstruction of pipeline and conduits (4 to 108 inch diameter) by the installation of a resin – impregnated flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water or introducing controlled stream within the tube. When cured, the finished pipe will be continuous and tight – fitting. This reconstruction can be applicable for process piping, pressure piping.

3.2.3. This paper will help to rehabilitate the pipeline using liner and its help to save time and money.

4.0.Different type of liners

4.0 Trenchless Rehabilitation Methods

Most nations in the world have aged pipeline, ie ; the design life of pieline is exceeded, the pipeline infrastracture require renovation by repair and replacement.The most of the cross- country oil and natural gas pipeline is badly corroded and leaks, the most common solution is to decommissio the pipeline and buil a replacement line, using the same pipeline right – of – way. For pipelines that passing through urban and other densely populated areas, it is very difficult and costly to build new pipelines. Pipeline renewal using trenchless technologies (ie; the technologies that require minimum digging or open cut) is prefferd to decommissioning and replacement of new pipelines. Major types of trenchless technologies to rehabilitate aged pipeline usin liner are described below.

4.1.Cured- In- Place Lining

This method involves using a flexible fabric tube that can be folded (deflected) and inserted into a leaking old pipe to form lining. By pulling the folded flexible tube into the pipe with upturn or hoist (pulley) under fluid pressure. The fluid pressure is used to cause the tube to inflate and attach firmly to the pipe wall. The tube, containing, a thermosetting resin and a catalyst, can then be inflated by a heated fluid, such as hot water or steam. The heat causes the resin to set, forming a strong lining to protect the old leaky pipe. To go for it is necessary to clean the pipe interior for success of the project. The types of thermosetting resin used in such linings include polyester, vinylester, and epoxy. The polyester is most commonly used, and it has higher resistance to acids than epoxy resins. Epoxy resins are adhesive to pipe and resistant to fluids having high PH values.Vynylester has superior corrosin resistance at high temperature. By using this type of lining the diameter of the pipe is slightly reduced.

4.2. Slip- Lining

Slip- lining involves the insertion (sliding) of a flexible new pipe into an old pipe to be renovated. The new pipe must be significantly small in diameter than the old pipe. The new pipe must be significantly smaller in diameter than the old, or else difficulties will be encountered in sliding the new pipe into the old pipe, especially if bends exist in the pipe. The sliplining has important draback is that a significant reduction of the hydraulic conveyance – due to reduction in cross-sectional area.

4.3. Pipe – Bursting

Old underground pipe can be replaced with new pipe of the same diameter or with larger diameter without having to dig a long trench and dig out the old pipe. This is done by in-situ bursting of old pipe, and subsequent installation of new pipe using some special type of machine.

The first type of machine involves inserting into old dteriorated pipe a pneumatic mole that contains a pair of braker (cracker) arms. These craker arms are hydraulically operated, they can burst the old pipe and push the fragments outward. After that , anew pipe of same diameter or larger diameter as the old pipe is pulled into the space created by the pipe bursting machine.

The second type of machine or method is that using microtunneling. In this method a vertical dig is done at both end and the dteriorated existing pipe segment is removed, and new pipe is installed.

4.4. Pipe – Shrinking

Pipe – shrinking involves taking a flexible plastic pipe such as HDPE or PVC,and compressing and deforming it into a U- shaped cross section, which results in a much smaller cross – sectional area than that of the orginal round pipe. This deformed and shrunk pipe is easily pulled into a pipe of larger diameter. Then the lining pipe is inflated into its orginal round shape and size by using heat and internal pressure. For HDPE pipes, shrinking can be done without change of shape or deformation. By applying a radial inward pressure on the pipe, the pipe shrinks. The shruken pipe can easily be slip – lined into clean old pipe. After the liner is in place and the inward pressure is removed , the pipe a gradually relaxes and liner and the old pipe. Applying internal pressure to the liner speeds up the recovery process.

4.5. Patching and Sealing

This method is mainly used for mitigate the localized damage of existing pipeline.The main reason for localized damage is due to accidents due to third party damage, impacts during construction. This method involves repair of hole , cut can be done by patching (bandaging) the hole from outside of the pipe. The hole can also be repaired from inside of the pipe by chemical grouting, which involves injecting resign through the first hole. An inflated blader is placed inside the pipe at the location of the hole that required to be sealed. Then, the injected resin is between the inflated blader and the pipe until the outer surface of the pipe and surrounding soil are get saturated with the resin. After the resin is set, the hole is sealed and blader can be removed.

5.0. Data used for design

Specification of line pipe material	– API 5LX 42.
Diameter of pipeline	: 8 inch
Length of pipeline	: 28 Km.
Location of pipeline	: Dikom to Dibrugarh tank firm.

Type and properties of material is carrying : Waxy Indian crude oils, having a middle-range API gravity (28-30), were studied. Dikom (DK) wax (> 10%) and asphaltene (> 2.5%) contents. Polybehenyl acrylate (PBA) with a range of molecular weights were prepared and their efficacy as flow improver (FI)/pour point depressant (PPD) were evaluated.Lower molecular weight PBA shows better efficacy as FI/PPD.

Location of major defect : the most of the defect are found under the river crossings.

(the detailed list of defects is mention in table 12.7)

Data required for Calculation are given below;

P = Allowable restrained buckling pressure in psi or N/m^2.

E_L = Long term modulus of elasticity in psi.

K = Enhncement factor (typically 7).

C = Ovality factor

N = Safety factor.

D – is outside diameter in meter.

I – Moment of inertia in m^3.

t- thickness in meter.

E_L – Long term (Flexural) modulus of elasticity in N/m^2 or psi.

N – Safety factor.

B' – Co- efficent of elastic support

H_s– Heigt of soil cover over the host pipe, in feet or meter.

R'_w– Water buoyancy factor.

The values of above are mention on the table 13.1 and 13.2

6.0. Liner design

6.1.0. Liner design issues

6..2.1. Lining design is currently undertaken on the assumption that deterioration of the host pipe results in purely static loading at gaps and voids which form due to a combination of corrosion, soil movements and external loading. Future research should consider the issue of structural performance (for fully structural and semi-structural linings and for a variety of embedment scenarios) following a dynamic host pipe failure. In particular liner responses during/after sudden longitudinal and circumferential fractures of cast iron pipes need to be investigated. Any risk of longitudinal fracture due to radial pressure transferred by a close-fitting liner will generally require a fully structural solution, but the demonstrated ability of certain semi-structural liners to survive a circumferential break (by far the most common mode of failure in small diameter cast iron pipes) is of special interest. The need to quantify the extent of such ability, and the long-term response of a semi-structural liner to any shear forces imposed across a fracture by subsequent soil movements.

6.1.2.Information on seasonal soil movements and the loads these impose on pipelines with a particular emphasis on a close-fit liner at a circumferential fracture. German research (included in DIN standards), work by O'Rourke in the US, Japanese experience of ground movements due to earthquakes, and the TRL work on trenching are the best available examples. Fundamental understanding relating to geotechnically induced stresses is still lacking.

6.1.3. Better knowledge of the shear capacity of a lining at a circumferential fracture is a research need (Crunkhorn et al., 2001, 2004) strongly related to soil movements. This is an important issue for semi-structural linings as it is the only significant additional source of external loading on the lined system following a circumferential fracture.

6.1.4. Initially liners were envisaged as being installed at a close-fit (i.e. gap small in comparison to the liner strain capacity) just before application of service pressure and current design guidelines are based on this assumption. However, contractors are now wishing to use standard liner pipes for a range of host pipe diameters, with lacks of fit of up to10% envisaged. Revised guidelines taking due account of initial lack of fit may therefore be needed; certainly research is required to investigate this issue so that revised guidelines can be issued if necessary.

6.1.5.Buckling capacities of close-fit liners (installed by various techniques), due to both surge and longer-term net external loading, are required for a comprehensive design.

6.1.6.Development of the ability to predict the factor of safety against brittle failure of pipe grade polyethylene system components under service loading; fundamental performance, rather than relative index performance (the current basis of design in this respect – see e.g. Beech et al., 2001; Leevers et al., 2001), needs to be understood.

6.1.7.Resolution of choice between adhesive linings and non-adhesive linings. Adhesion of thin-walled linings might be attractive to make use of host structure and collapse resistance, but adhesion is difficult to guarantee and may act to propagate failure of host pipe or lining. Specific need to determine effects of adhesive bond and/or interface friction, whether intended or not, on the ability of liners of different materials to survive different types of host pipe failure.

6.1.8. The effects of earthquakes on lined systems should be considered for international applications.

6.2.0. Optimal renovation of mains and service connections

6.2.1. On-going development and evaluation of new materials and installation techniques for pressure pipe renovation. Development of new materials should take into account durability issues to prevent the occurrence of premature failures, as occurred due to fatigue with early PVC systems.

6.2.2. Development of further improved materials for the installation of semi-structural linings by the spray lining process.

6.2.3. Development of improved remote patch repair systems that operate from inside the pipeline.

6.2.4. Further development of efficient connecting systems for services, end terminations, branches, valves and other network features. See also 2.4.4.4 below.

6.2.5. Although much significant work has been done (Groves and Goodrich, 2001), viable lining methodologies (and associated design criteria) for high-pressure oil and gas pipes for application to both new and old pipes remains a need (Boot and Naqvi, 1998).

6.2.6. Lining and making service connections. There is currently no widely available technique suitable for lining small diameter house connections for water pipes, though there are techniques available for gas pipes. The remote opening of service connections (trenchlessly) is an important need. The US systemof blown epoxy (developed in the marine industry) and blown film techniques proposed for lead pipe lining warrant further investigation in this respect.

6.3.0. Maintenance issues

6.3.1. Means of repairing lined pipe needs to be considered as a design requirement.

6.3.2. Means of identifying the presence of a lining within a pipe is an unresolved issue.

6.3.3. Development of 'Significance of Defects' criteria to govern actions related to damaged liners or those suffering less than perfect installation.

6.3.4. The need to hold stocks of special types of connection for many liner types can be a disincentive to lining– are universal lined/unlined pipe connections a viable prospect?

6.2.0. Design Methodology

6.2.1.Pressure liner design concept

This paper is mainly based on the design design methodology specified in ASTM F 1216. This code (F1216) contain design method of three parts. The parts in design method appendix are; X1.1 Terminology, X.1.2 Gravity pipe and Pressure pipe X 1.3. This paper only discuss about pressure pipe only. The design method recognizes mainly two design probabilities. The condition are for the pipe lined which are either partially or Fully deteriorated.

The terminology section X.1.1 provides definition of when the existing pipe should be considered either partially or fully deteriorated. In this section (definitions), both the present existing and the expected future condition throughout the design life of the lining are taken into account. While some other discussion is going on if there is a fully deteriorated condition is actually exist or not , but in this paper is not considering this confusion.

For the partially deteriorated design condition, the f1216 design method should requires to satisfy the two equations, X1.1 and X1.2. The required liner thickness determined from satisfying the equations. The two equations, X.1.1 and X.1.2 are;

$$P = \frac{2KE_L}{(1-\nu^2)} \times \frac{1}{(DR-1)^3} \times \frac{C}{N}$$ (ASTM F1216 X1.1)

$$\frac{\tau_L}{PN} = 1.5\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR$$ (ASTM F1216 X1.2)

For the fulley deteriorated pipe liner design, it is necessary to satisfy the four design equation in F1216. They are X.1.1, X.1.2, X.1.3, X.1.4. The required liner thickness determined from satisfying the equations. The required liner thickness is the highest thickness determined from satisfying the equations. Out of from the four equations, including the revised from X.1.3 are;

$$P = \frac{2KE_l}{(1-\nu^2)} \times \frac{1}{(DR-1)^3} \times \frac{C}{N}$$ (ASTM F1216- 07B Revised X1.1)

$$\frac{\sigma_L}{PN} = 1.5\frac{\Delta}{100}\left(1+\frac{\Delta}{100}\right)DR^2 - 0.5\left(1+\frac{\Delta}{100}\right)DR$$ (ASTM F1216- 07B Revised X1.3)

$$q_t = \frac{1}{N}\left(32R_W BE_S C\left(\frac{E_L I}{D^3}\right)\right)^{1/2}$$ (ASTM F1216- 07B Revised X1.3)

$$q_t = \frac{C}{N}\left(32R_W B' E's\left(\frac{E_L I}{D^3}\right)\right)^{1/2}$$ (ASTM F1216- old equation X1.3)

$$\frac{EI}{D^3} = \frac{E}{12(DR)^3} \geq 0.093$$ (F1216 equation X.1.4)

Where;

P – Allowable retained buckling pressure.

DR – Dimension ratio

$DR = D/t$

Where;

D – is outside diameter in meter.

t – is liner thickness in meter.

q_t – the total external pressure that liner can resist , in N/m^2.

I – Moment of inertia in m^3.

$I = t^3/12$

Where ;

t- thickness in meter.

C – Ovality correlation factor.

E_L – Long term (Flexural) modulus of elasticity in N/m^2 or psi.

N – Safety factor.

The F1216 design methods states, in equation states the CIIP liner's capacity to resist the external load pressure calculated for the liner thickness. This liner is helpachive same pressure rating , when the metal loss is 30% of its original wall thickness.

6.2.2. Design Equation used

Step 1. Calculation of buckling pressure.

$$P = \frac{2KE_L}{(1-v^2)} \times \frac{1}{(DR-1)^3} \times \frac{C}{N}$$

Where;

P = Allowable restrained buckling pressure in psi or N/m^2.

E_L = Long term modulus of elasticity in psi.

K = Enhncement factor (typically 7).

C = Ovality factor

N = Safety factor.

v = Poissons ratio

= 0.08

(it is taken from pipeline handbook)

Step 2. Calculation of liner thickness.

CIIP liner thickness calculation using modified Timoshenko formula;

$DR = D/t$ therefore;

$$t = \frac{D}{\left[\frac{2KE_L C}{PN(1-V)^2)}\right]^{1/3} + 1}$$

Where;

P = Allowable restrained buckling pressure in psi or N/m^2.

E_L = Long term modulus of elasticity in psi.

K = Enhncement factor (typically 7).

C = Ovality factor

N = Safety factor.

Step 3. Calculation of toatal external pressure.

$$q_t = \frac{C}{N}\left[32 \times R_W \times B' \times E_S' \times \left(\frac{E_L I}{D^3}\right)\right]^{1/2}$$

Where;

q_t = total external pressure in N/m^2 or in psi.

D – is outside diameter in meter.

I – Moment of inertia in m^3.

$I = t^3/12$

Where ;

t- thickness in meter.

C – Ovality correlation factor.

Obtained from ASTM F 1216 chart 1 in graph 12.2E_L – Long term (Flexural) modulus of elasticity in N/m^2 or psi.

N – Safety factor.

B' – Co- efficent of elastic support

$$B' = \frac{1}{\left[1 + 4e^{(-0.065 \times H_s)}\right]}$$

Where;

H_s– Heigt of soil cover over the host pipe, in feet or meter.

R'_w– Water buoyancy factor.

$$R_w = 1 - 0.33\left(\frac{H_w}{H_s}\right)$$

The minimum value of R_w is taken as 0.67.

Step 4. External preesure calculated by considering live load, soil contribution, and water contribution,and pressure generated by the flowing fluid.

$$q_t = 0.433H_W + \left[\frac{wH_S R_W}{144}\right] + W_S$$

Where;

H_w – Groundwater over top of pipe.

Hs – Soil cover

Ws – Soil density

Step 5. Minimum thickness design.

$$t = 0.721D \times \left[\frac{\left(\frac{Nq_t}{C}\right)^2}{E_L R_{W'} B' E'_S}\right]^{1/3}$$

Where;

t –thickness in meter.

q_t – total external pressure in N/m^2 or in psi.

D – is outside diameter in meter.

C – Ovality correlation factor.

E_L – Long term (Flexural) modulus of elasticity in N/m^2 or psi.

N – Safety factor.

R'_w – Water buoyancy factor.

B' – Co- efficent of elastic support

E_s – Plain strin modulus

$$E_S = \frac{E_L}{(1-v^2)}$$

Where;

E_L – Long term (Flexural) modulus of elasticity in N/m^2 or psi.

v– poisons ratio

7.0.Pipe lining method

The present invention relates to a method of lining a pipe, and relates particularly, but not exclusively, to a method of lining a rigid undersea pipe for transporting water and/or hydrocarbon liquid and /or gas. The importance of this method is that, pipes of various materials, such as concreate,clay,brick, mildsteel, castiron or lead often deteriorated with age and/or chemical attack. This method provide an added advantage rather than replacement of pipe. This method is also known as reline the pipe with plastic materials, such as polyethylene.

7.1.LINER INSTALLATION - CIPP

A. Install liner for cured-in-place pipe in accordance with ASTM F1216.

B. Resin Impregnation: Designate location where uncured resin in original containers and non-impregnated liner tube will be saturate prior to installation.

1. Permeate (saturate) liner tube by vacuum or other approved means.
2. SDR may inspect materials and "wet out" procedure.
3. Use resin and catalyst system compatible with requirement of this method.

C. Liner Insertion: Ensure that pressure in liner exceeds both pressure due to groundwater head and any pressure due to laterals or connecting side pipeline.

1. Insert impregnated tube through existing or new manholes by means of installation process, and application of hydrostatic head, compressed air, or

other means sufficient to fully extend it to next designated manhole or termination point.

a. Inflate and firmly adhere liner to pipe wall.

b. Install liner at rate greater than three feet (1 m) per minute and less than 10 feet (3 m) per minute.

2. Mark exterior of manufactured tube along its entire length at regular intervals not to exceed five feet (1.5 m) as a gage to measure elongation during installation.

   a. During insertion of resin impregnated tube into pipeline, maximum allowable longitudinal elongation or stretch of material shall be 5 percent.

   b. Longitudinal stretch of tube shall be gauged by comparing markers on fully inserted tube to actual length of pipe being rehabilitated.

3. Insertion by Inversion: Insert wet out liner through existing manhole by means of inversion process, and application of hydrostatic head or air pressure sufficient to fully extend it to next designated manhole.

   a. At lower end of standpipe or guide chute (pipe or tube) turn liner inside out and attach to standpipe (or chute) so that leak-proof seal is created.

   b. Adjust inversion head or air pressure to be of sufficient magnitude to cause impregnated liner to invert from manhole to manhole, hold tube tight to pipe wall, and produce dimples at service lateral connections and flared ends at manholes..

   c. Use lubricant if required.

4. Insertion by Winching: SDR will accept winched-in applications as alternate to inversion process, provided that liner tube and resin conform to materials and curing requirements of ASTM F1216 and this specification.

a. Insert wet out liner through upstream manhole, and pull through section with power winch and steel cable attached to end of liner with appropriate pulling head.

b. Provide monitoring device on cable to measure pulling force. Should the pulling force exceed manufacturer recommendations, tube shall be rejected and replaced.

c. Install rollers in upstream and downstream manholes to guide liner into and out of host pipe, and to guard against chafing of crowns at entry and exit from winch cable.

d. Cover sewer invert throughout section to be lined, with polyethylene foil or other suitable material to facilitate threading of liner and reduce risk of damage to liner material. Form CIPP with polyurethane coating on its interior surface.

e. Use flexible and impermeable calibration hose to inflate tube. Calibration hose may or may not remain in completed installation.

    1) Dry tube or inflation hose material that enters existing pipe that has not been previously vacuum impregnated with resin under controlled conditions cannot be included in structural wall of CIPP. Nominal thickness of this material shall be deducted from field sample thickness measured in order to verify that minimum specified wall thickness is achieved.

    2) Hose material remaining in installation shall be compatible with resin system used, bond permanently with tube, and be translucent to facilitate post-installation inspection.

    3) Hose material to be removed after curing shall be non-bondable material.

f. Introduce water, air and/or steam into liner. Pressure will inflate and press liner material in tight fit against inner walls of host pipe, producing dimples at lateral and side connections and flared ends at manholes.

D. Curing: After insertion of tube is completed, provide suitable heat source and distribution system to distribute and recirculate hot water, air, and/or stream throughout pipe as recommended by manufacturer,.

1. Equipment shall capable of delivering hot water, air, and/or stream throughout section by means of pre-strung hose to uniformly raise temperature above temperature required to affect cure of resin.

   a. Temperature shall be determined by manufacturer based on resin/catalyst system employed.

   b. Perforate hose in accordance with manufacturer's recommendations, or other methods acceptable to SDR

2. Fit heat source piping with suitable continuous monitoring thermocouples to gage temperature of incoming and outgoing curing medium.

3. Temperature of curing medium shall meet requirements of resin manufacturer as measured at heat source inflow and outflow return lines.

4. Place additional continuous monitoring thermocouples between impregnated felt tube and pipe invert at manholes.

5. Curing medium temperature in line during cure period shall be as recommended by resin manufacturer.

6. Take care during elevated curing temperature so as not to over stress liner materials.

7. Initial cure shall be deemed to be complete when inspection of exposed portions of liner appear to be hard and sound, and remote temperature sensor indicates that temperature is of magnitude to realize exotherm.

   a. Cure temperature shall be held for period recommended by resin manufacturer, during which time distribution and control of curing medium shall continue.

   b. Curing of CIPP shall consider host pipe material, resin/catalyst system, ambient temperature, moisture level, and thermal conductivity of soil.

E. Cool-Down: Cool hardened liner to temperature below 100 degrees F (38 degrees C) before relieving pressure in section.

   1. Cool-down may be accomplished by introduction of cool water or air into lined pipe to replace water or steam and water being drained.

   2. Drain water from small hole made in downstream end.

   3. Take care in release of static head or air pressure to prevent development of vacuum that could damage pipe or newly installed lining.

   4. After tube has cured, use cool-down period prior to opening downstream plug and returning normal flow back into system.

F. Sealing at Manholes: If CIPP fails to make tight seal at manhole walls, apply seal consisting of resin mixture compatible with liner/resin system, in accordance with manufacturer specifications and approved by SDR.

7.2. Materials used for liner

A. Liner Material: Provide light-colored or white liner to facilitate closed-circuit TV inspection.

   1. Deformed Polyethylene (PE) Liner: Comply with ASTM F1533, and minimum material requirements of ASTM D3350, Cell Class 345434-D.

2. Folded PVC Pipe Liner: Comply with ASTM F1504, and minimum material requirements of ASTM D1784, Cell Class 13223-B or 12344-B.

3. Cured-In-Place Liner: Comply with ASTM D5813 and F1216.

   a. Resin-impregnated tube liner material shall consist of one or more layers of flexible needled felt, or equivalent woven or non-woven material.

   b. Capable of carrying resin, and withstanding installation pressures and curing temperatures.

   c. Able to stretch to fit irregular pipe sections and negotiate bends.

   d. Resins shall be styrene-based, thermoset resin and catalyst system, or epoxy resin and hardener system that is compatible with installation process.

   e. Outside layer of tube should be plastic-coated with material compatible with resin system used.

B. Liners fabricated from PVC, PE, or resin-impregnated tubes shall meet the following physical requirements:

Refer table 12.10

(1) Impact testing performed with 20 lb (9.1 kg) Tup A and flat plat holder B.

(2) Without cracking, breaking, or splitting.

C. Pre-Liner Material: If used, pre-liner shall be manufactured from material capable of withstanding temperatures and pressures encountered during installation.

7.3 Execution

7.3.1 Examination

A. Take field measurement of pipe inside diameter of pipelines to be rehabilitated, is calculated by using the pig data. In most of the case the inner diameter is found out by calculating the metal lose from wall thickness. In some cases the average wall thickness is considered.

B. In conjunction with review of the existing pipeline is done by viewing the damage of pipeline , by attaching camera head to the pig, this will help us to view the interior of the line in color closed-circuit television (CCTV), provide correct liner diameter and wall thickness to ensure tight fit with existing pipe to be restored.

C. Confirm lengths of liner to be installed, this is done by evaluating the damage length of pipeline that has to be rehabilitated.

D. This is very important to assure that, the all live services prior to rehabilitation activities. Each service connection shall be noted by size, position from reference manhole, and orientation with respect to circumference of pipe.

Live Service: It is prime important in connection with the risk associated with rehabilitation. Inactive service lines to vacant lot, vacant building, or to occupied building with more than one service line serving property .

7.3.2 Preparations

A. Successfully complete the following items before installation of Work.

1. Control the flow.

It is very much opted option for controlling the line is by using sectionalizing valves. In some cases total shutdown is preferred.

2. Clean the pipe.

Cleaning of the pipe is done by three steps. The first step is covered along with pigging this help to remove all the wax that may be present over the pipeline. The second method is by using pressurized heated water or steam. This will help to give complete removal of impunities. The very important step in washing is that add corrosion inhibilitor in the liquid. The final step is passing dry compressed air through the line.

3. Perform television inspection of pipeline.

B. Take precautions to protect new liner, and existing pipe and manholes from damage that might result during insertion process.

7.3.3 Sequence of work

Perform Work in the following sequence:

A. Divert flow to comply with requirements of section, "flow control".

In most of the cases for rehabilitation of a pipeline is done by complete shut down of the line, this help to minimize the risk involved in the process of rehabilitation. In very rare case if the rehabilitation is done by patching then complete shutdown is not required.

B. Clean the line .

The cleaning of the line is very important in the liner rehabilitation process.

C. Perform the pre – insertion inspection using sophisticated tools.

D. Install liner and leak test liner with requirements.

E. Reconnect service connections.

F. Perform post inspection, using sophisticated tools

7.3.4 PIPELINE POINT REPAIR

A. Repair of the pipeline is found by the pigging report given by the company or consulting firm. the pigging report is verified by site investigation. The repair pipeline where point repairs are identified in Contract documents or specified as per the work order.

B. Pipe and repair materials shall be the same as host pipeline, unless otherwise indicated.

C. Trenching and excavation shall conform to Section 8 and 18, "Earthwork".

D. Bypassing and Dewatering: When required by the process, bypass flow around work area, " Flow Control".

E. Notify SDR minimum of 48 hours in advance of planned time to begin pipeline point repair work at particular location.

F. Installation and Field Inspection: Installation of replacement pipe and/or repair work shall conform to Section 8 and 18. All pipeline point repairs shall be inspected by SDR prior to back filling and compaction.

8.0. Economic Analysis

For a larger prospective , this method (Rehabilitation liner) is comparing with the rehabilitation using traditional method like pipe replacement, providing spool pipe, by providing clamp. The cost of pipeline, clam and resin is mention on the table 13.3 to 13.4. the cost comparison for these are done on the table 13.5.

Apart from the material cost, the cost of installation is also taken into consideration the replacement of pipeline cost will be more compared to all other method . If we take the clamp as a low cost one the major difficulties is that this is not a permanent type of repair and it require regular monitoring it is quite difficult.

The most advantages one is liner installation, the cost of liner is more than that of clamp, when we count the design life it will become more fesissible. The one of the draw back is that may it will get damaged by frequent pigging. But if we compare the thickness and clearance of pig with the mating diameter it is found good. The maintenance cost is also less compared to all other method.

9.0. Conclusion

Rehabilitation using liner is found advantage than other rehabilitation method. The suggestion is based on the economic analysis done on the various traditional method and the cost of installation and maintenance. The most advantage is that liner design life is high as compared to other .This method is also provide good in séance of flow increase due to decrease in the friction factor.

The installation of liner for a length of 800 meter is highly effective, compared to all the other method of rehabilitation. The stability analysis of the liner is also help to get better idea of the liner. The design life of the liner is high compared to other.

The process of installation period is another advantage , if we going to replace the pipe it require lot of time to replace the pipe in orginal shape and lot of procedure has to complete before restarting the pipeline. But for this method using liner is quite simple and the important thing is that shut down period is minimum compared to all other method of rehabilitation.

10.0.Referance

1. ASTM F 1216

2.. Willke, T.L., Shires, T.M., Cowgill, R.M., and Selig, B.J., U.S. risk management can reduce regulation, enhance safety, *Oil and Gas Journal,* June 16, 37–40, 1997.

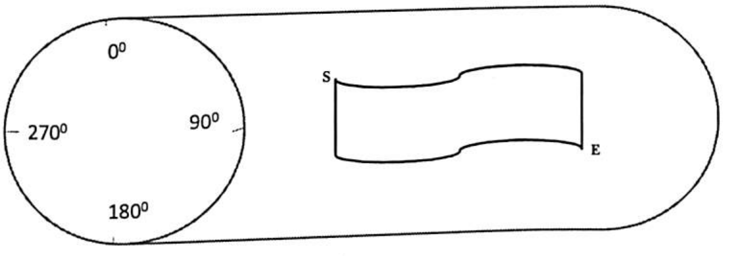
3. Nayyar, M.L., *Piping Handbook,* 6th ed., McGraw-Hill, New York, 1967.

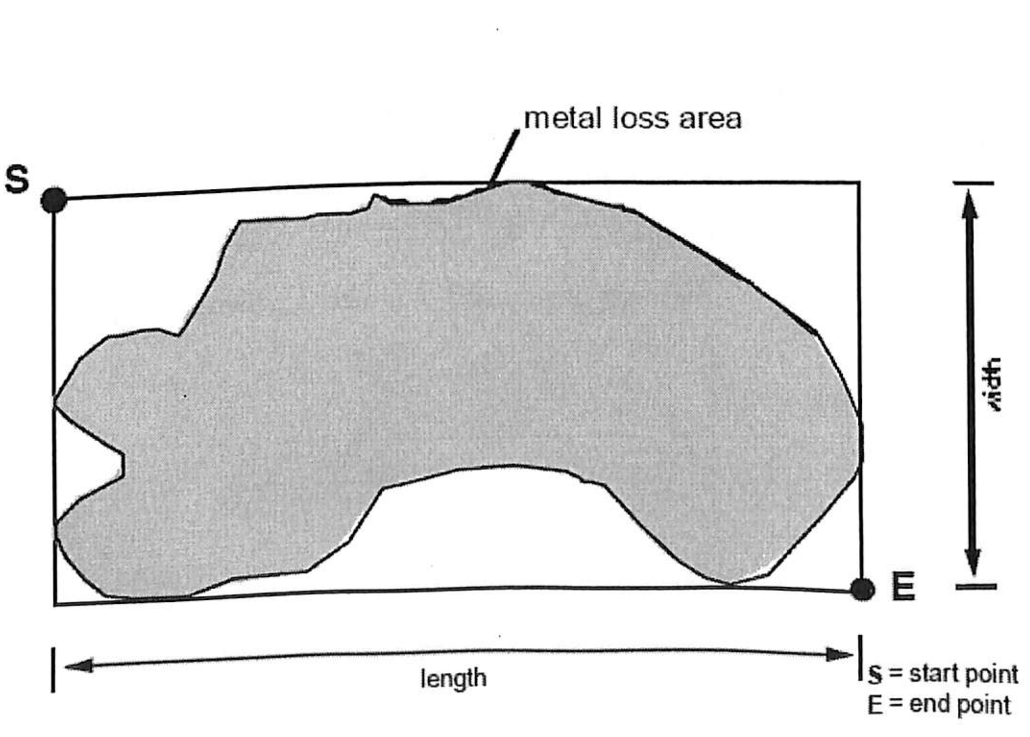
4. ASME B31.8 Code, *Gas Transmission and Distribution Piping,* American Society of Mechanical Engineers, New York, 1995.

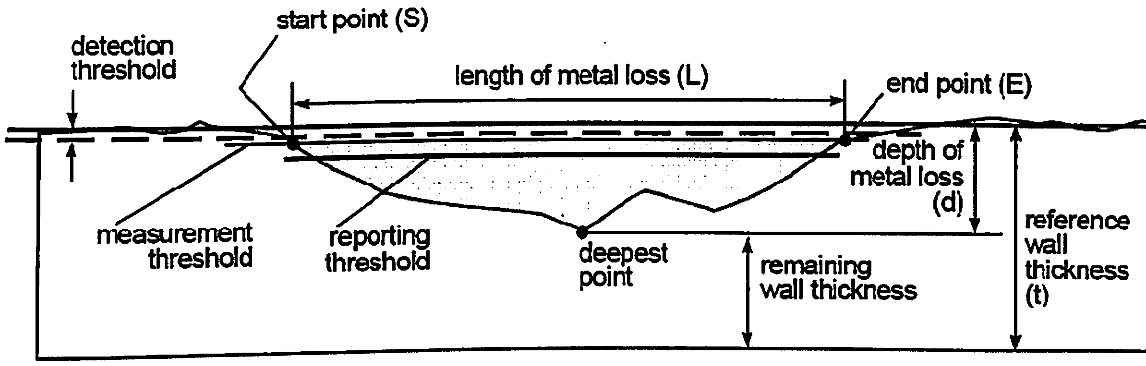
5. Iseley, D.T. and Najafi, M., *Trenchless Pipeline Rehabilitation,* National Utility Contractors Association, Arlington, VA, 1995.

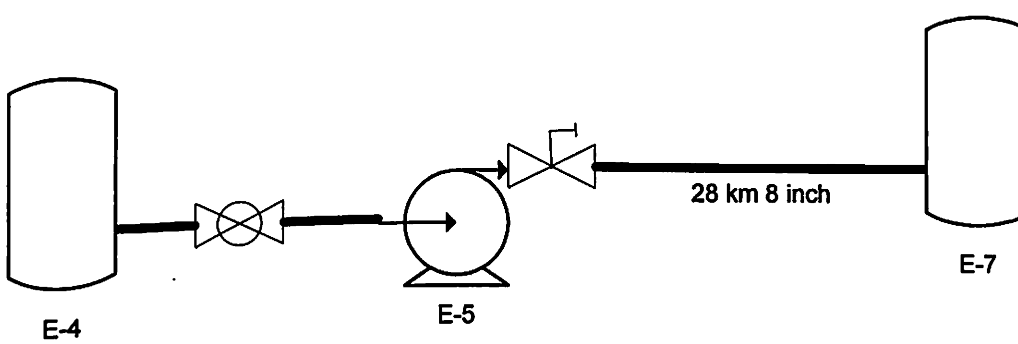
11.0.Figure

Data.1. Location and dimensions of metal-loss features









11.02Simple line diagram showing Dikkom to Diburagrah pipeline

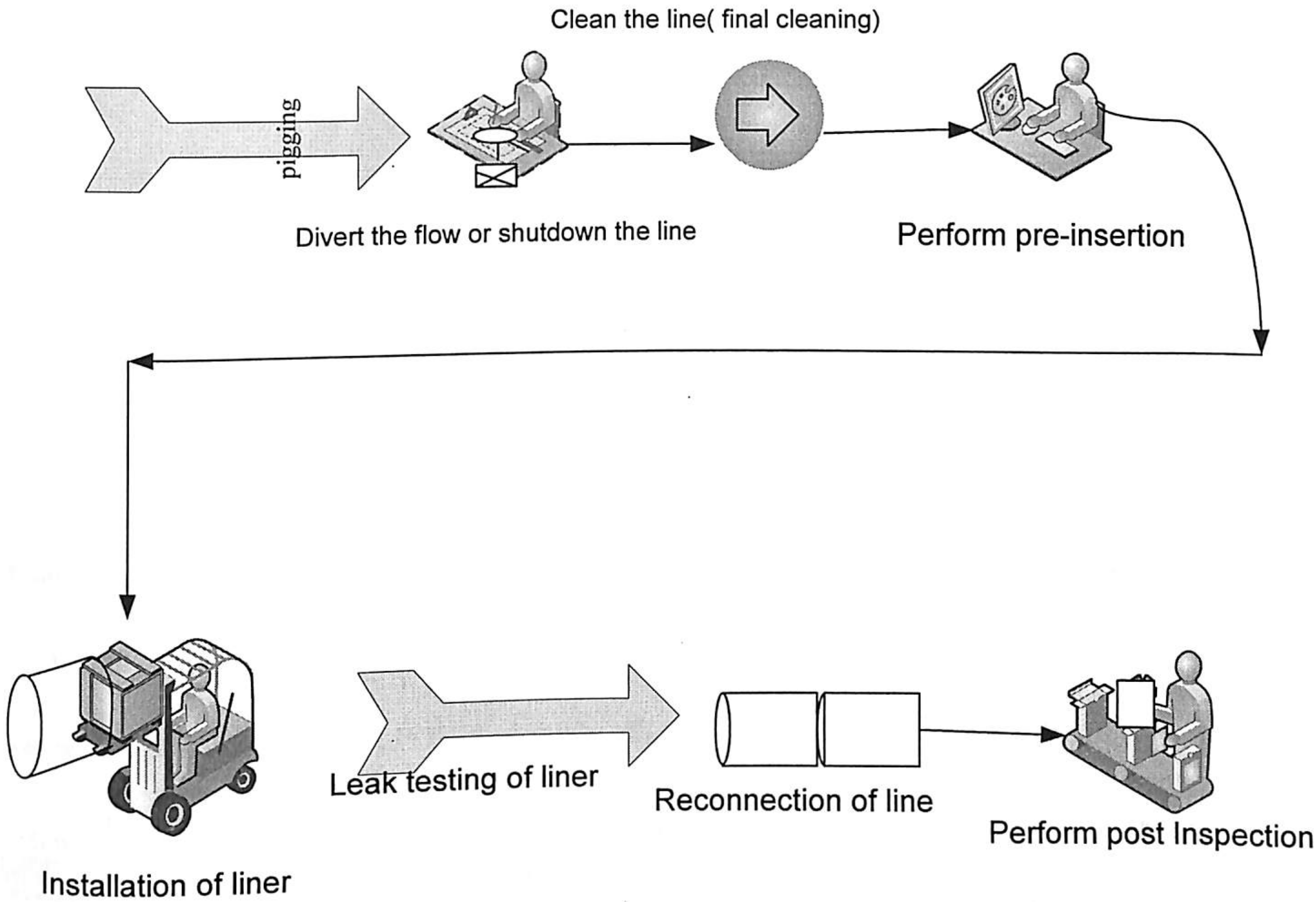
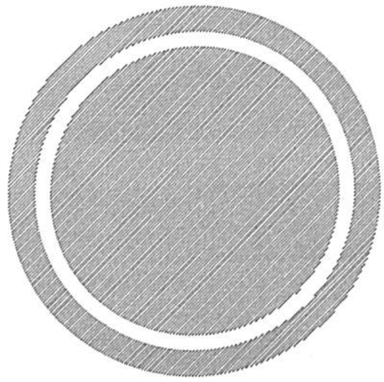


fig:11.03Installation procedure of liner

Fig:11.04 flow diagram showing steps in Rehabilitation



12.0.Tables and Graph

12.0.Tables and Graph

Table12.1. pipeline features (POI –Probability of identification)

Sl no	Features	Yes POI > 90%	NO POI <50%	May be 50%≤ POI≥90%
1	Internal/ External discriminATION	yes		
2	Metal- loss feature	yes		
3	Metal- loss pipe mill feature	yes		
4	Mid- wall feature		no	
5	Grinding			May be
6	Gouge		No	
7	Dent		no	
8	Dent with metal loss	Yes		
9	Spalling		No	
10	Axial Crack		No	
11	Circumferential crack		No	
12	Eccentric pipeline casing		No	
13	Sleeve repair	Yes		
14	fitting		No	
15	valve	Yes		
16	Bends(5d or less)		No	

Table 12.2 Full detection and sizing accuracy for metal-loss features in body of pipe

Sl: No:		Genaral metal loss	Pitting	Axial grooving	Circumferntial groving
1	Depth at POD = 90%				
2	Depth sizing accuracy at 80% confidence				
3	Width sizing accuracy at 80 % confidence				
4	Length sizing accuracy at 80% confidence				

Table12. 3. Full detection and sizing accuracy for metal-loss features in girth weld or heat

Sl: No:		Genaral metal loss	Pitting	Axial grooving	Circumferntial groving
1	Depth at POD = 90%				
2	Depth sizing accuracy at 80% confidence				
3	Width sizing accuracy at 80 % confidence				
4	Length sizing accuracy at 80% confidence				

Table 12.4. Automatic detection and sizing accuracy for metal-loss features in body of pipe

Sl: No:		Genaral metal loss	Pitting	Axial grooving	Circumferntial groving
1	Depth at POD = 90%				
2	Depth sizing accuracy at 80% confidence				
3	Width sizing accuracy at 80 % confidence				
4	Length sizing accuracy at 80% confidence				

Table12. 5.Automatic detection and sizing accuracy for metal-loss features in girth weld or heat affected zone

Sl: No:		Genaral metal	Pitting	Axial	Circumferntial

		loss		grooving	groving
1	Depth at POD = 90%				
2	Depth sizing accuracy at 80% confidence				
3	Width sizing accuracy at 80 % confidence				
4	Length sizing accuracy at 80% confidence				

Table 12.6 Physical properties of crude

Sl: No:	Physical Properties	Crude oils Dikkom
1	Four point (°c)	30
2	API gravity	28
3	Wax content (%)	11.7
4	Asphaltene content (%)	3.5
5	Average molecular weight	4500
6	Resin content (%)	14.5
7	PI viscosity at 30°c	690
8	ASTMdistilation	
	10% vol /vol	149
	20% vol /vol	215
	30%vol /vol	262
	40% vol /vol	282

Table 12.7. Maximum deviation of internal diameter from the nominal

Sl: No	Nominal diameter (in)	Maximum deviation (mm)
1	4	6
2	6	6
3	8-12	10
4	14-20	14
5	20- 36	16
6	36 and more	20

Table 12.8 inspection report

Oil India Crude Pipeline Ref: OI/P/DDJ/284	Dikkom-Duliajan pipeline Vissual Inspection : Observation	Inspected by external firm Date of Inspection : 12/ 01/10
Chainage (in Km) Actual Correlated	Observation and Parameter	
0.754 0.000	Coating Damage Severity : Light Length : 10 cm Breadth : 3% circum Position of Damage : Right (side B)	
5.42 0.000	Coating Damage Severity : Light Length : 10 cm Breadth : 100% circum Position of Damage : Left (side A)	
5.88 0.000	Coating Damage Severity : Medium Length : 30 cm Breadth : 100% circum Position of Damage : Left (side A)	
8.23 0.000	Coating Damage (river crossing) Severity : high Length : 20 cm Breadth : 66% circum Position of Damage : Right(side B)	
13.56 0.000	Coating Damage Severity : Light Length : 5 cm Breadth : 100% circum Position of Damage : Left(side A)	
18.44 0.000	Coating Damage (river crossing) Severity : high Length : 35 cm Breadth : 100% circum Position of Damage : Left (side A)	
19.22 0.000	Coating Damage Severity : Light Length : 10 cm Breadth : 100% circum Position of Damage : Left(side A)	
20.34 0.000	Coating Damage Severity : Medium Length : 10 cm Breadth : 100% circum Position of Damage : Left(side A)	
24.88 0.000	Coating Damage Severity : Light Length : 10 cm	

		Breadth Position of Damage	: 100% circum : Left(side B)
28.86	0.000	Coating Damage Severity Length Breadth Position of Damage	 : Light : 30 cm : 100% circum : Left(side A)

Table 8.Piging defect report

Reported		Investigated		Result		
Metaal Loss % of pipewall	Number of location	Wall loss found	Number Found Meassured	Actual Wall loss	Number Found	Percent
> 40%	4	>40%	4	>40% 20 – 40% 10 – 20% <10%	1 1 1 1	25 25 25 25
20 – 40%	142	20 – 40 %	102	>40% 20 – 40 % 10 – 20 % <10% No Data	8 47 27 18 2	4 56 37 2 1
10 – 20 %	229	10 – 20 %	157	>40% 20 – 40 % 10 – 20 % <10% No Data	8 87 48 12 2	0 12 52 30 6
0 – 10 %	329	0 – 10 %	212	>40% 20 – 40 % 10 – 20 % <10% No Data	8 67 87 42 8	0 12 52 30 6

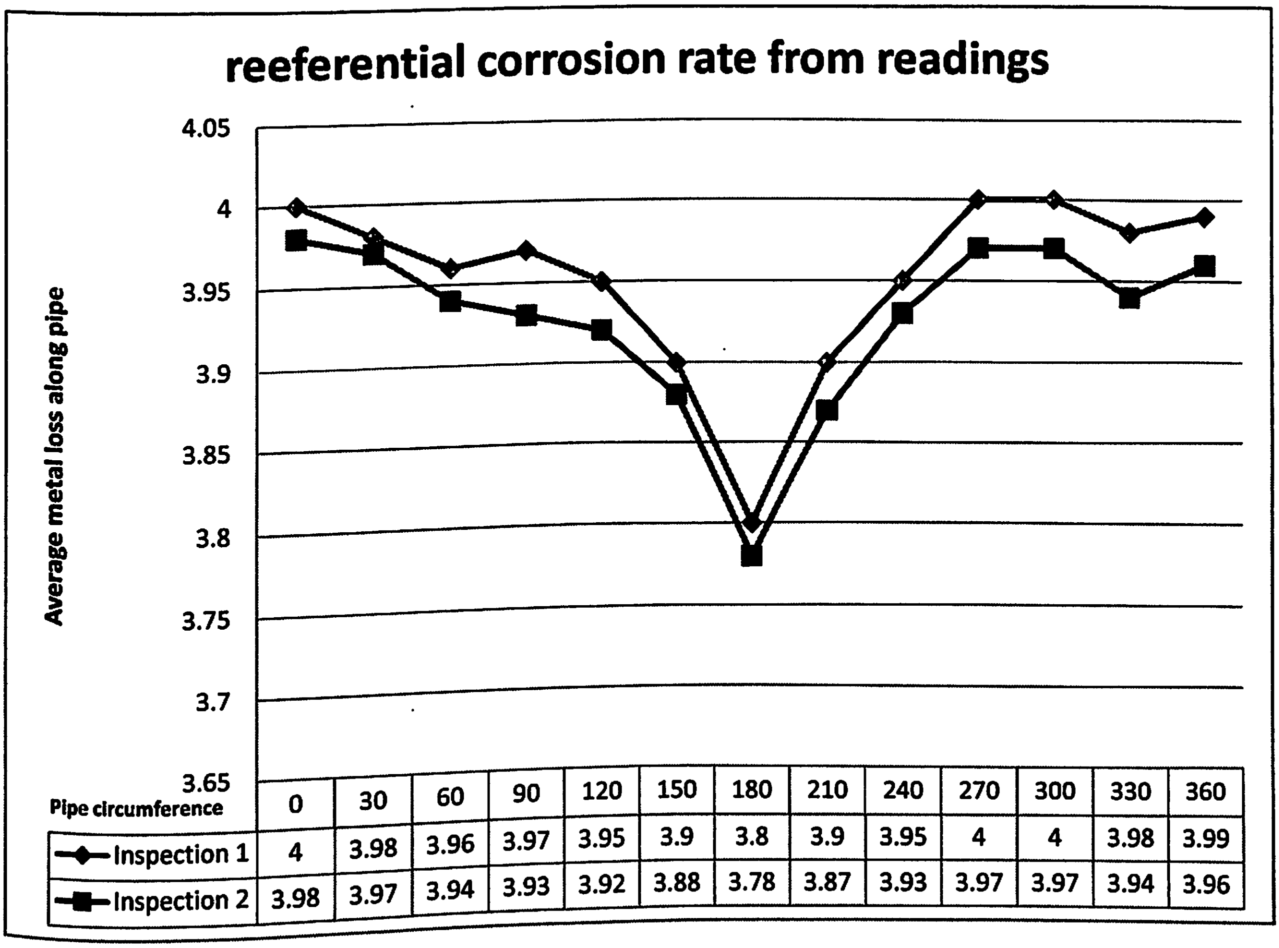
Table 9. Pig Inspection report

Property	Test Method	Minimum Values		
		Thermoplastic Systems	Polyester Resin Systems	Epoxy and Vinylester Resins
Corrosion Resistance			ASTM F1216 Section X2	Green Book Sec. 210-2.3.3

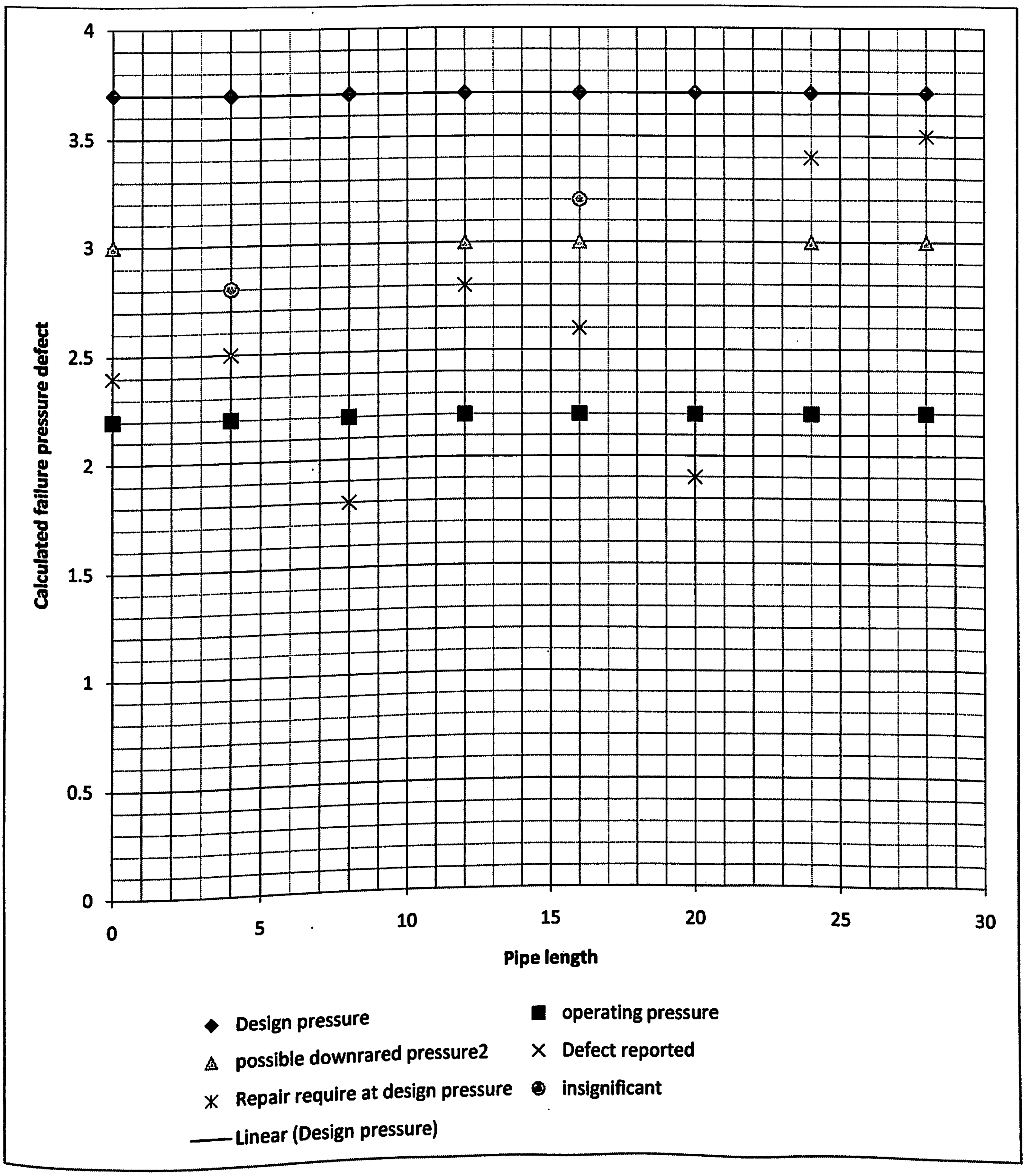
Flexural Modulus (Initial)	ASTM D790	136,000 psi (940 MPa)	250,000 psi (1720 MPa)	300,000 psi (2070 MPa)
Flexural Modulus (Long Term)	ASTM 2990	-	125,000 psi (860 MPa)	150,000 psi (1030 MPa)
Flexural Strength	ASTM D790	-	4500 psi (31 MPa)	5000 psi (34 MPa)
Tensile Strength (Yield)	ASTM D638	3200 psi (22 MPa)	3000 psi (21 MPa)	4000 psi (28 MPa)
Tensile Modulus (Initial)	ASTM D638	-	300,000 psi (2070 MPa)	250,000 psi (1720 MPa)
Tensile Modulus (Long Term)	ASTM D638	-	150,000 psi (1030 MPa)	125,000 psi (860 MPa)
Impact Resistance	ASTM D2444(1)	210 ft-lb (29 m-kg)	-	-
Pipe Flattening	ASTM D3034(2)	60% deflection	-	-
Pipe Stiffness	ASTM D2412	15 psi (103 kPa)	-	-
Environmental Stress-Crack Resistance	ASTM D1693 Condition C	2000 hours	-	-

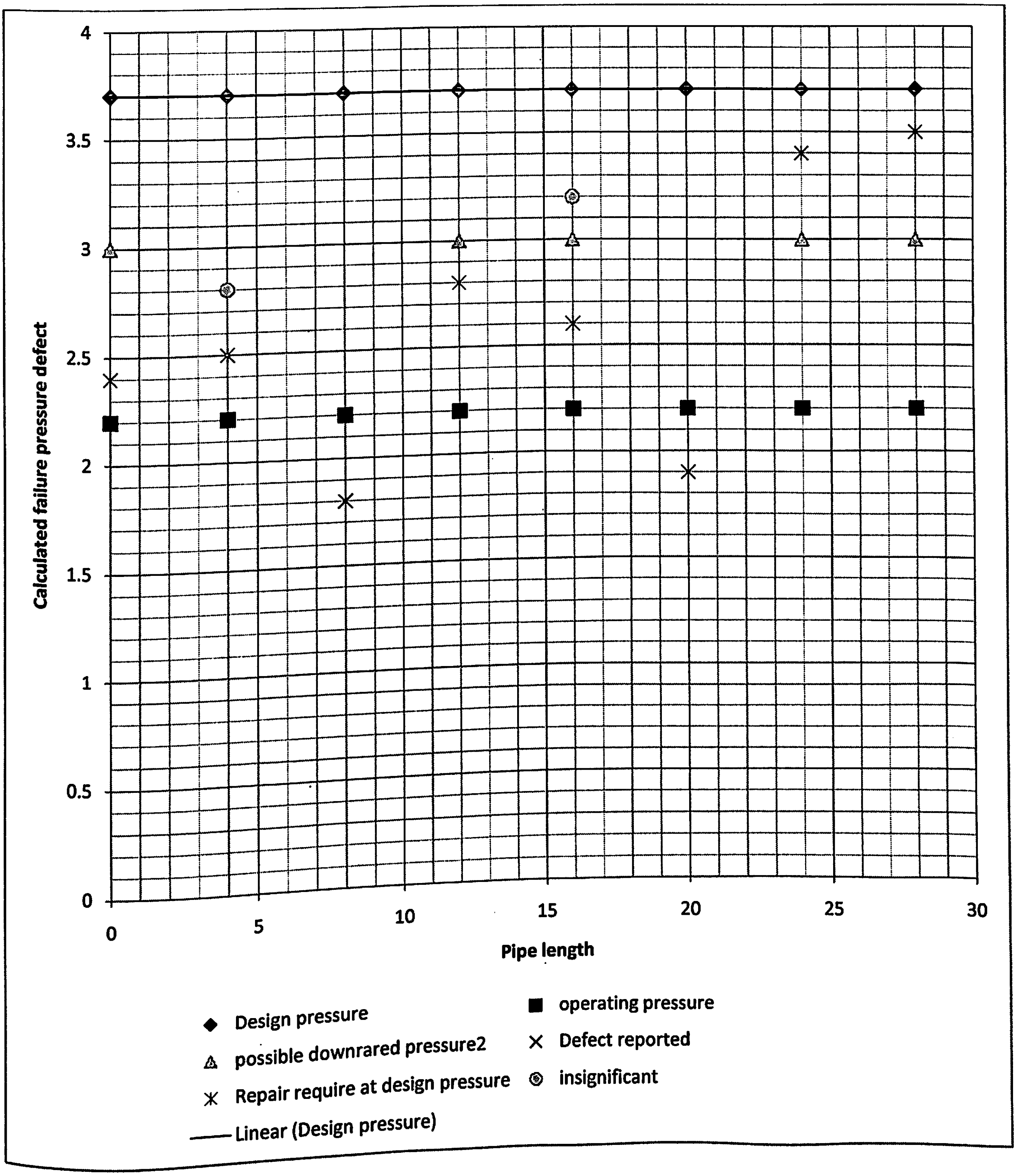
Table 10.materials for liners property

12.2. Graph

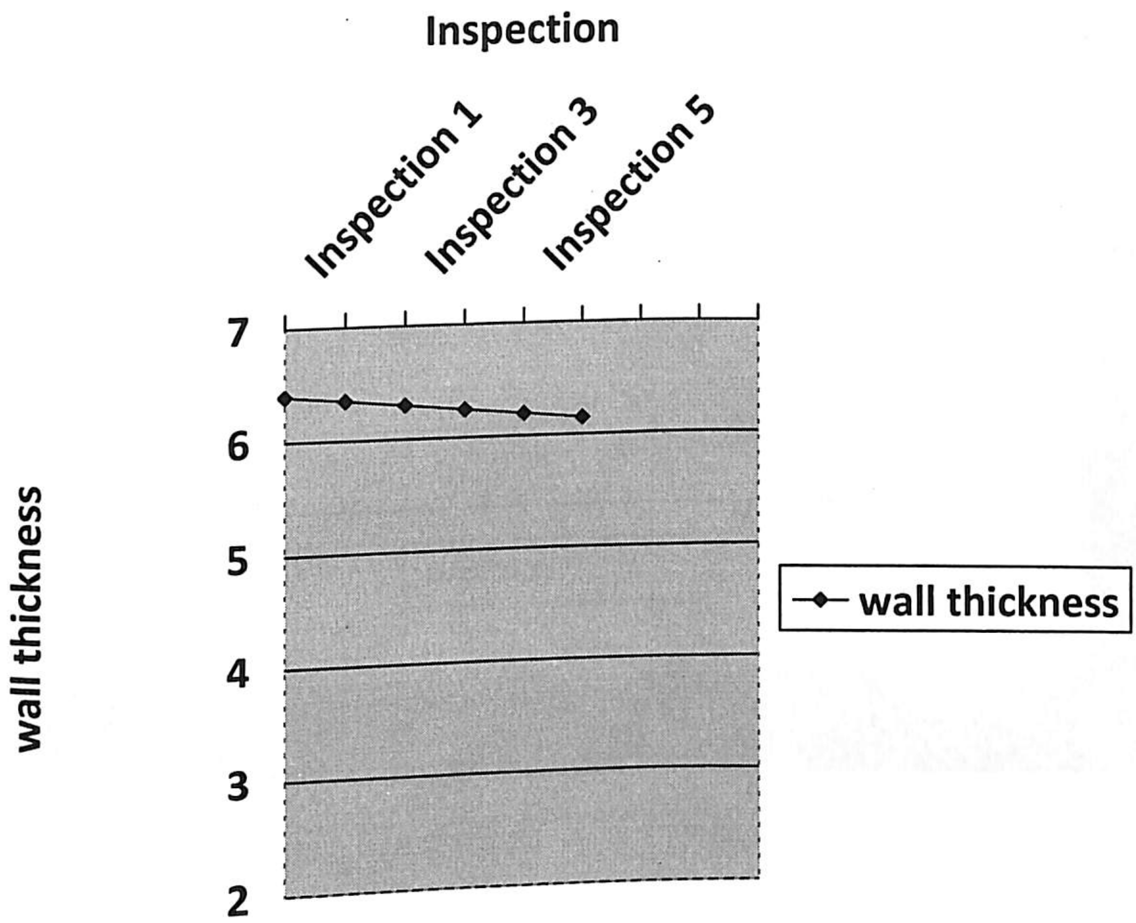


Pipe circumference	0	30	60	90	120	150	180	210	240	270	300	330	360
Inspection 1	4	3.98	3.96	3.97	3.95	3.9	3.8	3.9	3.95	4	4	3.98	3.99
Inspection 2	3.98	3.97	3.94	3.93	3.92	3.88	3.78	3.87	3.93	3.97	3.97	3.94	3.96


Calculated failure pressure defect
Pipe length
0
0.5
1
1.5
2
2.5
3
3.5
4
5
10
15
20
25
30
Design pressure
possible downrared pressure2
Repair require at design pressure
Linear (Design pressure)
operating pressure
Defect reported
insignificant



Calculated failure pressure defect
Pipe length
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
30
Design pressure
possible downrared pressure2
Repair require at design pressure
Linear (Design pressure)
operating pressure
Defect reported
insignificant



Corosion rate based on inspection 1

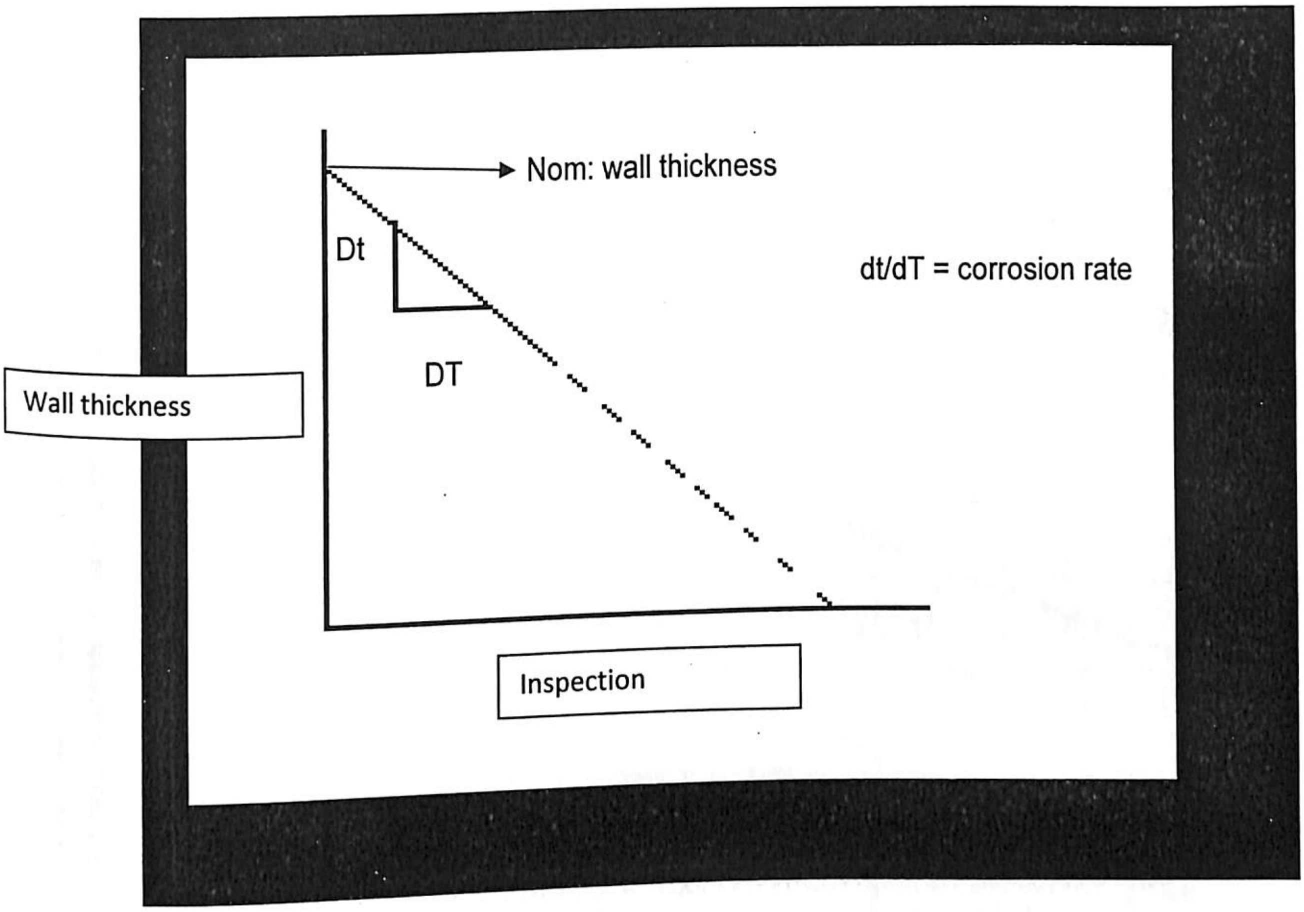
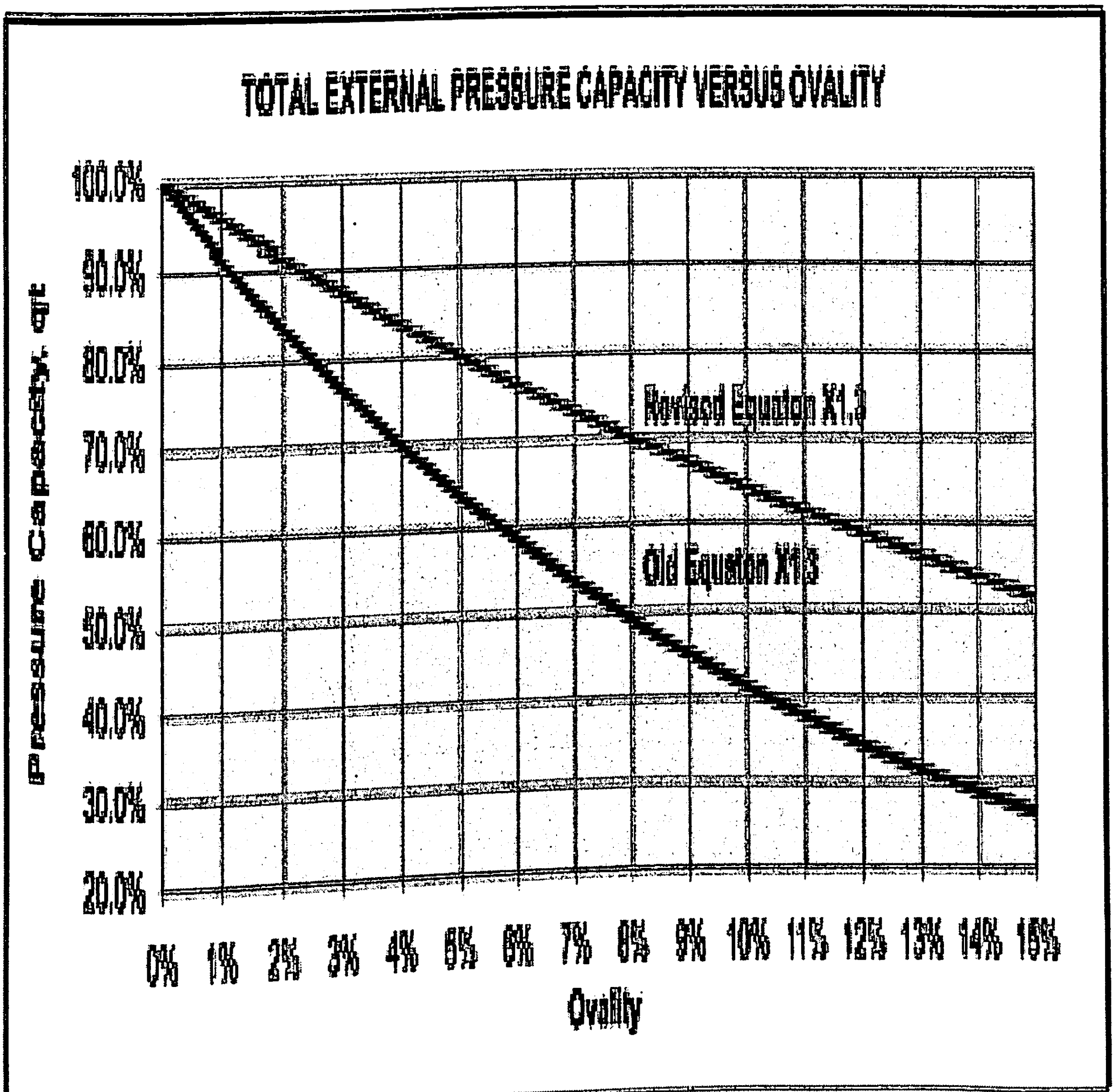

Nom: wall thickness
Dt
dt/dT = corrosion rate
DT
Wall thickness
Inspection

Chart1.ovality



Graph ASTM F1216. Relative total external Pressure capacity versus Ovality

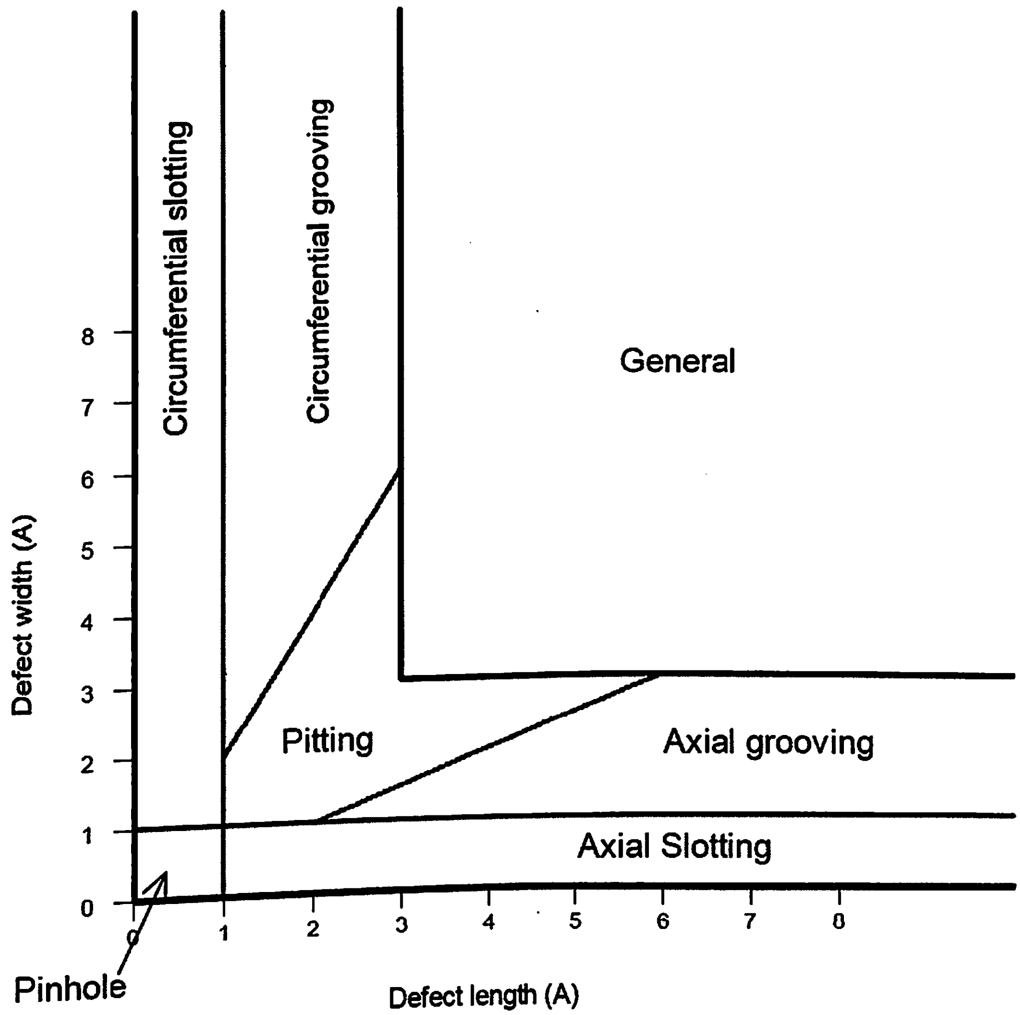
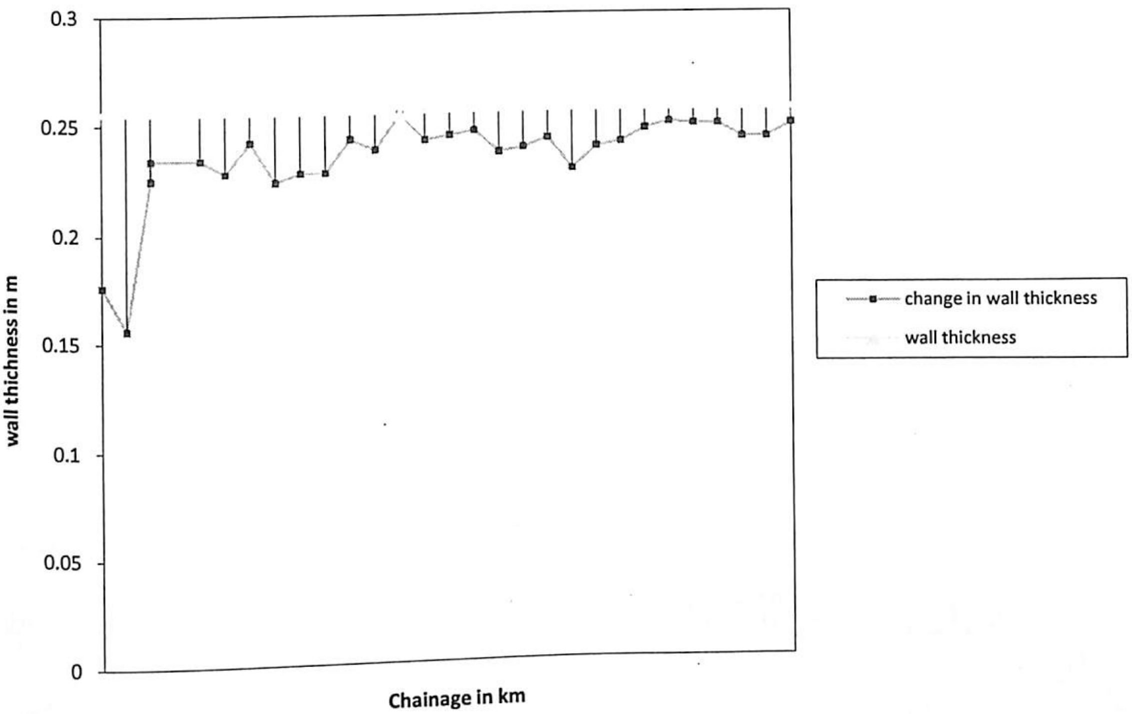


Figure 1 . Graphical presentation of metal-loss feature type definitions



Graph1 showing wall thickness difference

13.0.Calculation

Table 13.1 case 1 chainage 8

Data used for calculation			
water table below surface	=	1.2	meter
outside diameter of existing pipe	=	8.625	inch
Pressure of existing pipeline	=	1410	psi
Inside diameter of existing pipe	=	8.125	inch
wall thickness of orginal pipe	=	0.25	inch
Long term modulus of elasticity , EL	=	30000	psi
Enhncement factor, K	=	7	
Ovality factor,C	=	5%	(from graph)
Co- efficent of elastic support, B	=		
poisons ratio,v	=	0.25	
Groundwater over top of pipe,Hw	=	3.3	meter

Safety factor,N	=	3	
Soil density	=	120	lb/ft^3
	=	1923.94	kg/m^3

Buckling pressure, P				
Step 1				Units
Dimension ratio ,DR				
Inside disameter of pipe ,D		=	8.125	meter
wall thicknessof pipe ,t		=	0.00635	meter
Dimension ratio ,DR		=	1279.52756	meter
Buckling pressure, P				N/m^2
Poissons ratio		=	0.25	
Enhncement factor, K		=	7	
Long term modulus of elasticity , EL		=	2068.96552	N/m^2
Safety factor,N		=	3	
Ovality factor,C		=	5	
Buckling pressure, P		=	2.4639E-05	N/m^2
Calculation of liner thickness,t				
Step 2				
liner thickness		=	0.00535999	meter
liner thickness is found 6 mm				
Step 3				
Calculation of toatal external pressure, q_t				
Moment of inetia, I		=	4.2982E-27	m^3
Water Bouency, R'w		=	0.0925	
Plain strin modulus,Es		=	2206.89655	
B' – Co- efficent of elastic support		=	0.16877738	
Toatal external pressure, qt		=	5.6193E-11	N/m^2
Step 4				
External preesure calculated by considering the load				
External preesure using load, q_t		=	2.19973333	N/m^2

Minimum thickness design,t	=	0.002863123	meter
liner thickness is found 3 mm			

Table 13.2 case 2 chainage 18

Data used for calculation			
water table below surface	=	1.6	meter
outside diameter of existing pipe	=	8.625	inch
Pressure of existing pipeline	=	1410	psi
Inside diameter of existing pipe	=	8.125	inch
wall thickness of orginal pipe	=	0.25	inch
Long term modulus of elasticity , EL	=	30000	psi
Enhncement factor, K	=	7	
Ovality factor,C	=	5%	(from graph)
Co- efficent of elastic support, B	=		
Heigt of soil cover over the host pipe, Hs	=	1.2	meter
poisons ratio,v	=		
Groundwater over top of pipe,Hw	=	2.3	meter
Safety factor,N	=	3	
Soil density	=	120	lb/ft^3
	=	1923.94	kg/m^3

			Units
Step 1			
Dimension ratio ,DR			
Inside disameter of pipe ,D	=	8.125	meter
wall thicknessof pipe ,t	=	0.00635	meter
Dimension ratio ,DR	=	1279.52756	meter
Buckling pressure, P			N/m^2
Poissons ratio	=	0.25	
Enhncement factor, K	=	7	
Long term modulus of elasticity , EL	=	2068.96552	N/m^2
Safety factor,N	=	3	
Ovality factor,C	=	5	

Buckling pressure, P	=	2.4639E-05	N/m^2
Calculation of liner thickness,t			
Step 2			
liner thickness	=	0.00535999	meter
liner thickness is found 6 mm			
Step 3			
Calculation of toatal external pressure, q_t			
Moment of inetia, I	=	4.2982E-27	m^3
Water Bouency, R'w	=	0.3675	
Plain strin modulus,Es	=	2206.89655	
B' – Co- efficent of elastic support	=	0.16877738	
Toatal external pressure, qt	=	1.1201E-10	N/m^2
Step 4			
External preesure calculated by considering the load			
External preesure using load, q_t	=	4.0584	N/m^2
Step 5. Minimum thickness design	=	0.00245298	meter
liner thickness is found 3 mm			

Final Result obtained after calculation:

In both the calculation we found that that the thickness obtained is 3 mm(minimum).

Table 13.3 cost of resign

Cost of liner		
Nominal tube	Resin Qty	Resin cost
8 inch	2.47 kg/meter	3 $ /meter

Table 13.3 cost of resign

Cost of pipe

Nominal tube	Qty	Total quantity	cost	Total cost
8 inch	13.47 kg/meter3	128 kg	34 $ Kg/meter3	12800

Table 13.4 cost of resign

Cost of clamp				
Nominal tube	Clamp Qty	Total qty	Cost of one clamp	Total cost of clamp
8 inch	5.40 kg/meter	40.32	9 $ /meter	4017.66/-

Land	Size, in.	Length, miles	Estimated Costs, $ Materials	Estimated4 Costs, $ Labor
Land	8	0.25	22,553	47,975
Land	8	9.95	1,534,388	7,117,896
Land	8	13.18	1,255,800	1,771,800
Land	8	14.10	1,678,000	4,070,000
Land	8	1.80	455,000	2,387,000
Land	8	3.60	729,000	1,781,000

Customer Data

Specific Gravity of Crude	Viscosity of Crude in cSt	Q in MMPTA	Q in bbl/day	Q in cub.m/sec	Elevation in ft	Static Pressure in psi	Length of Pipeline in km	Residual Head in psi
0.88	40	0.8	17520	113.6363636	80	30.5492	28	44.1

Pipe Assumption

Outer Dia in inches	Wall thickness in mm	Grade of Steel in psi	Wall thickness in inches	Inner Dia in inches	Design Pressure in psi	MAOP in psi (S.F =0.95)
8	6.4	42000	0.2519685	7.496063002	1904.8819	1809.6378
8	6.4	42000	0.2519685	7.496063002	1904.8819	1809.6378
8	6.4	42000	0.2519685	7.496063002	1904.8819	1809.6378
8	6.4	42000	0.2519685	7.496063002	1904.8819	1809.6378

Hydraulic Calculations

Reynolds Number	Modified Reyonld Number	f, friction factor	Pressure Drop due to Friction in psi/mile	Pressure Drop due to Friction in psi	SDH in psi	No. of Pump Stations	Rounded value
5389.645	0.6961567	0.00933	25.65691	446.389013	521.0382	0.287924	1
5389.645	0.6961567	0.00933	25.65691	446.389013	521.0382	0.287924	1
5389.645	0.6961567	0.00933	25.65691	446.389013	521.0382	0.287924	1
5389.645	0.6961567	0.00933	25.65691	446.389013	521.0382	0.287924	1

Table 13.5 Cost analysis

Sl: No:	Method	Material	Length	cost	Total cost Material cost
1	Using Clamp	c- steel clamp of pin type (20 cm)	Total length of damage 8 meter	20,000	800,0000
2	Using spool piece	Same diameter same material using flange joining	Total length of damage 8 meter	80000	160000
3	Using pipe	Replacement of pipe	Total length of damage 8 meter	120000	240000
4	Using	Liner	Total length of damage 8 meter	43$	344$= 15480

14.0. Appendix