DESIGN OF ROAD RIVER RAIL AND MARSHY AREA CROSSING FOR CROSS COUNTRY PRODUCT PIPELINE

PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

MASTER OF TECHNOLOGY
IN
PIPELINE ENGINEERING

SUBMITTED BY

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Under the guidance of
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Dehradun

May 2007

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

CERTIFICATE

This is to certify that project work entitled "**DESIGN OF ROAD CROSSING RIVER CROSSING RAIL CROSSING MARSHY AREA CROSSING FOR CROSS COUNTRY PRODUCT PIPELINE**" is the bonafide work of **S.VINOTH KUMAR** from **University of Petroleum & Energy Studies, M. Tech (Pipeline Engineering)** who carried out the work under joint supervision of Mr. G.M.Ponnusamy, Gammon India Limited, Mumbai, and myself. This work has not been submitted anywhere else for a degree.

17/05/2007

May, 2007

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GAMMON

TO WHOM IT MAY CONCERN

This is to certify that Mr. s.vinoth kumar has done his M.Tech project "“"DESIGN OF ROAD RIVER RAIL MARSHY AREA CROSSING FOR CROSS COUNTRY PRODUCT PIPELINE" with Gammon India Ltd.

During this period he has proved himself a diligent and hard working person.

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Project Manager
GIL

ACKNOWLEDGEMENT

I hereby delineate my deep gratitude to my guide, mentor and course co-ordinate **Mr. R. P. Shriwas,** for his able guidance and support in making this project a successful one.

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I also thanks to **Mr. G.C.Ponnusamy,** Project Manager, Gammon Indian Ltd, for his great appreciation in the course of this project.

In this salutation I also place my whole hearted thanks to **University of Petroleum and Energy Studies** for providing me an opportunity to pursue my project work and for providing me sufficient help whenever I needed.

I am also thankful to my **Batch mates** and friends for their support and co-operation during my project. I would like to add that this report is an outcome of cooperation of all the **Faculty members** at UPES.

I place my inexpressible thanks quotes to the devotional and dedicational hearts which encouraged my project.

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ABSTRACT

This project report deals with design of four type of crossing each pertaining to Road, Rail, River and Marshy area crossing of Numaligarh - Siligurui pipeline project (NSPL) approx 206 km pipeline having 41 Rivers, 2 Marshy area and 34 Road and Rail crossings.

In this work the Load support calculation, determining Pipeline wall thickness, Pipeline Stability Analysis, Crossing Analysis (Highways and Roads), Stress Analysis for HDD River Crossing, and have been carried out.

This report covers road, rail, marshy area, and river crossings by adopting different methodologies.

Different forms of load acting on the pipeline has been discussed and calculated. For different wall thickness and diameter, the stability of the pipeline has been analyzed.

CHAPTER I

RELEVANT EXCERPTS FROM LITERATURE AND CODE

Chapter – I

1.1 Preamble

A cross country pipeline traveling a long distance from one places to another passes through different kind of terrain enroute the pipeline route. These terrains include road, rail, river and marshy area crossings.

The type of crossings and technical requirement are given here-in-after Road crossings, Rail crossings, Waterbody and Wetland Crossings, Stream crossings, Auger bore crossings, Existing Pipeline Crossing.

The rail crossing shall comply with the requirements of API 1102 and Indian standards. Road crossing shall comply with the requirements of API 1102 and the requirements of concerned road authorities. All water crossings shall be installed by open cut. Where there is an evidence of bank erosion, the banks shall be protected by using gravel and boulders filled embankment mattresses of galvanized iron wire to be laid over the backfilled, compacted and graded banks.

The design of pipelines is usually performed in three stages, namely Conceptual engineering, Preliminary engineering or pre-engineering, Detail engineering. Rail, road and river crossings fall under detailed engineering category. The detailed engineering phase is, as the description suggests, the development of the design to a point where the technical input for all procurement and construction can be defined in sufficient data. So that we can estimate the cost and also we can optimize the requirements.

M/s Oil India Limited (OIL), the nodal agency for state wide transportation and supply of product propose to install a 30"OD x approx. 206 km long Product pipeline from its Numaligarh to Siliguri pipeline project.

1.2 Types of crossings

- Road crossings
- Rail crossings
- Waterbody and Wetland Crossings
- Stream crossings
- Existing Pipeline Crossing

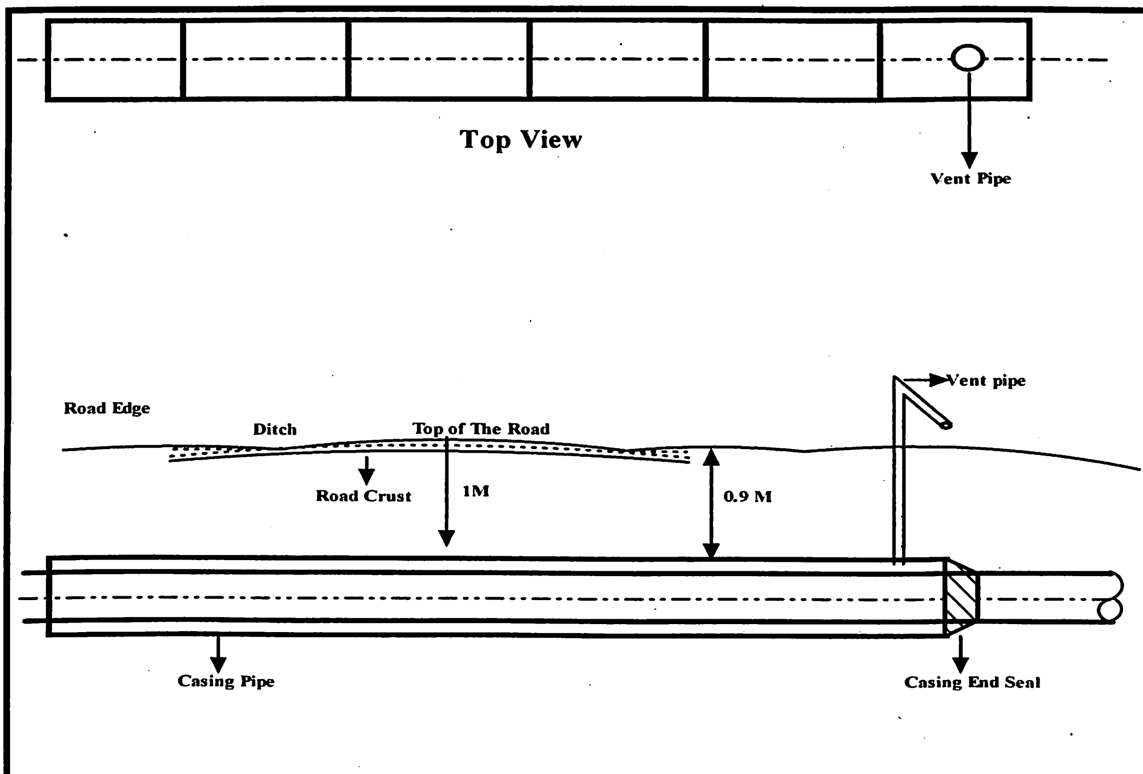
1.2.1 Road crossings

.Crossings of National, Provincial, District, Divisional, Special roads (herinafter called major roads) or such other roads as authorities might dictate, shall be made in flanged or butt welded steel pipes within a steel or reinforced concrete sleeve or a reinforced concrete culvert. Steel pipes to extend over the full width of road reserve plus 5 m on each side. Crossing of farm roads, unnumbered public roads, school roads, minor roads shall, except where otherwise dictated by authorities, be made by maintaining a one thousand (1 000) mm minimum compacted cover over the crown of the pipe at any point along the pipe centerline for the full width of the carriageway plus shoulders. The Engineer might instruct a 150 mm minimum thickness concrete surround to be placed around the pipe along any length of pipeline at such crossings.

Steel sleeve pipes shall have a 12 mm minimum wall thickness, be lined with a bitumen prime coat and shall be armour coated. Wherever possible reinforced concrete sleeve pipes shall be installed by push boring underneath carriageways unless otherwise specified.

Steel pipes at major road crossings shall have:

Wall thicknesses increased by at least 20% above the required structural thickness or shall be equal to the specified minimum thickness for the size of pipe whichever is the greater. The required structural thickness shall be that pipe wall thickness which shall limit steel stresses to a maximum of 60% of the minimum yield stress of the steel when the pipe is subjected to design pressure. The pipe of increased wall thickness shall extend for the full width of the road reserve up to points at least 5 m beyond reserve boundaries on each side. Either armour coating of a bitumen glass fiber or a 400 micrometers thick fusion-bonded epoxy coating for the length of sleeves or culverts, including manholes plus a distance of 1 m on each side of the sleeve or culvert. All field applied butt welds falling within reserves 100% radiographically inspected. All flanged joints molded as per specification.



TYPICAL ROAD CROSSING

Backfilling and reinstatement of road surfaces shall be to the requirements of the Roads Authority. Should the Roads Authority prefer to carry out reinstatement of surfaces by direct labour or otherwise, the Contractor shall pay all charges in connection therewith. Where no method of reinstatement is specified or requested by the Roads Authority, the following shall apply: Backfilling around and over sleeves or culverts shall be placed in layers not exceeding 150 mm, measured in the loose, using a selected sandy material. Each layer shall be dampened to optimum moisture content and be compacted to a density not less than 90% Modified AASHTO before succeeding layers are placed.

For surfaced roads, backfilling shall proceed to the underside of the sub-base level when 150 mm of approved sub-base gravel shall be placed and compacted to a density of at least 95% Modified AASHTO. On top of the sub-base layer, a 200 mm layer of crushed stone base course consisting of material passing a 40 mm square screen and mixed with an approved binder shall be compacted in two, 100 mm layers, each layer to be dampened and thoroughly compacted before placing the succeeding layer. The top layer shall be swept with a hard broom to remove all laitance from stone surfaces but without under pinning the individual crushed stone particles. The upper surface shall then be covered with a light application of primer or emulsion before placing a 32 mm to 40 mm bituminous premix wearing course which should be rolled to a solid layer.

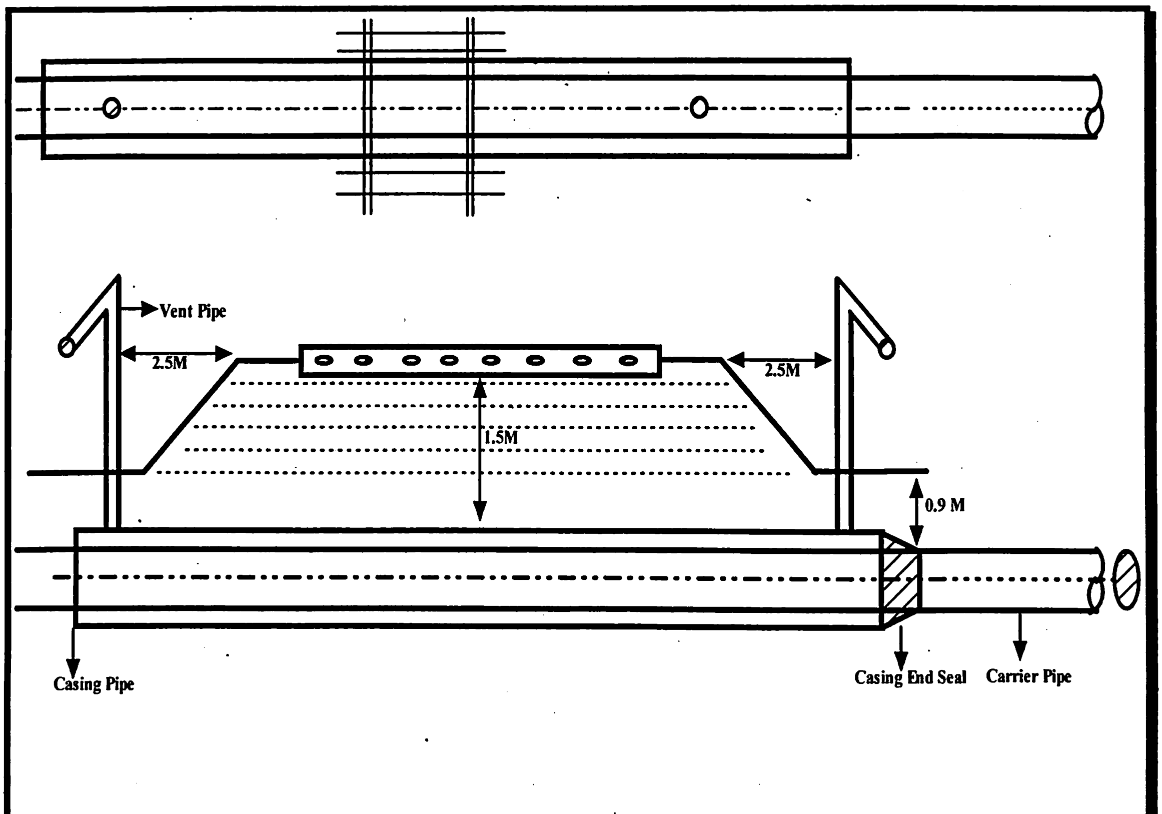
All underground telephone cables or overhead telephone lines within or adjacent to road reserves shall be properly supported and protected against damage during all phases of construction.

1.2.2 Rail crossings

Crossings of railway tracks shall be made by butt welded or flanged steel pipes within a steel or reinforced concrete sleeve or reinforced concrete culvert, all in accordance with approved drawings and the SABS 0121 Code of Practice. Pipes larger than 250 mm nominal bore shall cross through culverts only. Steel pipes shall extend over the full width of the rail reserve plus at least 5 m on each side.

Steel sleeve pipes shall have a 12 mm minimum wall thickness, be lined with a bitumen prime coat and shall be armour coated. Wherever possible reinforced concrete sleeve pipes shall be installed by pushboring underneath railway tracks unless otherwise specified.

Steel pipes at railway crossings shall have: Wall thicknesses increased by at least 20% above the required structural thickness or shall be equal to the specified minimum wall thickness for the size of pipe, whichever is the greater. Required structural thickness shall be that pipe wall thickness which shall limit steel stresses to a maximum of 60% of the minimum yield stress of the steel when the pipe is subjected to design pressure. The pipe of increased wall thickness shall extend for the full width of the rail reserve up to points at least 5 m beyond reserve boundaries on each side.



Typical railway crossing

Either armour coating of a bitumen glass fibre or a 400 micrometres thick fusion-bonded epoxy coating for the length of sleeves or culverts including manholes, plus a distance of 1 m on each side of the sleeve or culvert.

All field applied butt welds falling within reserves 100% radiographically inspected.

All flanged joints moulded as per specification.

Before any work within rail reserves is undertaken the Contractor shall at his own expense arrange with the SATS for the provision, installation and removal on completion of temporary support work for the tracks, in the form of birdcaging or otherwise. All work within rail reserves shall be performed and completed with the least possible delay and with the closest co-operation at all times with the SATS and the Engineer.

Backfilling and reinstatement of surfaces shall be to the requirements of the SATS. Should the SATS prefer to reinstate ballast by direct labour or otherwise the Contractor shall pay all charges in connection therewith.

Where no method of reinstatement of surfaces is specifically specified or requested by the SATS, the following shall apply:

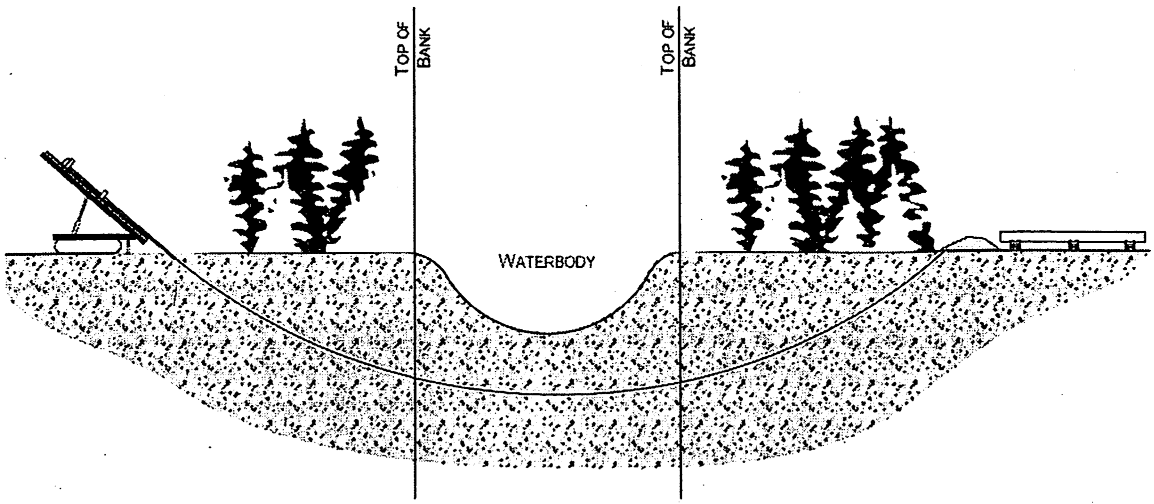
Backfilling around and over sleeves or culverts shall be placed in layers not exceeding 150 mm in the loose, using a selected sandy material. Each layer shall be dampened to optimum moisture content and be compacted to a density not less than 90% Modified AASHTO. All underground, aboveground or overhead cables, telephone lines or signaling cables or wires within or adjacent to rail reserves shall be properly supported and protected against damage during all stages of construction.

1.2.3 Waterbody and Wetland Crossings

The proposed Project would cross 2 perennial waterbodies, 70 man-made irrigation canals and drains, and 2653 desert washes. Only one Waterbody, the Colorado River, has a fisheries classification (warm water). The waterbody crossings would be constructed in accordance with Federal, State, and local permits .

We proposes to cross one of the perennial waterbodies (the Colorado River) and two of the canals (the All-American Canal [three times] and the East Highline Canal [once]) using the HDD method. This technique involves drilling a pilot hole under the waterbody and banks, then enlarging that hole through successive reamings until the hole is large enough to accommodate the pipe.

Throughout the process of drilling and enlarging the hole, a slurry made of naturally occurring non-toxic materials, such as bentonite clay and water, would be circulated through the drilling tools to lubricate the drill bit, remove drill cuttings, and hold the hole open. This slurry is referred to as drilling mud. Pipe sections long enough to span the entire crossing would be staged and welded along the construction work area on the opposite side of the waterbody and then pulled through the drilled hole.



At the Colorado River, the pipeline would be installed about 60 feet below the riverbed. In response to comments received during the scoping process, North Baja relocated the proposed alignment of the Colorado River crossing.

1.2.4 Stream crossings

Stream crossings comprise all crossings of defined water courses in which water flows or might flow as a result of surface run-off or otherwise. Stream crossings shall be constructed in steel pipe encased in reinforced concrete, all in accordance with approved drawings.

Steel pipes at stream crossings shall have: Wall thicknesses increased by at least 20% above the required structural thickness or shall be equal to the specified minimum wall thickness for the size of pipe, whichever is the greater. The structural wall thickness required shall be that pipe wall thickness which shall limit steel stresses to a maximum of

60% of the minimum yield stress of the steel when the pipe is subjected to design pressure. The pipe of increased wall thickness shall extend for the full length of concrete encased zones plus 2 m on both sides. A bitumen-glass fibre coating or a 400 micrometres thick fusion-bonded epoxy coating as specified in either the Departmental Specification DWS 1131 or as indicated on the drawings or in the Schedule of Quantities whenever encased in concrete.

All field applied butt welds within concrete encasements 100% radiographically inspected.

The top surfaces of concrete encasements or adjacent pipes shall not protrude above natural bed level of streams, nor shall it in any way interfere with water flow or be the cause of bed erosion. The Contractor shall be responsible for diversion of flow, if any, over or away from the trench and shall dewater the trench immediately before pipe laying and keep it dewatered until completion of backfilling. He shall be responsible for and shall repair at his own expense, foundations, structures or other parts of the Works caused by flooding due to failure of any part of the diversion or protective works or due to any other cause.

The Contractor shall remove cofferdams, other protective works and surplus spoil immediately after having served its purpose and shall reinstate the site to its original condition. Flooding of adjacent land, bed erosion or changes in location of water courses due to the Contractor's failure to comply with this clause shall be made good at his own expense.

1.2.5 Existing Pipeline Crossing

The minimum clearance between the lines shall be 300 mm unless specified otherwise. Road crossings shall be constructed by auger boring or by **open- cut** method as shown on the Drawings or as required by owners or relevant authorities. Track crossings may be constructed by open-cut method. Auger bore crossings shall be in accordance with Clause 14.9. While road or track crossings are being installed, the Contractor shall provide, erect, maintain and man all signs, traffic lights, stop-go boards and barriers necessary to ensure safety and as required by the relevant authorities. At open cut crossings interference with the flow of traffic and access of pedestrians shall be to the minimum extent necessary to construct the crossing. Procedures to be approved by the Engineer and the relevant authorities shall include proposed measures to keep this interference to a minimum. Surface materials over made up roads and paved footpaths shall be removed only over the width of the pipe trench. Adequate measures shall be taken to support the sides of the trench and to ensure the stability of adjacent road structure. Where steel plates are placed over the trench for the passage of traffic, adequate bearing and means of securing the plates in position shall be provided. Where road traffic is diverted during construction, the pipeline crossed by the diversion shall be protected against loads imposed by road and construction traffic. For any open trench across a road-bed, all backfilling of such open trench on the ROW shall be mechanically compacted with a pneumatic tamping device (or equal) to a minimum of 95% of compaction as per ASTM D 1557-78, or as required by the appropriate agency. The Contractor shall verify that the 95% compaction has been achieved by testing every 450mm depth. In the event that the material removed from the open trench is not suitable for backfill and tamping due to water saturation or nature of the material, the Contractor, at his expense, shall obtain suitable material from other sources.

After backfilling, the surface of the road shall be replaced at the Contractor's expense with material of quality and quantity in a manner satisfactory to authority having jurisdiction. Any work which any local authority (street work authorities, sewer authorities etc) elect to carry out shall be excluded from the work, subject to the

Employer receiving such written conformation. The Contractor shall give the Employer not less than 2 working days notice of its intention to carry out permanent reinstatement work of each highway or road crossing. The Contractor shall maintain the trench in a safe manner until such time as permanent reinstatement has been completed. Should the authority or managers concerned make any charge for repairs to the permanent reinstatement undertaken within one year from completion thereof and in the opinion of the Employer, such repairs are made necessary by insufficient consolidation of the backfilling, such repairs shall be undertaken by the Contractor at Contractor's own cost.

When making roadway crossings, care shall be taken not to block traffic while such crossings are being installed. The Contractor shall provide, erect, and maintain all necessary barricades, suitable and sufficient lights, danger signals signs and other traffic control devices as required, and shall take all necessary precautions for the protection of the work and safety of the public At major highway crossings, wherever heavy plant moves on or across the highway, a flagman shall be stationed adjacent to the work to warn traffic of the danger. When heavy equipment moves across a highway, the pavement shall be protected from damage by suitable planking, rubber tyres or other approved means. If deemed necessary the crossing may be constructed by using a horizontal directional drill (HDD) in order to cross any major highway as described in Section 15 Clause 15.10.

CHAPTER II

Chapter - II

2.0 CROSSING TECHNIQUES

The following river crossing techniques have been considered as a part of the pipeline construction planning process:

- Above ground (pipeline bridges);
- Horizontal directional drilling (HDD);
- Wet cut crossing; and
- Dry cut crossing.

These crossing methods are described in more detailed below.

2.1 Above Ground (i.e. pipeline bridges)

An above ground (or aerial) crossing has a number of advantages over other methods including minimum streambed and bank disturbance and that the fact that during construction passage for fish can be maintained. An indirect but nonetheless welcome benefit is that any accidental oil leaks can be identified at a much earlier time compared to an underground pipeline. From an international best practice standpoint, aerial crossings are rarely applied and only in specific circumstances when burial are impractical. An example would be the crossing of a very narrow and deeply incised channel (e.g. greater than 30 m depth and less than 30 m width) with high potential for very deep scouring (e.g. flood drainage features that occasionally handle torrential rains in a desert). In Sakhalin, however, the presence of large floodplains and meandering characteristics would require bridges of several kilometers in length and the use of supporting structures that would need to be constructed in the watercourse. The complexity of construction would lead to potentially longer periods of impact and the placement of structures in river channels would increase the risk of scour compared to a buried pipeline crossing. Additionally, consideration of the factors listed below determined that aerial routing would not constitute an appropriate and safe technique for the crossings:

- Ambient and dramatic temperature changes (e.g. between day and night; summer and winter; and freezing and thawing) can affect the long-term integrity of an exposed pipeline (see examples below);

• Adverse effects on the coating of the exposed pipeline leading to increased external corrosion;

• Lowering of the effectiveness of the cathodic protection system leading to increased external corrosion, higher maintenance costs and an increased potential for leaks;

• More regular expansion and contraction of the pipeline (i.e. changing the length of the pipe span on an hourly basis, which in-turn, increases the cost and complexity in design of supporting structures;

• Potential plugging of the pipeline system due to increased viscosity of the oil in the pipeline;

• The abutments and supports holding the pipeline may be subject to movement, particularly during seismic events;

• Scouring and non-uniform settlement of abutments and supports due to changes in-river morphology or flooding when the river overflows, particularly in floodplains;

• Natural physical impacts (e.g. falling trees; trees floating upstream) that may hit the pipeline;

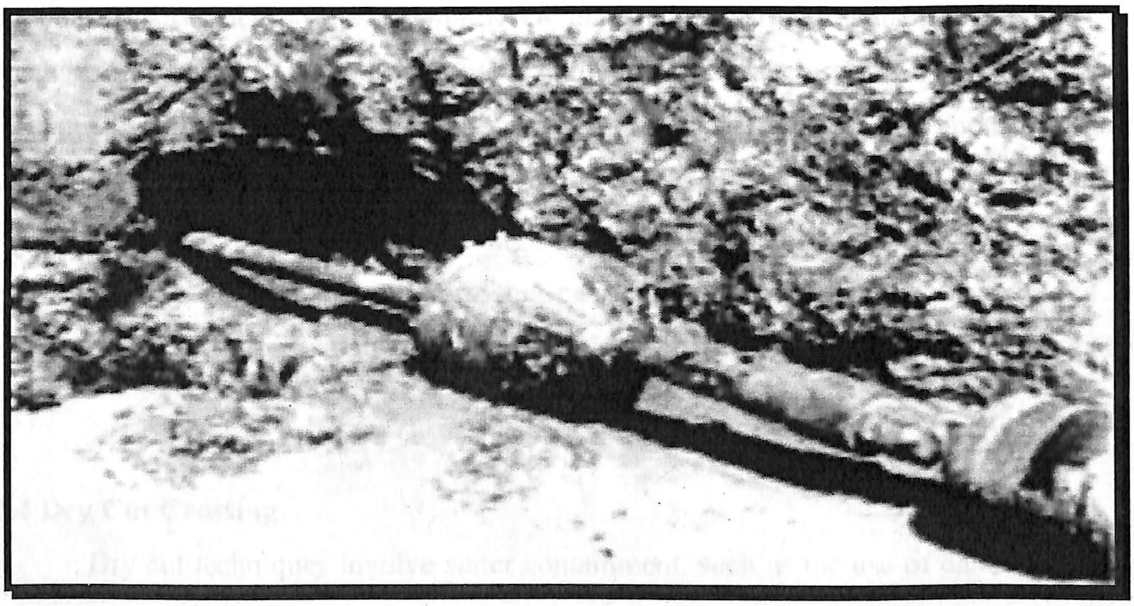
• Mechanical impact caused by third parties (pipelines used by hunters and poachers for target practice, pipeline used to cross watercourses with heavy loads, watercraft impact etc);

• Exposure to vandalism, terrorism and/or sabotage.

2.2 Horizontal Directional Drilling (HDD)

With HDD, a well bore, similar to that for constructing oil and gas wells, is drilled beneath the bed of the watercourse. The process involves the use of drilling mud (e.g.

bentonite) under pressure to facilitate the removal of cuttings from the borehole and to maintain hole integrity (i.e. preventing wall collapse). Once the hole is complete, a pre-welded and hydrotested section of pipe is then pulled through the mud-filled well bore for tie-in. Like small aerial crossings, HDDs have the advantage that there is potentially no streambed and bank disturbance, thus significantly reducing the creation of in-stream suspended sediment concentration increases during construction. This technique also ensures that fish passage during construction is maintained. However, HDD is only viable as a crossing option within a range of specific circumstances where factors such as width, depth and substrate type make it technically feasible. It is also applicable in the following applications:



- Presence of ship traffic and where navigational and anchorage issues must be mitigated;
- Where excessively high levels of pollutants are entrained in bottom sediments and there is a desire to not re-introduce or re-suspend them into the water column during construction;
- Wide and/or deep river channels;
- Sensitive fish species or habitats in areas that are a poor candidate for the open cut methodology because of flow volumes or river geometry.

The use of HDD is not always possible due to topographical or geological characteristics and features. The use of HDD must be carefully balanced against the risk of fracturing into the bottom of a stream and causing more extensive environmental damage than would have been the case using a wet cut. This is especially true of high-energy streams with gravel substrate . a common occurrence in Sakhalin.

2.3 Wet Cut Crossing

The wet cut technique is used around the world in the majority of watercourse crossings. In the wet crossing method, a trench is dug and a pre-welded and hydrotested (for widths greater than 10m) pipe section is lowered into the trench. The trench is backfilled while the stream continues flowing in the stream/river channel (through the work site). In most cases, pipeline trenches are cut with an excavator or, because of the excavator.s limited reach, a dragline. Sediment is typically placed into decanting structures or a trench on the pipeline ROW and trenches are subsequently refilled with clean spoil from the ROW or a borrow pit. Without appropriate use of water management measures, sediment disturbance and transport can be severe, depending upon the water velocity and the nature of the substrate that is being excavated. This could have implications in terms of direct and indirect impacts on fish, invertebrate, and aquatic plant communities. However, the crossing can be undertaken relatively quickly and is normally used to cross smaller and/or less sensitive (from an ecological perspective) rivers.

2.4 Dry Cut Crossing

Dry cut techniques involve water containment, such as the use of dam and pump or diversion of the watercourse by damming or other means, to allow work in .dry. stream/river beds. The dry cut technique minimises the degree of sediment mobilisation and, subject to certain considerations, is the most appropriate methodology for crossing watercourses with high biological or fisheries. sensitivities. In Russia, however, the use of the dry cut method is less common and there has been objection to its use by the local fishing authority (Sakhrybvod2). SEIC has engaged in consultation with Sakhrybvod to explain the benefits of the different types of dry cut crossings on several occasions, however, Sakhrybvod has maintained the position that the wet cut method is more favourable and that they will not permit the use of dry cut crossings. Their main arguments are that a wet cut can be executed faster than a dry cut and that a dry cut requires more equipment, enlarging the potential construction footprint of the crossing. These arguments do not apply in situations where crossings are naturally dry i.e., when a stream is completely frozen (in winter) or dried up (in summer).

2.5 AUGER BORE CROSSINGS

General Requirements

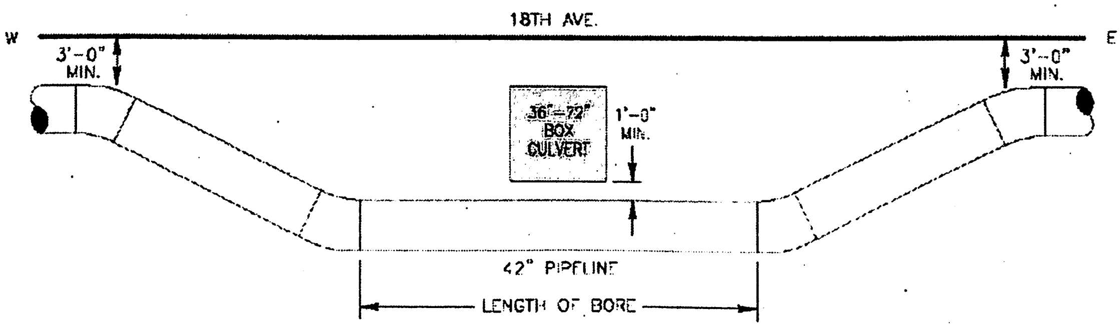
Details of auger bore crossings to be submitted by the Contractor for approval by the Engineer shall include:

(a) Thrust and reception pits with calculations as necessary.

(b) Site plan of the Works.

(c) Proposed method of keeping pits free of water and any ground dewatering.

At unsleeved auger bores, carrier pipe shall not be used for boring. The method adopted shall incorporate the use of scrap pipe for the boring operation. The carrier pipe shall be drawn into position as the auger pipe is withdrawn.



The Contractor shall, where practicable, complete the work in one continuous operation. Every precaution shall be taken by the Contractor to ensure that the line and level of the first pipe are set accurately. The Contractor shall control the rate of penetration of the pipe to suit the rate of progress of the auger. Care shall be taken to prevent cavitations as a result of the auger getting too far ahead of the pipe. All materials used in constructing the boring shall be removed from the pits on completion of the work. All welds in the auger bore will be subject to 100% radiographic inspection.

Protection and Testing of Carrier Pipe Coating

Precautions shall be taken by the Contractor to ensure that the pipe coating is not damaged during insertion of the carrier pipe assembly. After insertion of uncased carrier pipe, and before it is tied into the pipeline, a current drainage test shall be carried out by the Contractor. A maximum of eight milliamps shall be impressed at one end of the pipeline to produce drain point pipe to soil potential of -1.4 volts and a pipe to soil potential at the other end of the pipeline of not less negative than -1.2 volts.

All potentials shall be measured using a high resistance voltmeter and copper/copper sulphate reference electrode. Should the coating fail to meet the requirement of the test the Contractor shall propose remedial measures which may include coating repair or supplementary cathodic protection.

Dewatering

Both thrust and reception pits shall be kept dry at all times and the Contractor shall dewater all excavations and discharge the water to waste. Where running sand conditions exist along or adjacent to the route of an auger bore the Contractor shall allow for all necessary ground de-watering measures.

Auger Bores Running Out of Line

In the event of an auger bore running out of line the Contractor shall immediately cease the crossing and notify the Engineer. If, in the opinion of the Engineer, the line of the bore appears to be within acceptable limits the Contractor shall continue the bore as planned. If, in the opinion of the Engineer, the line of the bore is unsatisfactory the bore shall be abandoned. After retrieving the Auger, the Contractor shall grout up and blank off the casing or scrap carrier pipe. The amount of grout used shall be measured to ensure that the hole is completely filled. The crossing shall then be re-bored on a line as close as possible to that of the original bore. The Contractor shall modify the thrust and reception pits as required and re-submit all design details and construct the re-bore as specified herein.

STATUTORY PLANNING PROVISIONS AND APPROVALS

We will follow the approvals process for pipelines set out in the Pipelines Act 1967 and Pipelines Amendment Regulation 2006. Part 3A of the EP&A Act was recently introduced in order to integrate approvals for major projects. The report has been prepared to accompany an application for this project to be declared to be a project to which Part 3A applies and a critical infrastructure project under section 75C of the EP&A Act. The Proponent is of the view that this project satisfies the requirements for a critical infrastructure project because it is essential for the State for economic and environmental reasons.

Relevant Acts and Regulations in NSW include but are not limited to:

- Pipelines Act 1967
- Pipelines Regulation 2005
- Environmental Planning & Assessment Act 1979
- Environmental Planning & Assessment Regulation 2000
- Rivers & Foreshore Improvement Act 1948
- Water Act 1912
- Native Vegetation Act 2003
- Threatened Species Conservation Act 1995
- National Parks & Wildlife Act 1974
- Mine Subsidence Compensation Act 1961
- Mine Subsidence Compensation Regulation 2002
- Numerous LGA Local Environmental Plans
- Heritage Act 1977

In addition to these providing essential planning and design guidance, it is anticipated that additional applications for specific aspects of the project may need to be made under several of these acts.

Hunter Energy will contact landholders and authorities controlling land impacted by the proposed pipeline route where access is required to compile data for the Environmental Assessment. Prior to applying for a Licence, all landholders will be approached with a view to agreeing easements on mutually acceptable terms for the purpose of construction, operation and maintenance of the pipeline and facilities. In Queensland, preparation of an Environmental Management Plan is simultaneously underway.

Thereafter, in order to build and operate the Proponent must also obtain:

- Pipeline License under the Petroleum and Gas (Production and Safety) Act 2004
- Environmental authority under the Environment Protection Act 1994

The requirements of several other pieces of Queensland legislation must also be met including:

- Aboriginal Cultural Heritage Act 2003
- Environmental Protection Regulations 1994
- Nature Conservation Act 1992
- Petroleum and Other Legislation Amendment Act 2004
- Petroleum and Gas Regulations 2004

At the Commonwealth level the project must satisfy at least:

- Environment Protection & Biodiversity Conservation Act 1999
- Native Title Act 1993

The diverse nature and number of Local, State and Commonwealth participants involved means a very complex approval process. Considerable contact, coordination and cooperation will be essential to avoid debilitating duplication of investigations and documentation and an unacceptable timeframe for the project.

CHAPTER III

Chapter - III

3.0 PROJECT WORK DETAILS

Name Of the Project - Design Of Road, Rail, River, Marshy Area Crossings for Cross Country Product Pipeline

Aim of the Project

To bring out the optimal design Specification in respect of following

1. Pipeline Wall thickness for Crossing Marshy Area and River keeping in view Pipeline Stability.
2. Wall thickness pipeline for Railroad and Highway Crossing consider the probable subjected load and stress caused due to seam.

3.1 Basic Input

1. Pipeline Wall thickness for Crossing Marshy Area and River keeping in view Pipeline Stability.

The pipeline data and densities are as under:

Pipe Data:

Do (Pipe outside diameter of steel.)	=	762mm	
Wt(Pipe wall thickness)	=	10.3/11.9/14.3 mm	
tc(coating thickness)	=	2.5mm	
tcc (concrete coating thickness)	=	115 mm	

Densities:

ρ Steel	=	7850 kg/m3	Carbon Steel
ρ water	=	1000 kg/m3	
ρ polyethylene	=	950 kg/m3	
ρ conc.	=	2245 kg/m3	

1. Calculation of Stress calculation for Railroad and Highway Crossing.

Pipe data:

D (inch)=30"

Design pressure =92kg/cm^2 =1308.51 psia

Steel grade = X-70

SMYS = 70000 psia

Design factor

For NH/SH crossings F=0.72, 0.6

Longitudinal joint factor = 1

Wall thickness.t_w =10.3mm= .4055 inch for class 1

=11.9 mm=. 4684 in for class 2

=14.3 mm =0.56297 in for class 3

Source Of Input

2. Pipeline Wall thickness for Crossing Marshy Area and River keeping in view Pipeline Stability.

The Source of Input has been taken from Oil India Limited.

Some Assumptions has been made for the following data The datas are

tcc (concrete coating thickness) = 115 mm

Densities:

ρ Steel	=	7850 kg/m3	Carbon Steel
ρ water	=	1000 kg/m3	
ρ polyethylene	=	950 kg/m3	
ρ conc.	=	2245 kg/m3	

1. Calculation Stress calculation for Railroad and Highway Crossing.

The followings are the datas taken from Oil India Limited.

D (inch)=30"

Design pressure =92kg/cm^2 =1308.51 psia

Steel grade = X-70

SMYS = 70000 psia

Design factor

For NH/SH crossings F=0.72, 0.6

Longitudinal joint factor = 1

Wall thickness.t_w =10.3mm= .4055 inch for class 1

=11.9 mm=. 4684 in for class 2

=14.3 mm =0.56297 in for class 3

CHAPTER IV

Chapter – IV

4.0 Design Steps

Pipe and Operational Characteristics:

1. Nominal Diameter, ND	30 in.
2. Outside diameter, D	762 mm
3. Operating Pressure, P	1308.51 Psig.
4. Steel grade	API 5L X70
5. Design Factor	0.7, 0.6
6. Longitudinal Factor	1
7. Design Pressure	92 Kg/cm^2

Installation and site characteristics:

1. Depth, H	1.2 mm
2. Bored Diameter, B_d	32 in. (D+2)
3. Soil Type	Sands and Gravel (Loose)
4. Poisson's ratio	0.30
5. Coefficient of Thermal Expansion	$1.17E-05°C^{-1}$
6. Unit Weight of Soil, γ	120 $\frac{lb}{ft^3}$
7. Modulus Of Soil Reaction, E',	0.5 ksi
8. Excavation Factor for Earth Load	1
9. Tandem axle loading, w	69.4
10. Resilient Modulus	5 ksi.
11. Type of Pavement	Flexible

1. Wall Thickness Calculation for the Crossings

$$P = \frac{2St}{D} FET$$

2. Check Allowable Barlow Stress

$$S_{Hi} = \frac{pD}{2t_w} \leq FET * SMYS$$

Where

S_{Hi} = Circumferential Stress from internal pressure calculated using the average diameter.

p = Internal Pipe Pressure, Psi.

3. Circumferential Stress due to Earth Load:

$$S_{He} = K_{He} B_e E_e \gamma D$$

Where

K_{He} = Stiffness factor for circumferential stress from earth load

B_e = Burial factor for earth load

E_e = Excavation factor for earth load

γ = Soil unit weight, in pounds per cubic inch

D = Pipe Outside diameter, inch

4. Stiffness factor for circumferential stress from earth load

Wall thickness to diameter ratio, $\frac{t_w}{D}$

5. Burial factor for earth load

Depth to bored diameter ratio, $\frac{H}{B_d}$

6. Impact Factor and Applied Design Surface Pressure

TThe applied design surface pressure, w is determined by

$$w = \frac{P}{A_P}$$

Where,

P = either the design single wheel load, P_S, or the design tandem wheel load, P_t.

A_P = the contact area over which the wheel load is applied;

A_P is taken as 144 square inches.

For the recommended design loads of P_S = 12 pounds and

P_t = 10000 pounds, the applied design surface pressures are as follows

a. Single axle loading: w = 83.3 pounds per square inch.

b. Tandem axle loading: w = 69.4 pounds per square inch.

7. Cyclic Stresses

The cyclic circumferential stress due to highway vehicular load, may be calculated from the following

$$\Delta S_{Hh} = K_{Hh} G_{Hh} R L F_t w$$

Where

K_{Hh} = highway stiffness factor for cyclic circumferential stress.

G_{Hh} = highway geometry factor for cyclic circumferential stress.

R = highway pavement type factor.

L = highway axle configuration factor.

F_t = impact factor.

w = applied design surface pressure in pounds per square inch.

8. Circumferential Stress due to Internal Pressurization, S_{Hi}

$$S_{Hi} = \frac{p*(D-t_w)}{2*t_w}$$

Where,

p = internal pressure, taken as the MAOP, in psi.

D = Pipe outside diameter, in inches

t_w = wall thickness, in inches

9. Principal Stress, S_1, S_2, S_3

$$S_1 = S_{He} + \Delta S_H + S_{Hi}$$

Where,

S_1 = maximum circumferential stress.

$\Delta S_H = \Delta S_{Hh}$, in pounds per square inch.

$$S_2 = \Delta S_L - E_S \alpha_T (T_2 - T_1) + \gamma_s (S_{He} + S_{Hi})$$

Where,

S_2 = maximum longitudinal stress.

$\Delta S_L = \Delta S_{Lh}$, in pounds per square inch.

E_S = Young's modulus of steel, in pounds per square inch.

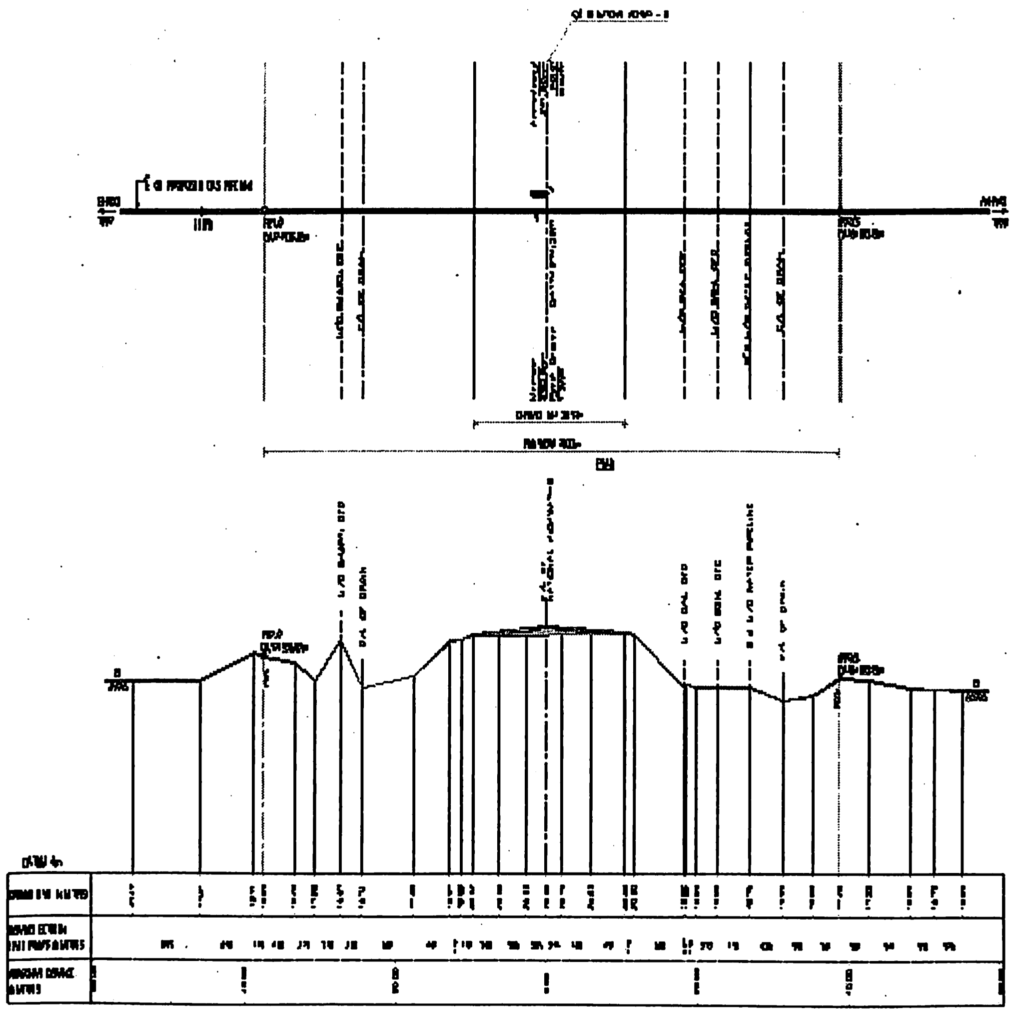
α_T = coefficient of thermal expansion of steel, per degree Celsius.

T_1 = temperature at the time of installation, in degree Celsius.

T_2 = maximum or minimum operating temperature, in degree Celsius.

γ_s = poisson's ratio of steel.

4.1 Schematic Representation of Crossing



Cross sectional drawing

CHAPTER V

Chapter - V

5.0 DESIGN CALCULATION

5.1 PIPELINE STABILITY ANALYSIS

This section covers the anti-buoyancy measures to be provided at water crossing, marshy and water logged areas along the pipeline route. The continuous concrete coating has been considered for anti buoyancy measures.

The pipeline data and densities are as under:

Pipe Data:

Do (Pipe outside diameter of steel.) = 762mm

Wt(Pipe wall thickness) = 10.3/11.9/14.3 mm

tc(coating thickness) = 2.5mm

tcc (concrete coating thickness) = 115 mm

Densities:

ρ Steel = 7850 kg/m3 Carbon Steel

ρ water = 1000 kg/m3

ρ polyethylene = 950 kg/m3

ρ conc. = 2245 kg/m3

The following criteria has been adopted for calculating concrete coating thickness:

Wp = W1+W2+W3, kg(f)/m

Where Wp = Net weight pipe including coatings

W1 = Steel pipe weight, kg(f)/m

W2 = PE coating weight, kg(f)/m

W3 = Concrete coating weight. kg(f)/m

W_b= Buoyancy force, N/m=(π /4) ((D+(2*tc)+(2*tcc))*.001)^2 * density of water N/m

Factor of safety = Wp/Wb> 1.3

The floatation check has been carried out for buried pipeline in empty condition. The calculations are:

Wall thickness = 10.3 mm

W1 (kg (f)/m)= (Π*((D*.001)^2-(ID*.001)^2/4)* ρ steel

=(Π*((762*.001)^2-(741.4*.001)^2/4)*7850

=193.76 kg (f)/m

W2 (kg (f)/m)=(Π*(((D+(2*tc))*.001)^2-(D*.001)^2/4)* ρ polyethylene

=(Π*(((762+(2*2.5))*.001)^2 –(762*.001)^2/4)*950

=5.7 kg(f)/m

W3 (kg (f)/m)=(Π*(((D+(2*tc)+(2*tcc))*.001)^2-((D+(2*tc))*.001)^2/4)* ρ conc

=(Π*(((762+(2*2.5)+(2*115))*.001)^2-((762+(2*2.5))*.001)^2/4)*2245

=715.6 kg(f)/m

Wb = Π/4*((762+(2*2.5)+(2*115))*.001)^2 * 1000

=781.00 kg(f)/m

Wp=W1+W2+W3=193.76+5.7+715.6=915.06

FOS=Wp/Wb>1.3=1.17 so FOS = 1.3

For Wt=11.9 mm,

W1 (kg (f)/m)= (Π*((D*.001)^2-(ID*.001)^2/4)* ρ steel

$=(\Pi*((762*.001)^2-(738.2*.001)^2/4)*7850$

$=220.13$ kg (f)/m

W2 (kg (f)/m)=$(\Pi*(((D+(2*tc))*.001)^2-(D*.001)^2/4)*\rho$ polyethylene

$=(\Pi*(((762+(2*2.5))*.001)^2-(762*.001)^2/4)*950$

$=5.7$ kg(f)/m

W3 (kg (f)/m)=$(\Pi*(((D+(2*tc)+(2*tcc))*.001)^2-((D+(2*tc))*.001)^2/4)*\rho$ conc

$=(\Pi*(((762+(2*2.5)+(2*115))*.001)^2-((762+(2*2.5))*.001)^2/4)*2245$

$=715.6$ kg(f)/m

$Wb = \Pi/4*((762+(2*2.5)+(2*115))*.001)^2 * 1000$

$=781.00$ kg(f)/m

Wp=W1+W2+W3=220.13+5.7+715.6=941.43

FOS=Wp/Wb>1.3=1.21 so FOS = 1.3

Same will be the calculations for Wt=14.3 mm for calculation sheet refer annexure 1.

5.2 STRESS CALCULATION RAILROAD AND HIGHWAY CROSSING

Pipe data:

D (inch)=30"

Design pressure =92kg/cm^2 =1308.51 psia

Steel grade = X-70

SMYS = 70000 psia

Design factor

For NH/SH crossings F=0.72,0.6

Longitudinal joint factor = 1

Wall thickness.t_w =10.3mm= .4055 inch for class 1

=11.9 mm=. 4684 in for class 2

=14.3 mm =0.56297 in for class 3

The first step in calculating the stresses is:

Stresses due to external loads

External loading on the carrier pipe will produce both circumferential and longitudinal stress both. It is assumed that all external loads are conveyed vertically across a 90 degree arc centered on the pipe crown and resisted by a vertical reaction distributed across a 90 ^{o} arc centered on pipe invert.

Stresses due to earth load

The circumferential stress at the pipeline invert caused by earth load, S_{HC} (psia or kpa) is:

$$S_{HC}= K_{HC}*B_e*E_e*U_i*D$$

U_{i}=120 pounds per cubic foot (.069 psia)

K_{HC}= stiffness factor for circumferential stress from earth load

B_e =burial factor for earth load

E_e =excavation factor for earth load

K_{HC} depends on t_w /D and E'(modulus of soil resistivity),it is recommended to take E' as 0.5 kips (3.4 Mpa) and

t_w /D=.4055/30=0.0135

Using the two values K_{HC} can be calculated using the figure 1, we get value as K_{HC} = 4600. The burial factor , B_e is a function of the ratio of pipe depth to bored diameter, H/B_d. B_d is taken as D+2 at the time of design for bored and D for open cut crossings.

H= 3.94 ft = 1.2 m

B_d = 32 in= 2.657 ft

H/B_d =1.48

Using the values given, the value of B_e is calculated from the figure 2,for A type of soil which comes to B_e = 0.48

Now, for E_e i.e. excavation factor, which is a function of ratio of bored diameter to pipe diameter, B_d /D is calculated from the figure 3.

B_d /D = 32/30 = 1.07, from the graph for this value we get Ee = 0.94

So,

S_{HC}= K_{HC}*B_e*E_e*U_i*D

= 4600*0.48*0.94*.069*30

=4296lb/in²

Stresses due to live load

Surface live loads

The live external load for **railroad** is the vehicular load, w applied at the surface of crossing .it is recommended that cooper E – 80 loading of

w= 13.9 psi (96 Kpa) be used.

The live external highway, w is due to wheel load, P applied at the surface of the road way

$$W = P/ A_p$$

P_t ie tandem axle wheel load, its value recommended for design is 10kips=10000 pounds =44.5kilonewtons. And A_p ie the contact area over which the wheel load is applied, is taken as 144 in^2(0.093 m^2).thus ,

W = 10000/144=69.4 lb/in^2

There is P_s i.e. the single axle load of which is the max wheel load from a trucks single axle, whereas Pt ie tandem axle wheel load is the max wheel load from a trucks tandem axle .the table helps in determining the values. As from the table we get to know that for D>12 in and H>=1.2 m we use tandem axle load.

Impact Factor

Impact factor is a function of the depth of burial, H, of the carrier pipeline at the crossings. Impact factor for both railroads and road are specified, which is 1.75 for railroad and 1.5 for roads.

Highway cyclic stresses

- Cyclic circumferential stress due to high way vehicular load,

$$\Delta S_{Hh} = K_{Hh} * G_{Hh} * R * L * F_i * w$$

K_{Hh} = highway stiffness factor for cyclic circumferential stress.

G_{Hh}= railroad geometry factor for cyclic circumferential stress

R = highway pavement type factor

L = highway axle configuration factor

F_i = impact factor = 1.5,

W =applied design surface pressure, in psia or Kpa

The R and L depend on the burial depth, H; pipe diameter, D; and design axle configuration. table 2 gives us the respective details .

K_{Hh} is presented as a function of the pipe wall thickness to diameter ratio, t_w/D and soil resilient modulus, Er in fig 4 annexure I.

$K_{Hh} = 20$

$E_r = 10$ ksi and $t_w/D = 0.4055/30 = 0.0135$

G_{Hh} ie the railroad geometry factor is presented as a function of pipe diameter, D and depth of burial, H, in figure 5 annexure I

$G_{Hh} = 1.1$

F=1

L=1

W=69.4lb/in^2

$$\Delta S_{Hh} = K_{Hh} * G_{Hh} * R * L * F_i * w$$

$$=20*1.1*69.4*1*1*1.5$$

$$\mathbf{=2290.2psi}$$

- Cyclic longitudinal stress due to highway vehicular load, ΔS_{Lh} (psi)

$$\Delta S_{Lh} = K_{Lh} * G_{Lh} * R * L * F_i * w$$

K_{Lh} = highway stiffness factor for cyclic longitudinal stress.

G_{Lh}= railroad geometry factor for cyclic longitudinal stress

R = highway pavement type factor

L = highway axle configuration factor

F_i = impact factor = 1.5,

W =applied design surface pressure, in psia or Kpa

The R and L depend on the burial depth, H; pipe diameter, D; and design axle configuration. Table 2 gives us the respective details.

K_{Lh} is presented as a function of the pipe wall thickness to diameter ratio, t_w/D and soil resilient modulus, Er in fig 4 annexure I.

$K_{Lh} = 15$

$E_r = 10$ksi and $t_w/D = 0.4055/30 = 0.0135$

G_{Lh} i.e. the railroad geometry factor is presented as a function of pipe diameter, D and depth of burial, H in figure 5, annexure I.

$G_{Lh} = 1.1$

F=1

L=1

W=69.4lb/in^2

$\Delta S_{Lh} = K_{Lh} * G_{Lh} * R * L * F_i * w$

$= 15*1*1*0.9*69.4*1.5$

$=$ **1405.36 psi**

Stresses due to internal load

The circumferential stress due to internal pressure, S_{hi} (psi) may be calculated by:

$S_{Hi} = p(D-t_w)/2*t_w$

P= internal pressure, taken as MAOP or MOP Iin psia or KPa

D outer dia, in or mm

t_w wall thickness, in or mm

$S_{Hi} = 1308.51*(30-.4055)/2*.4055$

$=$ **47749.32psi**

Limits of Calculated Stresses

The stresses calculated may not exceed allowable values. The allowable stresses for controlling yielding and fatigue in the pipeline.

Check for allowable stresses

Barlow formula: To calculate the circumferential stress due to internal pressure, calculated using: -

S_{Hi}= pD/2 t <= F*E*T*SMYS

S_{hi} =1308.51*30/2*0.4055=48403.57 psia

F*E*T*SMYS=0.72*1*1*70000=50400 psia

The second check for allowable stress is accomplished by comparing the total effective stress, against the SMYS*f. Principal stress is used for calculating S_{eff}.The principal stresses are calculated from the following

$S_1 = S_{He} + \Delta S_H + S_{Hi}$

Where:

S_1=max circumferential stress

$\Delta S_H = \Delta S_{Hr}$ in psi or kilopascals for railroads, and

$\Delta S_H = \Delta S_{Hh}$ in psi or kilopascals for highways

S_1 = 4296.37+47749.32+2290 = 54336.07 psi

$S_2 = \Delta S_L - E_s \alpha_T (T_2 - T_1) + v_s (S_{He} + S_{hi})$

S_2 =maximum longitudinal stress

$\Delta S_L = \Delta S_{Lr.}$ in psia for railroad, and

$\Delta S_{Lh.}$ in psia for highways

E_s = young's modulus of steel, in psi

α_T = coefficient of thermal expansion of steel, per °F or per °C

T_2 = temp at the time of installation, in °F or °C

T_1 = max or min operating temp, in °F or °C

v_s = poission's ratio of steel

$\Delta S_{Lh.}$ =1405 psi

E_s = 30000ksi

α_T = 0.0000065

T_1 = 149°F

T_2 = 77 °F

v_s = 0.3

S_{He} =2801.95 psia

S_{Hi} = 34210.37 psi

S_2 =1405-30000*. 0000065*(77-149)+. 3*(4296.37+47749.32)

=17033.15 psi

And

S_3 = -p= -1308.5 psi

The total effective stress, $S_{eff}=[½((S_1-S_2)^2+(S_2-S_3)^2+(S_3-S_1)^2)]^{½}$

S_{eff} =[½((54336.07 –17033.15)²+(17033.15+1308.5)²+(-1308.5- 54336.07)²)]^½

=49113.34.96899 psi

SMYS F= 70000*.72= 50400 psia

=S_{eff} <= SMYS*F, which is true.

Check For Fatique

The check is performed by comparing a stress component normal to a weld in the pipeline against an allowable value of this stress.

A. Girth weld

The cyclic stress that must be checked for potential fatigue in a girth weld located beneath a railroad or highway crossing is longitudinal stress due to live load. The design check is accomplished by assuring that the live load cyclic longitudinal stress is less than the factored fatigue endurance limit. The fatigue endurance limit is 12000 psi (82,740 kilopascals).

The design check against fatique limit is given by:

$$\Delta S_L <= S_{FG} * F$$

Where:

$\Delta S_L = \Delta S_{Lr}$ for railroads and ΔS_{Lh} for highways

S_{FG} = fatique endurance limit of girth weld =12000psi

F = design factor=. 72

$$\Delta S_{Lh} = 1405.35 \text{ psia}$$

$$S_{FG} * F = 12000*.72 = 8000$$

Thus $\Delta S_L <= S_{FG} * F$

B .Longitudinal weld

The cyclic stress that must be checked for potential fatique in a longitudinal weld located beneath a rail road crossing is the circumferential stress due to live load .the design check is accomplished by assuring that the live load cylic circumferential stress is less than the factored fatique endurance limit. The fatique endurance limit if longitudinal weld depends on the type of weld and the minimum ultimate tensile strength. The design check is mentioned as follows:

$$\Delta S_H <= S_{FL} *F$$

Where: S_{LG} = Fatique endurance limit of longitudinal weld.

$$\Delta S_{Hh} <= S_{FL} *F$$

$$\Delta S_{Hh} = 2404.71$$

$$S_{FL} = 25000$$

$F = .72$

$\Delta S_{Hh} <= S_{FL} * F$

$2404.1 <= 18000$

More details about the highway crossing can be obtained from annexure 11,where F=0.6 and Tw = 11.9 mm

Railway crossings

The railway crossings are cased crossings so we calculate according to the casing .for railway crossing the calculations are based on casing, the dimensions are:

P=0

F= 0.72

SMYS = 35000 psia

D = 32 in

Tw = .4066 mm

Stresses due to earth load

The circumferential stress at the pipeline invert caused by earth load, S_{HC} (psia or kpa) is:

$$S_{HC} = K_{HC} * B_e * E_e * U_i * D$$

U_i=120 pounds per cubic foot (.069 psia)

K_{HC}= stiffness factor for circumferential stress from earth load

B_e =burial factor for earth load

E_e =excavation factor for earth load

K_{HC} depends on t_w /D and E'(modulus of soil resistivity),it is recommended to take E' as 0.5 kips (3.4 Mpa) and

t_w /D=.0127

Using the two values K_{HC} can be calculated using the graph 3,from the graph we get value as K_{HC} = 6000

The burial factor, B_e is a function of the ratio of pipe depth to bored diameter, H/B_d. B_d is taken as D+2 at the time of design for bored and D for open cut crossings.

H= 1.7 m = 5.58 ft

B_d = 34 in= 2.86ft

H/B_d =1.97

Using the values given, the value of B_e is calculated from the figure 4 for a type of soil which comes to Be = 0.65

Now, for E_e i.e. excavation factor, which is a function of ratio of bored diameter to pipe diameter, B_d/D is calculated from the figure 5.

B_d/D = 32/30 = 1.06, from the graph for this value we get Ee = 0.92

$$S_{HC}= K_{HC}*B_e*E_e*U_i*D$$

$$= 6000*0.65*0.92*.069*30$$

$$\mathbf{=7922.34 lb/in^2}$$

Stresses due to live load

Surface live loads

The live external load for **railroad** is the vehicular load; w applied at the surface of crossing .it is recommended that cooper E – 80 loading of

w= 13.9 psi (96 Kpa) be used.

Impact Factor

Impact factor is a function of the depth of burial, H, of the carrier pipeline at the crossings. Impact factor for both railroads and road are specified, which is 1.75 for railroad and 1.5 for roads.

Railroad cyclic stress

- The cyclic circumferential stress due to rail load

$\Delta S_{Hr} = K_{Hr} * G_{Hr} * N_H * F_i * w$

Where:

K_{Hr} = railroad stiffness factor for cyclic circumferential stress.

G_{Hr} = railroad geometry factor for cyclic stress

N_H = railroad single or double trak facytor for cyclic circumferential stress.

F_i = impact factor = 1.75,

W =applied design surface pressure, in psia or Kpa

K_{Hr} is presented as a function of the pipe wall thickness to diameter ratio, t_w/D and soil resilient modulus, Er in fig 8.

K_{Hr} = 340

E_r = 10ksi and t_w /D=0.0127

G_{Hr} ie the railroad geometry factor is presented as a function of pipe diameter, D and depth of burial, H, in figure 9

G_{Hr} = 0.7

N_H = 1.2 for double track, from fig 10.

W= 13.9 lb/in^2

$\Delta S_{Hr} = K_{Hr} * G_{Hr} * N_H * F_i * w$

$= 340*.7*1.2*13.9*1.75$

=6947.22 lb/in^2

- The cyclic longitudinal stress due to rail load,

$\Delta S_{Lr} = K_{Lr} * G_{Lr} * N_L * F_i * w$

Where

K_{Lr} = railroad stiffness factor for cyclic longitudunal stress.

G_{Lr} = railroad geometry factor for cyclic longitudunal stress

N_L = railroad single or double track factor for cyclic longitudunal stress.

F_i = impact factor = 1.75,

W =applied design surface pressure, in psia or Kpa

K_{Lr} is presented as a function of the pipe wall thickness to diameter ratio, t_w/D and soil resilient modulus, Er in fig 11.

$K_{Lr} = 350$

E_r = 10ksi and $t_w /D=0.0127$

G_{Lr} ie the railroad geometry factor is presented as a function of pipe diameter, D and depth of burial, H, in figure 12

$G_{Hr} = 0.7$

$N_H = 1.08$ for double track, from fig 13

W= 13.9 lb/in^2

$\Delta S_{Lr} = K_{Lr} * G_{Lr} * N_L * F_i * w$

$= 350*.7* 1.08*1.75*13.9$

=6436.40 psi

<u>Stresses due to internal load</u>

The circumferential stress due to internal pressure, S_{hi} (psi) may be calculated by:

$S_{Hi} = p(D-t_w)/2*t_w$

P= 0

D outer dia ,in or mm,

t_w wall thickness, in or mm

tw = .4066 mm

Thus $S_{Hi} = 0$

Limits of Calculated Stresses

The stresses calculated may not exceed allowable values. The allowable stresses for controlling yielding and fatique in the pipeline.

A Check for allowable stresses

(i) Barlow formula: To calculate the circumferential stress due to internal pressure, calculated using: -

For railroad crossings

S_{Hi}= pD/2 t <= F*E*T*SMYS

S_{hi} =0

F*E*T*SMYS=0.72*1*1*35000= 25200 psia

(ii) The second check for allowable stress is accomplished by comparing the total effective stress, against the SMYS*f. Principal stress is used for calculating S_{eff}.The principal stresses are calculated from the following

$S_1 = S_{He} + \Delta S_H + S_{Hi}$

Where:

S_1=max circumferential stress

$\Delta S_H = \Delta S_{Hr}$ in psi or kilopascals for railroads, and

ΔS_{Hh} in psi or kilopascals for highways

Thus **for railroads**

S_{He} =7922.304 psia

S_{Hi} = 0

ΔS_{Hr} = 6947.22 psi

S_1 = 14869.52 psia

$S_2 = \Delta S_L - E_s \alpha_T (T_2 - T_1) + v_s (S_{He} + S_{hi})$

S_2 =maximum longitudinal stress

$\Delta S_L = \Delta S_{Lr,}$ in psia for railroad, and

$\Delta S_{Lh,}$ in psia for highways

E_s = young's modulus of steel, in psi

α_T = coefficient of thermal expansion of steel, per °F or per °C

T_2 = temp at the time of installation, in °F or °C

T_1 = max or min operating temp, in °F or °C

v_s = poission's ratio of steel

$\Delta S_{Lr,}$ =6439.40 psi

E_s = 30000ksi

α_T = 0.0000065

T_1 = 149°F

T_2 = 77 °F

v_s = 0.3

S_{He} =7922.304 psia

S_{Hi} = 0 psi

S_2=6439.40-30000*. 0000065*(77-149)+. 3*(7922.304)

=8827.126psi

S_3 = -p= 0

The total effective stress, $S_{eff}=[\frac{1}{2}((S_1-S_2)^2+(S_2-S_3)^2+(S_3-S_1)^2)]^{\frac{1}{2}}$

For railroad

$S_{eff}=[\frac{1}{2}((14869.52 - 8827.126)^2+(8827.126+0)^2+(0- 14869.52)^2)]^{\frac{1}{2}}$

= 12952.441psi

SMYS F= 35000*.72= 25200 psia

S_{eff} <= SMYS*F, which is true.

5.3 Check For Fatigue

The check is performed by comparing a stress component normal to a weld in the pipeline against an allowable value of this stress.

A. Girth weld

The cyclic stress that must be checked for potential fatique in a girth weld located beneath a railroad or highway crossing is longitudinal stress due to live load. The design check is accomplished by assuring that the live load cyclic longitudinal stress is less than the factored fatique endurance limit.the fatique endurance limit is 12000 psi (82,740 kilopascals).

The design check against fatique limit is given by:

$$\Delta S_L <= S_{FG} * F$$

Where:

$\Delta S_L = \Delta S_{Lr}$ for railroads

S_{FG} = fatique endurance limit of girth weld =12000psi

F = design factor=. 72

$$\Delta S_{Lr} = 6436.40 \text{ psia}$$

$$S_{FG} * F = 12000*.72 = 8640$$

Thus $\Delta S_L <= S_{FG} * F$

B. Longitudinal weld

The cyclic stress that must be checked for potential fatique in a longitudinal weld located beneath a rail road crossing is the circumferential stress due to live load .the design check is accomplished by assuring that the live load cylic circumferential stress is less than the factored fatique endurance limit. The fatique endurance limit if longitudinal weld depends on the type of weld and the minimum ultimate tensile strength. The design check is mentioned as follows:

$\Delta S_H <= S_{FL} *F$

Where:

S_{LG} = Fatique endurance limit of longitudinal weld.

For **railroad crossings**

ΔS_{Hr}=6947.2 psi

S_{FL} =25000

F = .5

$\Delta S_H <= S_{FL} *F$

6947.2<= 12500

CHAPTER VI

Chapter - VI

6. RESULTS AND DISCUSSION

INPUT

Out side diameter	=	762 mm
Wall thickness	=	10.3 / 11.9 / 14.3 mm
coating thickness	=	2.5mm
concrete coating thickness	=	115 mm

Densities:

ρ Steel	=	7850 kg/m3	Carbon Steel
ρ water	=	1000 kg/m3	
ρ polyethylene	=	950 kg/m3	
ρ conc.	=	2245 kg/m3	

The following criteria has been adopted for calculating concrete coating thickness:

Wp	= W1+W2+W3, kg(f)/m
Where Wp	= Net weight pipe including coatings
W1	= Steel pipe weight, kg(f)/m
W2	= PE coating weight, kg(f)/m
W3	= Concrete coating weight. kg(f)/m

RESULTS

Wall thickness = 10.3 mm

W1 (kg (f)/m) = 193.76 kg (f)/m

W2 (kg (f)/m) = 5.7 kg(f)/m

W3 (kg (f)/m) = 715.6 kg(f)/m

Wb = 781.00 kg(f)/m

Wp =W1+W2+W3=193.76+5.7+715.6=915.06

FOS =Wp/Wb>1.3=1.17 so FOS = 1.3

Wall thickness =11.9 mm,

W1 (kg (f)/m) = 220.13 kg (f)/m

W2 (kg (f)/m) = 5.7 kg(f)/m

W3 (kg (f)/m) = 715.6 kg(f)/m

Wb = 781.00 kg(f)/m

Wp =W1+W2+W3=220.13+5.7+715.6=941.43

FOS=Wp/Wb>1.3=1.21 so FOS = 1.3

STRESS CALCULATION

RAILROAD AND HIGHWAY (NH) CROSSING

Pipe data:

D (inch) = 30"

Design pressure = 92kg/cm^2 =1308.51 psia

Steel grade = X-70

SMYS = 70000 psia

Design factor

For NH/SH crossings F=0.72, 0.6

Longitudinal joint factor = 1

Wall thickness.t_w =10.3mm= .4055 inch for class 1

=11.9 mm=. 4684 in for class 2

=14.3 mm =0.56297 in for class 3

Stresses due to earth load

S_{HC} = $K_{HC}*B_e*E_e*U_i*D$

S_{HC} = **4296lb/in²**

Stresses due to live load

W = P/A_p

W = **69.4 lb/in²**

Highway cyclic stresses

Cyclic circumferential stress due to high way vehicular load,

ΔS_{Hh} = $K_{Hh}*G_{Hh}*R*L*F_i*w$

ΔS_{Hh} = **2290.2psi**

Cyclic longitudinal stress due to highway vehicular load, ΔS_{Lh} (psi)

ΔS_{Lh} = $K_{Lh}*G_{Lh}*R*L*F_i*w$

ΔS_{Lh} = **1405.36 psi**

Stresses due to internal load

The circumferential stress due to internal pressure, S_{hi} (psi) may be calculated by:

S_{Hi} = $p(D-t_w)/2*t_w$

S_{Hi} = **47749.32psi**

Limits of Calculated Stresses

S_{Hi} = $pD/2\,t <= F*E*T*SMYS$

S_{hi} = 48403.57 psia

F*E*T*SMYS = 50400 psia

S_l = $S_{He}+\Delta S_H+S_{Hi}$

S_l = 54336.07 psi

S_2 = 17033.15 psi

The Total effective stress,

S_{eff} = $[½((S_1-S_2)^2+(S_2-S_3)^2+(S_3-S_1)^2)]^{½}$

S_{eff} = 49113.34.96899 psi

SMYS F = 50400 psia

The above mentioned results are for road and rail crossings results. We have identified, for same diameter pipeline, we are using different wall thickness according to the load, stress, earth load etc, that a carrier pipe at a crossing subjected to both the internal and external load are safe with in the allowable stress.

API 1102 include circumferential ending stress act on the buried pipe under a road crossings.

CHAPTER VII

Chapter - VII

CONCLUSION

The design specification of Road, Rail, Marshy area and River for Numaligarh – Siliguri Pipeline project (NSPL) pipeline is given below

1. Road Crossings	Pipe: 30"O.D X 10.3mm WT X X-70 Grade X 290M long
2. Rail Crossings	Pipe: 30"O.D X 10.3 mm WT X X-70 Grade X 382M long
3. River Crossings	Pipe: 30"O.D X 10.3 mm WT X X-70 Grade X 762M long
4. River Crossings	Pipe: 30"O.D X 10.3 mm WT X X-70 Grade X 232M long

CHAPTER VIII

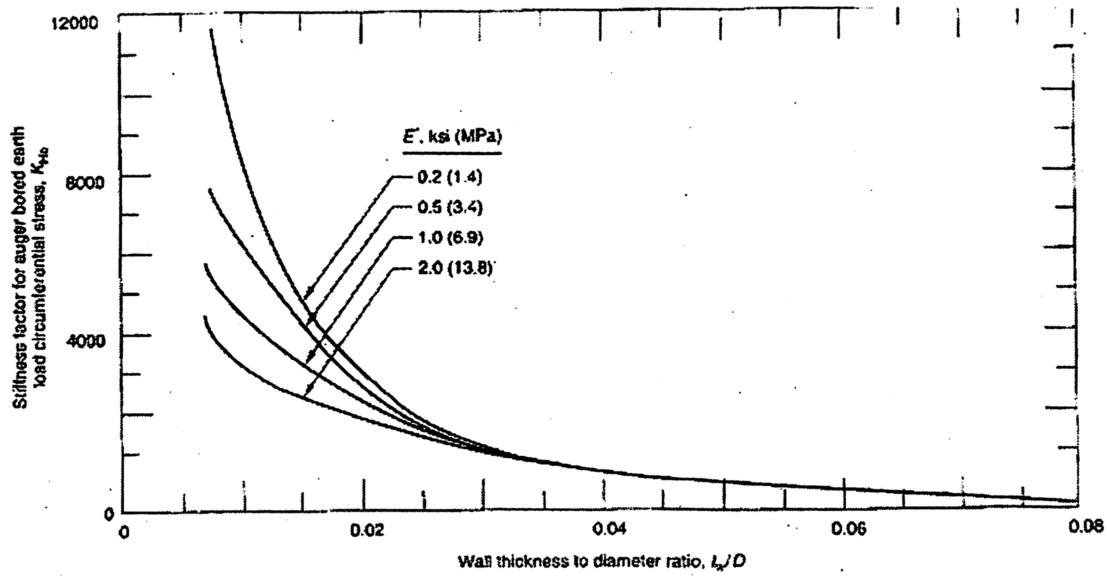
Chapter VIII

REFERENCES ;

- Mohitpore, Goulshan. -Pipeline design and construction
- Louis Wincet - Fundamentals of pipeline engineering.
- Peabody's - Control of pipeline corrosion.
- Petroleum transportation handbook.
- ASME B 31.8 – Gas transmission and distribution piping system.
- OISD 141 - Design and construction requirement for cross country hydrocarbon pipelines.
- API 5 L - Specification for line pipe.
- API 1102 - Steel pipelines crossing railroads and highways.

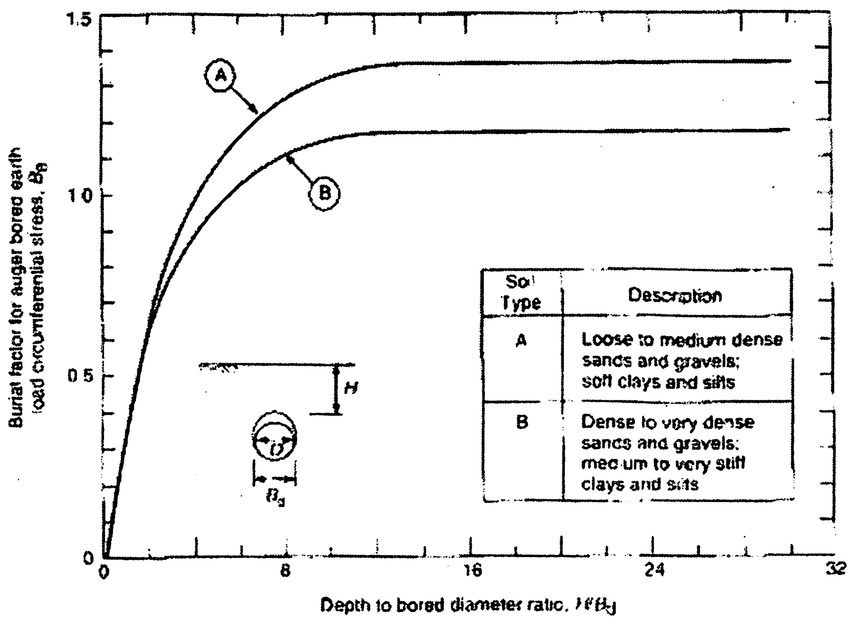
Annexure - I

8. LIST OF GRAPH



Note. See Table A-1 for soil descriptions.

Figure 1 —Stiffness Factor for Earth Load Circumferential Stress, K_{He}



Soil Type	Description
A	Loose to medium dense sands and gravels; soft clays and silts
B	Dense to very dense sands and gravels; medium to very stiff clays and silts

Figure 2 —Burial Factor for Earth Load Circumferential Stress, B_e

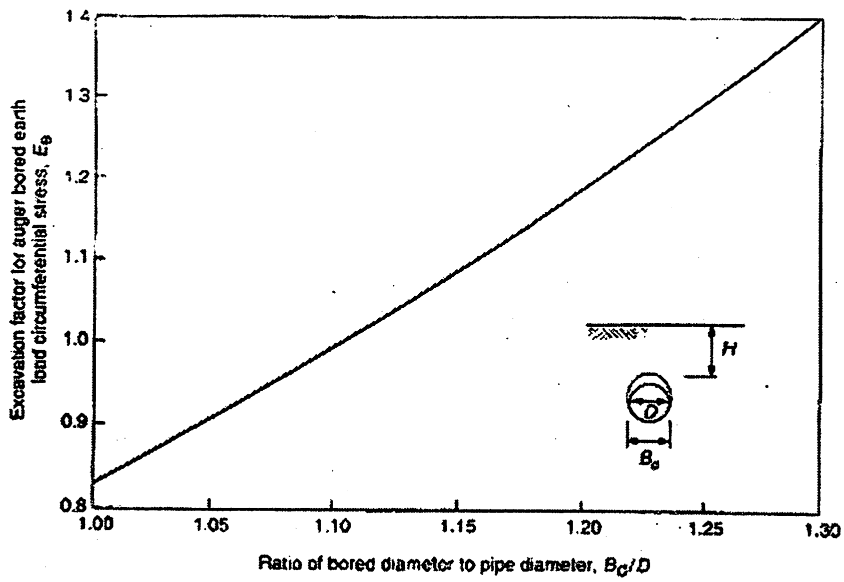
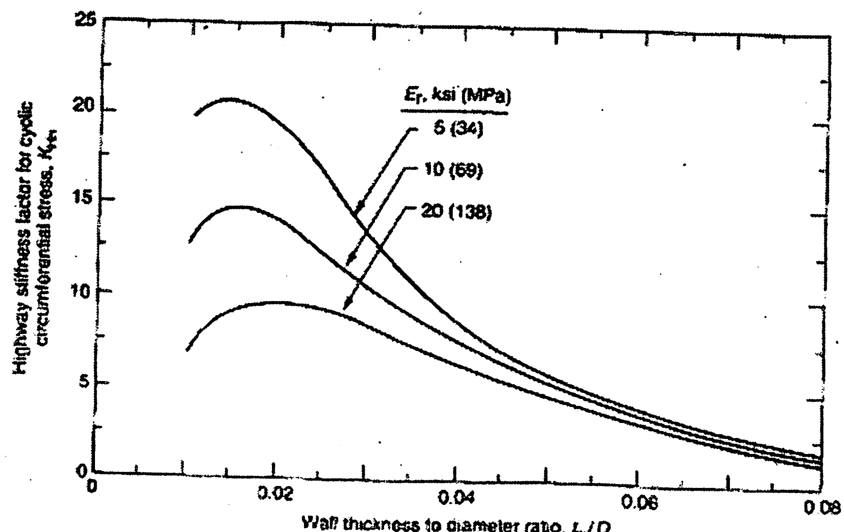


Figure 3 —Excavation Factor for Earth Load Circumferential Stress, E_e



Note: See Table A-2 for soil descriptions.

Figure 4 —Highway Stiffness Factor for Cyclic Circumferential Stress, K_{Hh}

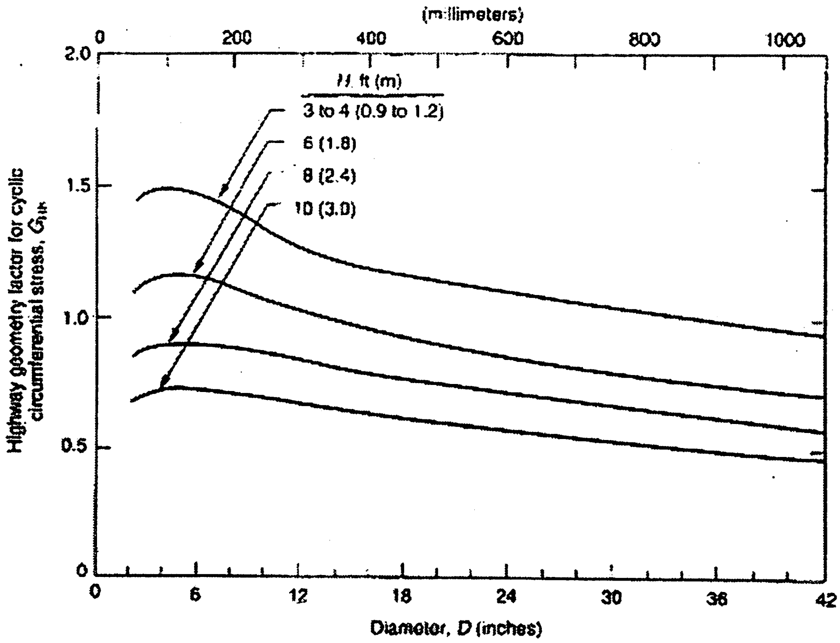
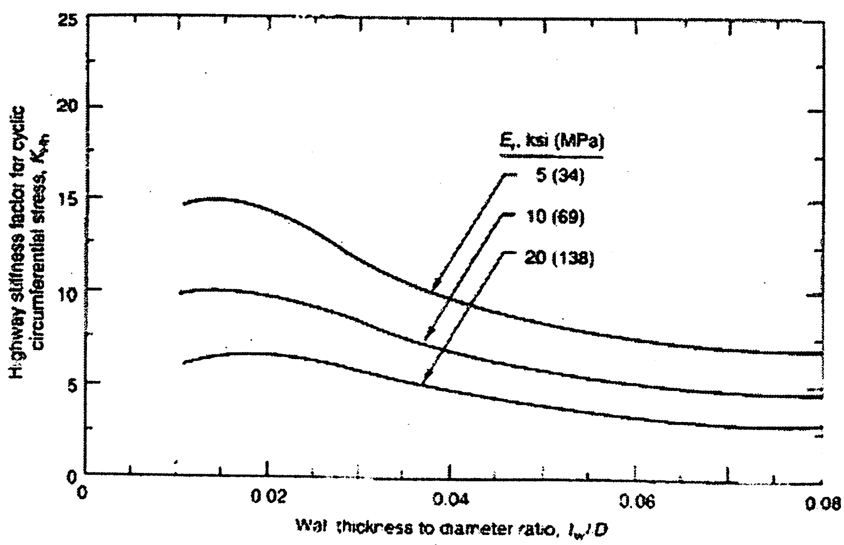


Figure 5 —Highway Geometry Factor for Cyclic Circumferential Stress, G_{Hh}



Note: See Table A-2 for soil descriptions

Figure 6 —Highway Stiffness Factor for Cyclic Longitudinal Stress, K_{Lh}

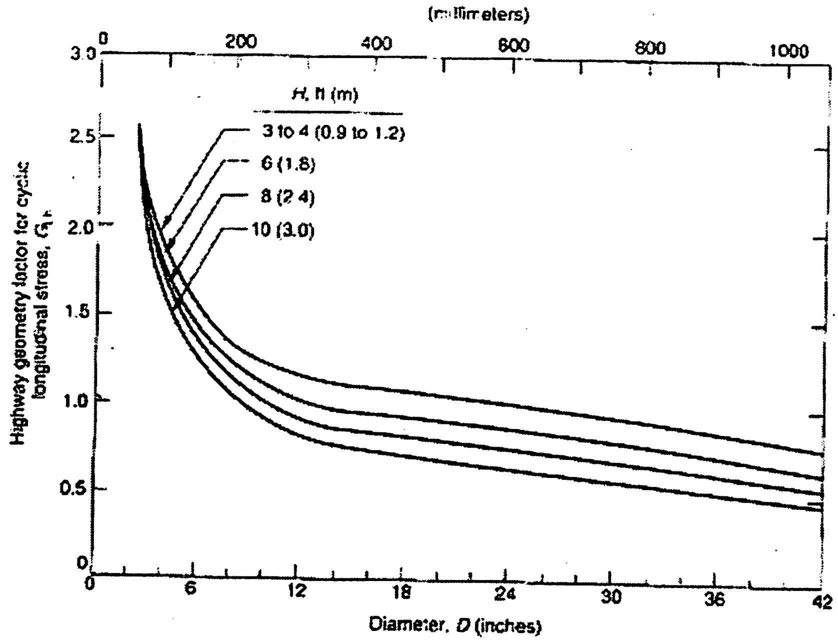
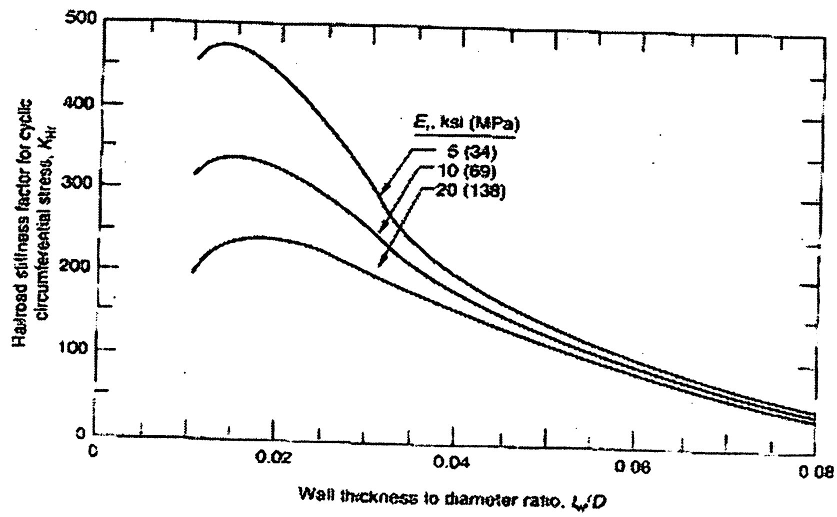


Figure 7—Highway Geometry Factor for Cyclic Longitudinal Stress, G_{Lh}



Note. See Table A-2 for soil descriptions.

Figure 8—Railroad Stiffness Factor for Cyclic Circumferential Stress, K_{Hr}

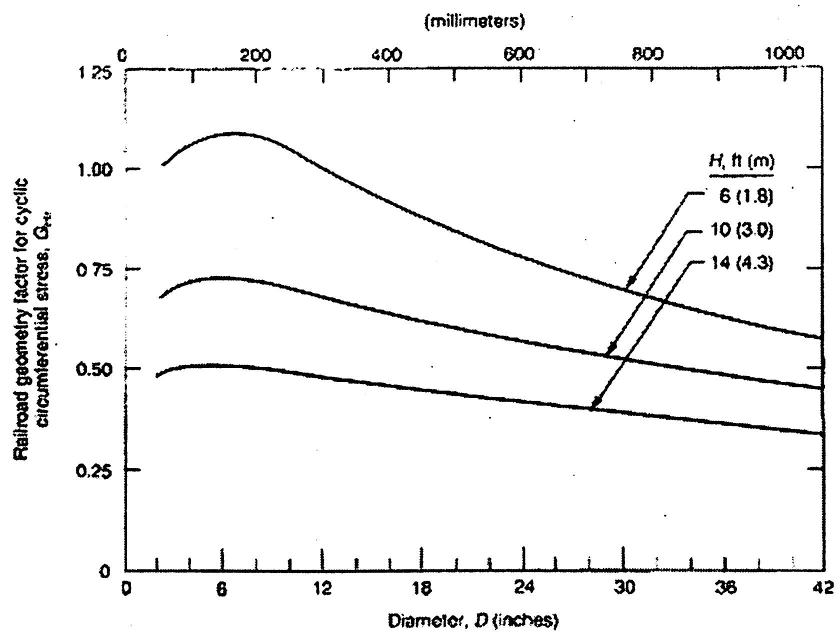


Figure 9—Railroad Geometry Factor for Cyclic Circumferential Stress, G_{H}

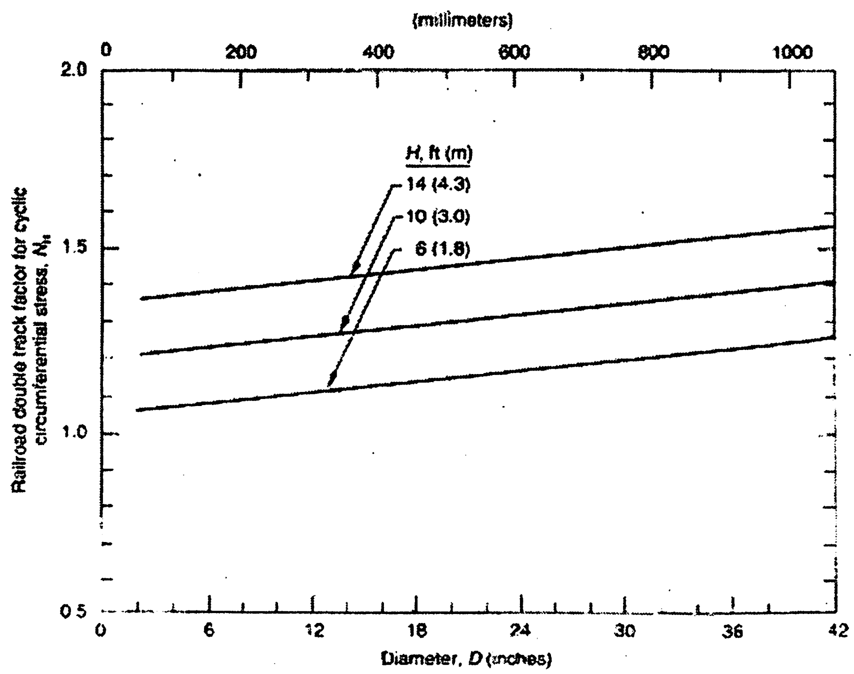
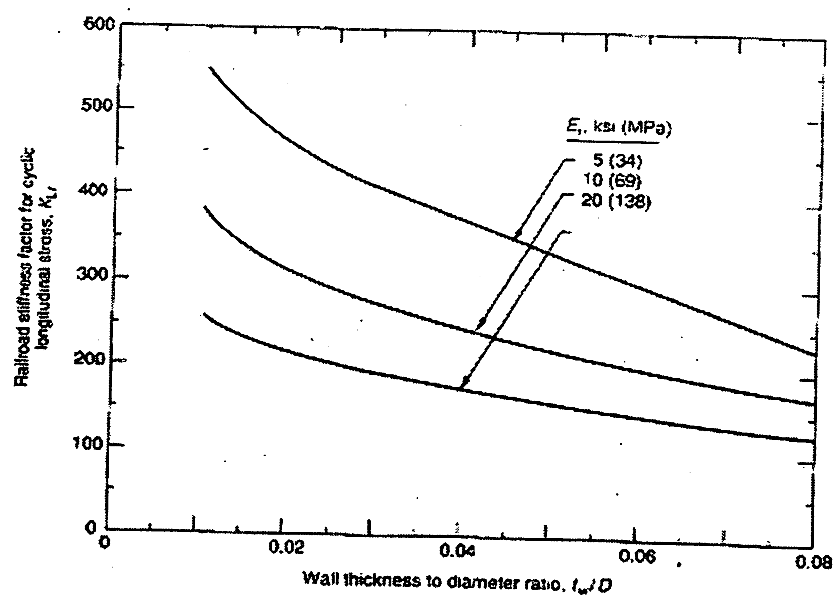


Figure 10—Railroad Double Track Factor for Cyclic Circumferential Stress, N_{H}



Note: See Table A-2 for soil descriptions.

Figure 11—Railroad Stiffness Factor for Cyclic Longitudinal Stress, K_{Lr}

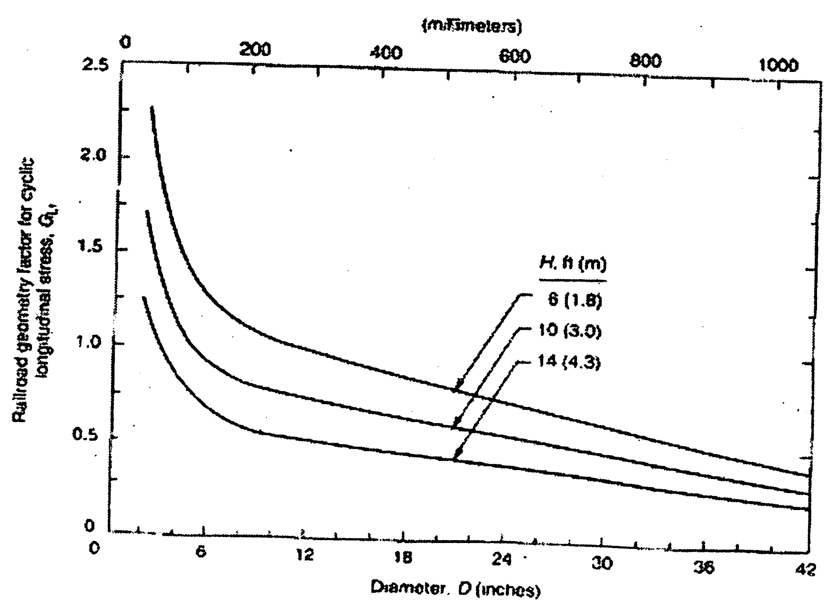


Figure 12—Railroad Geometry Factor for Cyclic Longitudinal Stress, G_{Lr}

8.1 LIST OF TABLES

Table:1 Highway Pavement Type Factors, R, and Axle Configuration Factors, L

Depth, H, < 4 feet (1.2 meters) *and* diameter, D, ≤ 12 inches (305 millimeters)

Pavement Type	Design Axle Configuration	R	L
Flexible pavement	Tandem axle	1.00	1.00
	Single axle	1.00	0.75
No pavement	Tandem axle	1.10	1.00
	Single axle	1.20	0.80
Rigid pavement	Tandem axle	0.90	1.00
	Single axle	0.90	0.65

Depth, H, < 4 feet (1.2 meters) *and* diameter, D, > 12 inches (305 millimeters);
Depth, H, ≥ 4 feet (1.2 meters) for all diameters

Pavement Type	Design Axle Configuration	R	L
Flexible pavement	Tandem axle	1.00	1.00
	Single axle	1.00	0.65
No pavement	Tandem axle	1.10	1.00
	Single axle	1.10	0.65
Rigid pavement	Tandem axle	0.90	1.00
	Single axle	0.90	0.65

Table 2 —Fatigue Endurance Limits, S_{FG} and S_{FL}, for Various Steel Grades

Steel Grade	*SMYS* (psi)	Minimum Ultimate Tensile Strength (psi)	S_{FG} (psi) All Welds	S_{FL} (psi) Seamless and ERW	S_{FL} (psi) SAW
A25	25000	45000	12000	21000	12000
A	30000	48000	12000	21000	12000
B	35000	60000	12000	21000	12000
X42	42000	60000	12000	21000	12000
X46	46000	63000	12000	21000	12000
X52	52000	66000	12000	21000	12000
X56	56000	71000	12000	23000	12000
X60	60000	75000	12000	23000	12000
X65	65000	77000	12000	23000	12000
X70	70000	82000	12000	25000	13000
X80	80000	90000	12000	27000	14000

Note: 1 pound per square inch (psi) = 6.895 kilopascals (kPa).

Table 3 —Minimum Nominal Wall Thickness for Flexible Casing in Bored Crossings

Nominal Pipe Diameter (inches)	Minimum Nominal Wall Thickness (inches)	
	Railroads	Highways
14 and Under	0.188	0.134
16	0.219	0.134
18	0.250	0.134
20	0.281	0.134
22	0.281	0.164
24	0.312	0.164
26	0.344	0.164
28	0.375	0.164
30	0.406	0.164
32	0.438	0.164
34	0.469	0.164
36	0.469	0.164
38	0.500	0.188
40	0.531	0.188
42	0.562	0.188
44	0.594	0.188
46	0.594	0.219
48	0.625	0.219
50	0.656	0.250
52	0.688	0.250
54	0.719	0.250
56	0.750	0.250
58	0.750	0.250
60	0.781	0.250

Table 4 —Critical Axle Configurations for Design Wheel Loads of P_s = 12 Kips (53.4 Kilonewtons) and P_t = 10 Kips (44.5 Kilonewtons)

Depth of burial, H, < 4 feet (1.2 meters) *and* diameter, D, ≤ 12 inches (305 millimeters)

Pavement Type	Critical Axle Configuration
Flexible pavement	Tandem axles
No pavement	Single axle
Rigid pavement	Tandem axles

Depth, H, < 4 feet (1.2 meters) *and* diameter, D, > 12 inches (305 millimeters);
Depth, H, ≥ 4 feet (1.2 meters) for all diameters

Pavement Type	Critical Axle Configuration
Flexible pavement	Tandem axles
No pavement	Tandem axles
Rigid pavement	Tandem axles

Annexure - II

LIST OF CODES AND STANDARDS

In addition to the codes/standards mentioned, the latest edition of the below listed equivalent codes and standards shall also be used for design of proposed pipeline. The listing includes, but is not limited to, the following:

1. Line Pipes

API 5L	Specification for Line pipe
API 5L1	Recommended Practice for Railroad Transportation of Line pipe
API 5LW	Recommended Practice for Transportation of Line pipe on Barges & Marine Vessels

2. Testing & Welding

ANSI/AWS D1.1	Structural Steel Welding
API 1104	Standard for Welding Pipelines and Related Facilities
AWS A5.1	Welding Electrodes
AWS A5.5	Specification for Low Alloy Steel Covered Arc Welding Electrodes
ASTM E165	Liquid Dye Penetrant Inspection of Pipeline Welds
ASTM A370	Standard Methods and Definitions for Mechanical Testing of Steel Products.
ASTM E18	Standard Hardness Test for Metals
ASTM E23	Standard for Impact Test for Metals
ASTM E84	Standard Test Method for Micro-hardness of Metals

ASTM E92	Standard Test Method for Vickers Hardness of Metallic Materials
ASTM E110	Standard Test Method Indentation Hardness for Metallic Materials by Portable Hardness Testers
ASTM E709	Standard Guides for Magnetic Particle Examination
MSS-SP-53	Quality Standard for Steel Casting & Forging-Magnetic Particle Method
MSS-SP-54	Quality Standard for Steel Casting & Forging-Radiographic Examination
MSS-SP-55	Quality Standard for Steel Castings & Forgings-Visual Method.

3. Surface Preparation, Painting and Coating

SIS-05-59	Pictorial Surface Preparation Standards for Painting Steel Surfaces
SSPC-SP-01	Solvent Cleaning
SSPC-SP-03	Power Tool Cleaning
SSPC-SP10	Structural Steel Painting Council – Joint Surface
NACE No.2	Preparation Standard - Near-White Metal Blast Cleaning
NACE-RP-0274	High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

4. Safety Systems

IP Model Code of Safe Practice in the Petroleum Industry part 3, 6 & 9.