FEASIBILITY STUDY ON SELECTION OF HIGH GRADE(X80) LINE PIPE MATERIAL

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(FEASIBILITY STUDY ON SELECTION OF HIGH GRADE(X80) LINE PIPE MATERIAL)

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CERTIFICATE

This is to certify that the work contained in this thesis titled "**FEASIBILITY STUDY ON SELECTION OF HIGH GRADE(X80) LINE PIPE MATERIAL** "has been carried out by **Vishnu Prasad Barik** under my/our supervision and has not been submitted elsewhere for a degree.

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ABSTRACT

Many basic decisions about as pipeline project are made at a very early stage in its development these include the pipeline route and the line pipe material. In many cases the steel grade choice does not reflect sound engineering principles but rather fear of the unknown assisted by a less than robust capital cost estimation and economic evaluation process. The economic analysis is addressed elsewhere perhaps the commercial regulation process (optimized replacement cost) will drive people to place more importance on the potential for reductions in cost of the component that makes a contribution of about 40% to the cost of the pipeline, to reducing transportation tariffs. The purpose of this project is to identify the engineering issues associated with designing a high pressure transmission pipeline using X80 grade steels and to analyze the processes by which these issues can be addressed during the material procurement and the detailed design process to mitigate any potential risk from the use of X80 grade steels in high pressure transmission pipelines. Simultaneously we will cover the case studies where the X80 had been used earlier.

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ABBREVIATIONS

TM: Thermo Mechanical

ERW: Electric Resistance Welding

PSL: Production Specification Level

API: American Petroleum Institute

Capex: Capital Expenditure

Opex: Operating Expenditure

AS: Australian Standard

BHP: Brake Horse Power

GMAW: Gas Metal Arc Welding

HACC: Hydrogen Assisted cold cracking

SMYS: Specified Minimum Yield Strength

NDT: Non Destruction Test

1.0 INTRODUCTION:

Many basic decisions about as pipeline project are made at a very early stage in its development these include the pipeline route and the line pipe material. In many cases the steel grade choice does not reflect sound engineering principles but rather fear of the unknown assisted by a less than robust capital cost estimation and economic evaluation process. The economic analysis is addressed elsewhere perhaps the commercial regulation process (optimized replacement cost) will drive people to place more importance on the potential for reductions in cost of the component that makes a contribution of about 40% to the cost of the pipeline, to reducing transportation tariffs. The purpose of this project is to identify the engineering issues associated with designing a high pressure transmission pipeline using X80 grade steels and to analyze the processes by which these issues can be addressed during the material procurement and the detailed design process to mitigate any potential risk from the use of X80 grade steels in high pressure transmission pipelines.

The demand for high strength line pipe for applications has increased considerably because of the challenges that the offshore pipelines should be constructed in deeper waters and that for reasons of reducing operational costs pipeline should be operated at increased pressure. The development of new steels and improved pipe manufacturing capabilities enable high strength line pipe with appropriate toughness to be supplied. The desire to increase the through put by increasing the operating pressure or by increasing the usage factor has led to ever increasing demands for large diameter steel pipe. These requirements refer in particular to strength properties and tolerance on dimensions. At the same time it is endeavored not to compromise on operational safety and even to improve it, where possible.

Thanks to the intensive research and development work carried out and the quality assurance measures consistently implemented in pipe production. It has been possible so far to meet the requirements placed by the market. However the limits of physical and technical feasibility have almost been reached when producing high strength pipe that can be meet the ever increasing requirements. As the strength increases, it becomes extremely difficult, if not impossible to achieve the specified limits for the yield to tensile ratio or to fulfill increased toughness requirements.

2.0 HISTORY OF X80 LINE PIPE:

The ever increasing demand for energy worldwide requires the construction of high-pressure gas transmission lines with the greatest possible transport efficiency, so that the cost of pipeline construction and gas transportation is minimized. This is particularly true when large distances are to be covered. The trend is therefore towards using line pipe of larger diameter and/or increasing the operation pressure of the pipeline. This, in turn, necessitates the use of higher strength steel grades to avoid large wall thickness that would be otherwise needed. Also, in some long distance lines, where an increase of the capacity is not required, a reduction of wall thickness (no change of diameter and pressure) can be economic incentives for applying X80 pipe. The development started about 30 years ago along with the introduction of thermo mechanical (TM) rolling practices, and will continue in future. It was mainly governed by the large-diameter pipe manufactures, due to the fact that TM-treatment (with or without accelerated cooling) can optimally be applied for plate only. Therefore, the availability of high strength hot strip material for manufacturing spiral and ERW pipes seems to be limited to grade X80. It is also limited with respect to the available maximum wall thickness In the early 70s, grade (X70) was introduced for the first time in Germany for the use as line pipe in construction of gas transmission pipelines. Since then, grade X70 material has proven a very reliable material in the implementation of numerous pipeline Following satisfactory experience gained with X70 in the subsequent period, grade X80 line pipe came into use for the first time as a 3.2 km pipeline section in 1985 on a trial basis. Subsequently, the material was used in the construction of several additional trial sections. In 1992/93, Ruhr gas constructed the world's first ever pipeline of 250 km length in this material, again in Germany. The reason why Ruhr gas selected this material was the reduction in pipe wall thickness needed in the construction of the pipeline designed to operate at 100 bar pressure. The yield strength values specified in various standards for the different high strength line pipe steels differ only slightly between 550 MPa and 555 MPa

3.0 WHAT IS X80?

According to API 5L the standard grades of pipeline are A, A25, B, X42, X46, X52, X56, X60, X65, X70, X80.The alphabets denote the strength and numeric value indicates the yield strength value in 1000 psi. So X80 stands for the grade of pipeline whose yield strength will be 80,000 psi. According to API 5L there are two Product Specification Level(i.e PSL1 and PSL2).PSL1 pipe can be supplied in grade A25 through X70 and PSL 2 pipe can be supplied in grade B through X80.

4.0 CHEMICAL COMPOSITION OF X80:

	C	P	Mn	Si	S	Ni	Cr	Mo	Cu	Al	V	Nb	Ti	Ceq
X80 pipe	.065	.014	1.55	.31	.002	.023	.027	.28	.019	.026	.002	.068	.018	.39

5.0 WHAT DOES STEEL STRENGTH OFFER?

High steel strength offers saving in pipeline capital cost as a direct result of the reduction in the mass of steel that must be purchased and incorporated in the pipeline. The following tables show the pressure design wall thickness for pipelines of various diameters calculated for a design pressure of 15.3 MPa and design factors of 0.72 and 0.80 respectively.

Diameter	Wall Thickness for Steel Grade (mm) – Design Pressure = 15.3 MPa, F_d = 0.80								
	X42	X46	X52	X56	X60	X65	X70	X80	X100
200	7.3	6.7	5.9	5.5	5.1	4.8	4.4	3.9	3.1
250	9.1	8.3	7.3	6.8	6.4	6.0	5.5	4.8	3.8
300	10.8	9.8	8.7	8.1	7.6	7.1	6.5	5.7	4.5
350	11.8	10.8	9.5	8.9	8.3	7.7	7.1	6.2	5.0
400	13.5	12.3	10.9	10.1	9.5	8.8	8.1	7.1	5.7
450	15.2	13.8	12.3	11.4	10.6	9.9	9.1	8.0	6.4
500	16.9	15.4	13.6	12.6	11.8	11.0	10.1	8.9	7.1
550	18.5	16.9	15.0	13.9	13.0	12.1	11.1	9.7	7.8
600	20.2	18.5	16.3	15.2	14.2	13.2	12.2	10.6	8.5
650	21.9	20.0	17.7	16.4	15.3	14.3	13.2	11.5	9.2
700	23.6	21.5	19.0	17.7	16.5	15.4	14.2	12.4	9.9
750	25.3	23.0	20.4	18.9	17.7	16.5	15.2	13.3	10.6

The tables show that the principal advantage of the higher steel strength is that for the same diameter and pressure, the steel thickness progressively reduces with increasing steel strength.

Thus the primary benefit of higher steel strength is that the mass of steel purchased to satisfy a given design is reduced, directly reducing the capital cost of the pipeline. While the material cost increases with grade (because of increasing alloy content and specification requirements), the cost saving flows through all subsequent processes including convert to coated pipe (through reduction in energy to weld and coat the pipe), transportation, field welding, weld inspection and coating.

6.0 WHY SHOULD WE GO FOR X80?

The main advantage of X 80 pipeline is the reduction of cost. Project cost reduction is the result of the sum of the many benefits when using high strength steel. When the price per ton increases with higher grades

- Lower amount of steel is required
- Lower transportation cost
- Lower laying cost

6.1 EXAMPLE OF RHURGAS X80 PROJECT:

The use of X80 causes the material reduction of about 20000 t compared with X70 pipes by reducing wall thickness from 20.8mm for X70 to 18.3mm for X80.This results also in reduction of pipe laying costs with respect to transportation and with a bigger contribution to welding caused by reduced welding time for thinner walls.

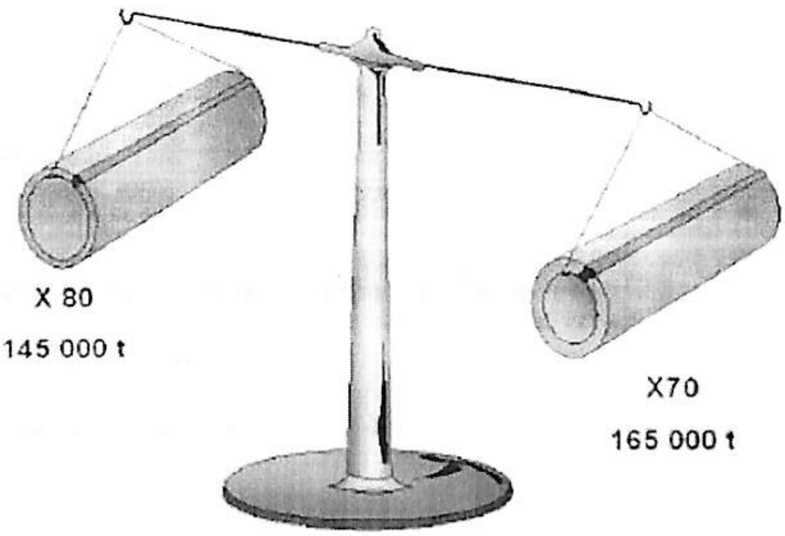

Figure 1: Weight comparison

7.0 COSTING OF THE PROJECT:

X80 line pipe has been available for over a decade, it appears to offer considerable cost benefits but has achieved essentially no market penetration.

If a pipeline has the following characteristics:

Capital cost of: $300MM

Annual operating cost of $3MM

Annual Revenue of $37MM

It will provide a return to shareholder over 20 years of 15% pa. But it includes many inherent risks:

- Capital and /or operating cost changes
- Technical risk
- Regulatory risk
- Market risk
- Financing risk

Pipeline owners develop pipelines in order to provide an investment return for their shareholders. If there is no return on investment then there is no issue on investing in pipeline development. Thus if the cost of the investment can be reduced without increasing risk, then the owners will wish to realize that reduction and the value improvement inherent in it.

Let's look at a theoretical, and grossly simplified, pipeline that has an initial capital cost of $300MM and annual operating cost of $3MM and an annual revenue of $37.4MM. This pipeline will provide its investors with a nominal return of 15%pa, dependent of course on financing structure, tax treatment, length of contract and many of other factors.

- There is risk in this investment
- The original capital and operating estimates for the pipeline are just that, estimates the actual cost will be higher or lower.
- There are major risk inherent within the regulatory environment that we are all aware of
- There are risks that the technology used, be it steel, coating, equipment, control system or whatever will not perform as expected
- The market may not develop as expected or a major customer may have problems
- Debt is a key part of all major pipeline developments and thus investors are exposed to the interest rate market.

The sensitivity to the cost risks include:

Parameter	Nominal Return
Base Case	15%
Capex +10%	12.3%
Capex -10%	17.9%
Opex +20%	14.4%
Opex -20%	15.5%

- These sensitivities form part of the technical and commercial decision making process. For example a possible design change may reduce the capital cost of this pipeline by 5% but lead to an operating cost increase of 10%.

- This would change the nominal return to 15.7%

Of course this matrix of risk is extremely complex and not necessarily relevant but lets just look at the cost risks on our theoretical pipeline

- If Capex increases by the rate of return decreases by 2.7%

- If Capex decreases by 10% the rate of return increases by 2.9%

- If Opex increases by 20% the rate of return decreases by 0.6%

- If Opex decreases by 20% the rate of return increases by 0.5%

- These types of analyses are all part of the decision making process. For example a potential design change, for example a change in pipe coating or compressor type might reduce estimated Capex by 5% but increase estimated Opex by 10%. This would lead to an increase in the rate of return of 0.7% thus making the proposed change a value adding one, provided of course that it did not increase risks in other areas.

- Any detailed project analysis will include numerous of such sensitivity analyses

Lets assume that our pipeline now uses X80 linepipe instead of X70

- Assumed total cost of X70 linepipe - $100MM
- Weight reduction with X80 - 14%
- Assumed X80 premium - 7%
- Thus reduction in pipe cost - $7MM
- Assumed reduction in logistics and welding costs - $1MM
- Total cost saving for using X80 - $8MM or 2.67% of Capital
- If all this saving could be realized and not offset by other increases then the nominal return increases to 15.7%

- As investors we need to understand if this saving in capital and improvement in return is real
- The $8MM saving appears to be the best case scenario, unlikely to be realized.

- So what might happen if we decided to use X80 line pipe instead of X70 line pipe for our theoretical pipeline?

- If we assume that of the $300MM of original capex $100MM was for bare line pipe

- The reduction in steel weight is 14%, but the premium per ton paid for X80 over X70 is 7%,then the saving in steel cost is $7MM

- Assume that there is a further saving of $1MM due to a reduction in logistics and field welding costs giving a total cost saving of $8MM or 2.67% of total Capex

- This saving, if realized, would increase the nominal rate of return by 0.7%

- However, all changes have inherent risks and as investors we need to understand if this saving, and thus the value improvement, is real or only apparent.

- On the face of it, the $8MM appears to be the upper bound of the available costs saving and thus the real saving is likely to be lower.

8.0 X80 RISK PROFILE:

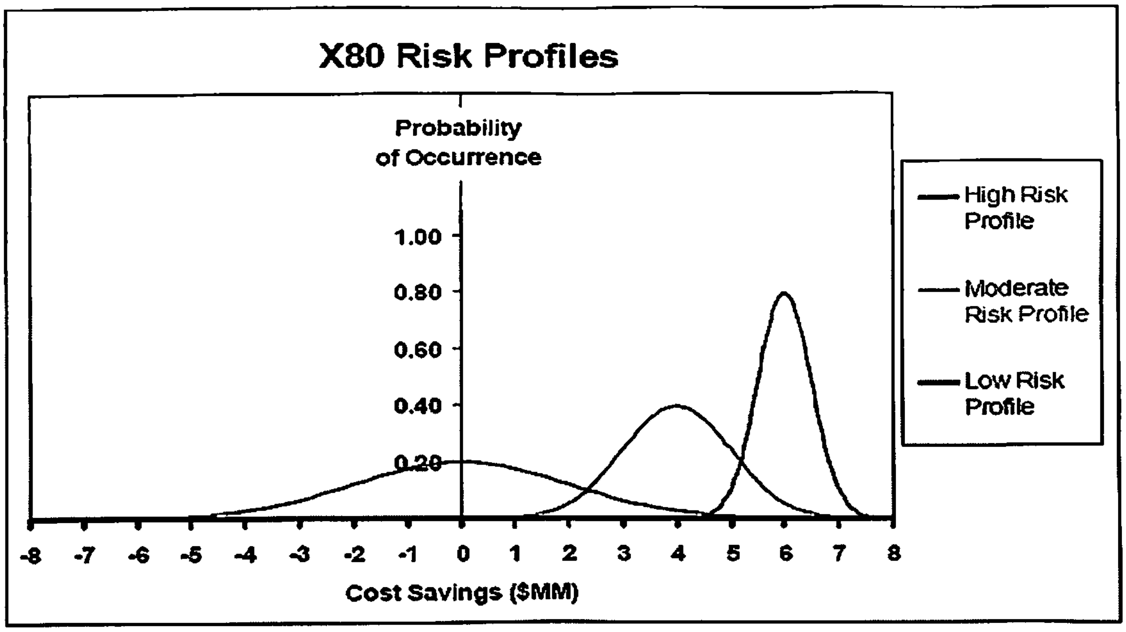

Figure 2: Risk Profile

- If the low risk profile is the correct one then clearly the use of X80 linepipe for this theoretical pipeline would be expected to add value
- Conversely, if the high risk profile is the correct one, then the value of X80 linepipe for our pipeline is quite problematical
- With the moderate risk profile there still remains some question mark as to whether the use of X80 is worth the effort
- The technical managers of the industry need to be able to define the risk profile and/or improve the level of potential savings available from X80 if the investors are going to be influenced to use it

9.0 DESIGN CONSTRAINTS AGAINST THE USE OF X80

Using API 5L Grade X80 steel, even though the material provides an opportunity for significant project cost benefits pipeline industry, together with steel and line pipe manufacturers have spent very significant amounts money undertaking research to understand the material manufacturing, converting and joining parameters of the steel .Here we will considers the design constraints that could create a technical or commercial risk to a project that is constructed using X80 grade steels. It finds that there are no significant risks provided the proper design process is followed, and provided that adequate technical resources are used in escalating the specification for supply and manufacture of the line pipe. Some developmental work will be necessary to establish suitable procedures for constructing the first X80 pipelines and some welding staff training may be required to establish proficiency and productivity levels in these people The same challenge was faced in moving from X42 to X65 steel grades, and from X65 to X70 grade as well as moving from a maximum operating pressure of 7 MPa to 10.2 and now commonly, 15.3 MPa. we have all forgotten the detailed analyses that were made to develop the confidence in each of those major contributions to the cost effectiveness of the pipeline industry .The X80 challenge is a continuation of that efficiency development. Some constraints are as follows.

- Reduces the penetration resistance (the reduction in thickness is not offset by tensile strength increase)
- Increases the toughness required to arrest fracture

- Introduces specific issues with field welding, including weld metal matching (where this is required)
- Introduces issues relating to interfacing with pipeline assemblies
- May introduce other construction issues in areas of bending, buoyancy control, cad weld attachment
- May have some impact in the response of the pipe to a stress corrosion cracking environment
- May increase the cost of pipeline development and maintenance (by increasing the difficulty of welding onto a live pipeline)
- May reduce the strain to failure reserve provided by lower strength steels that have a lower yield to tensile strength ratio

10.0 DESIGN RISK OF X80

- Pipe Wall thickness
- Pipeline Assemblies
- Coating
- Material Specification
- Welding
- Bending
- Field hydro testing
- Pipe handling and laying

10.1 PIPE WALL THICKNESS:

For any high pressure pipeline design, the wall thickness must be selected to satisfy the governing design constraint at each location along the whole of the pipeline. Many of these constraints are interactive, and all interact with the material grade choice. The risk associated with using X80 steel rather than a lower grade is given in the table.

Thickness Design Item	**Risk in shifting from lower grade to X80**
Thickness required for pressure containment	Nil Every pipeline is tested to a hydrostatic strength test at 1.25 *design pressure to establish its minimum allowable operating pressure. The pressure strength margin is totally independent of steel grade.
The sum of the pressure design thickness and allowances.	Nil Allowances have nothing to play with steel grade
Thickness required for resistance to penetration	Nil Increase tensile strength provided by X80 partially counteracts the reduction in

	penetration resistance
Thickness required to satisfy the stress and strain criteria	Nil Higher grades can sustain a higher stress value without exceeding the limit
Thickness required to control fast running fracture	
Thickness required achieving a design stress level selected for its contribution to SCC mitigation at location where the SCC risk is increased by operation at temperature above 45° C and location subject to high pressure fluctuation.	The SCC threshold stress appears to be approximately a constant proportion of the actual yield stress .If X70 and X80 pipeline are each designed for the same % of SMYS they will be operating at roughly the same proportion.
The thickness required to achieve adequate fatigue life where this is determined to be a consideration in the operating life of the pipeline.	Small Fatigue is a function of the stress range and the number of cycles through the stress range. For pipelines that operate at the same percentage of yield stress, the fatigue risk is essentially independent of material.
The thickness required for maintainability of the pipeline including provision for future hot tapping where required.	Risk exists Welding becomes more difficult with increasing grade and reducing thickness. At the design stage the cost impact of providing sections of thicker. More weldable pipe or

	installing branches for future connection is relatively small. Duration operation it is normally possible to plan a construction or maintenance activity around a time of reduced transmission demand that will permit the pressure to be reduced to facilitate welding. This risk exists in thin wall pipes that are currently in service. The risk is managed by the above procedure.

10.1.1 IS X80 TOO "THIN"?

One of the criticisms of thin wall pipe that is available as a consequence of using higher grades of pipe steel is that it is too "thin". The following graph plots the force required to puncture a pipe using an excavator equipped with a single "tiger" (two pointed penetration) tooth The graph illustrates the puncture force for X70 and X80 grades of steel, with thicknesses for each pipe calculated as the pressure design thickness using a design factor of 0.72 The important conclusion to be drawn from this graph is that

- The pressure design thickness for larger diameter and higher strength pipelines significantly increases their resistance to penetration
- The reduction in pressure design thickness provided by using X80 grade steel makes a small

reduction in the force to puncture

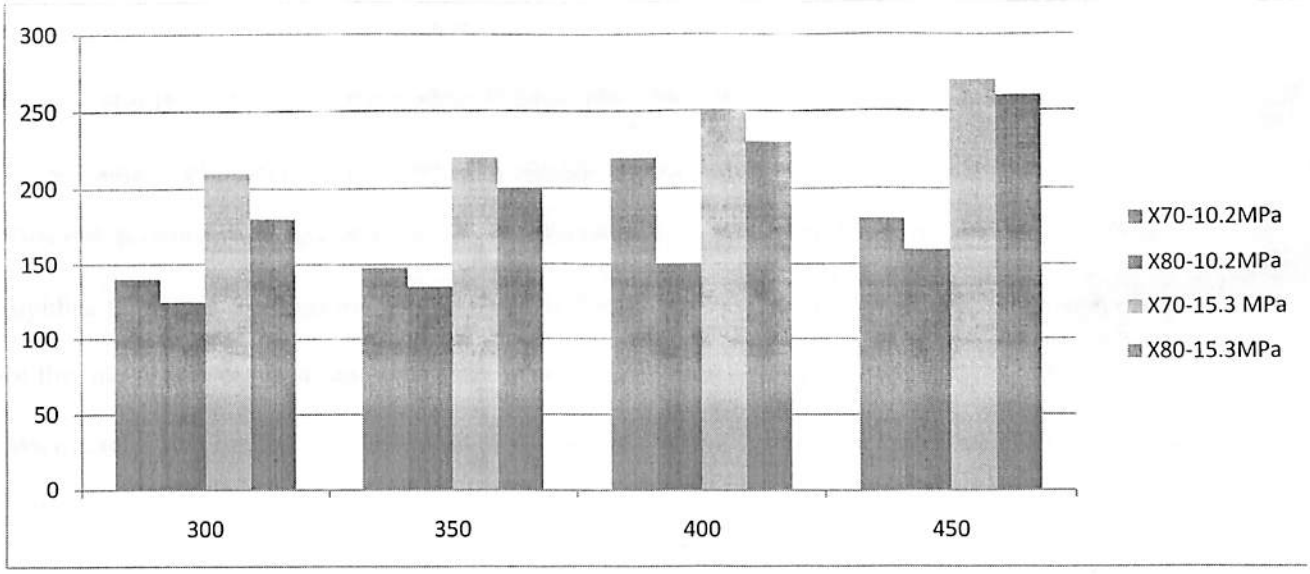

Figure 3:Force to puncture with tiger tooth

Horizontal: **Nominal Pipe Diameter (mm)**

Vertical: **Force to puncture with "Tiger" tooth (KN)**

10.2 PIPELINE ASSEMBLIES:

Pipeline assemblies are designed and fabricated in accordance with the requirements of AS 2885.1. This is intended to permit them to be fabricated from line pipe and high test components that are typically used in the pipeline construction. The pressure design factor for pipeline assemblies is set in AS 2885 as 0.6. This is the same as the value typically used for "heavy" wall pipe in the pipeline. There is no reason that this same philosophy could not be applied with X80 line pipe. The main material problems are associated with material availability and thickness matching and include:

- Supply of "pup" pipe for welding to the mainline valves, and developing a suitable welding procedure to safely weld the valve and pipe.
- Supply of fittings of appropriate strength and thickness.
- Supply of transition pipes between unequal thicknesses.

This risk is managed by undertaking the necessary calculations early in the project (as part of the pipeline thickness calculation), and purchasing the required material as long lead items at the time of the line pipe order to ensure that there is no construction constraint. Too often the detail design associated with pipeline assembly design is left until late in the project where even with existing X70 steel grades, delivery of the required material become critical.

10.3 COATING:

As with recent major Australian pipelines, the coating process for large diameter high pressure pipelines will be either fusion bonded epoxy (single or dual layer) or a three layer system. Each of these processes involves heating the pipe to 230-250°C. This heating has the ability to cause embrittlement by strain ageing, together with an increase in the pipe yield strength (and an increase in the yield – tensile ratio). Some testing undertaken as part of the API hydrostatic testing research project has shown that the yield strength of X70 pipe increases by around 35 MPa during the coating process. There is insufficient data on these effects to fully understand the potential impact on X80 grade pipe..

10.4 MATERIAL SPECIFICATION

Steel and Pipe Specification:

There is a relatively small body of experience in the manufacture of ERW line pipe in X80 grade material. Most of the existing X80 pipe production has been in diameters that require submerged arc welding techniques. In Australia, One steel and BHP have undertaken extensive development and several successful pipe making trials, including the installation of some X80 pipe in a new pipeline to establish production and construction data. X80 steels involve more complex chemistry and processing than X65/X70 steels, and the strength grade can be achieved through a number of routes. Unless there is close liaison between the steel maker, the pipe maker and the end user (the pipeline welder) there is a significant risk that the delivered product will contain defects, or characteristics that impact on the performance of the product –during pipe manufacture, production girth welding, or field hydrostatic testing. A weakness in any of these areas will impact on the cost effectiveness of the X80 material. While X80 grade steels are relatively new to the pipeline industry they are by no means novel. The control measure to manage this risk is simple:

- Recognize that the specifications and procedures copied from the last three projects do not apply to X80 steel pipe.
- Engage the services of a qualified professional to assist in developing the steel and pipe specification.
- Carefully pre-qualify both steel and pipe makers.
- Allow a little more time at the start of the project to undertake qualification testing of each of the processes (steel making, pipe making and girth welding).

10.5 WELDING:

Specific girth welding issues are not part of this – however performance of the welded joint, and its ability to deliver a joint that satisfies the design load requirements for the pipeline are part of this paper's scope. It has been argued that the ability of the girth weld in an onshore pipeline to tolerate significant axial strain should not be a design requirement of the girth weld, because the loading condition is not applicable to almost every weld on an onshore pipeline constructed in Australia. That is, the pipeline is effectively restrained by burial. This proposition suggests that the designer should be capable of identifying the locations where axial loading is credible (including land slip areas where there may be displacement loads, areas subjected to settlement, and areas subject to thermal stresses and bending).

AS 2885.2 has made it mandatory that the welding procedure for Tier defect acceptance criteria produce girth welds that are at least as strong as the pipe. This is to ensure that in a situation where the weld containing defects up to the limits permitted in Tier 2 is subjected to an axial strain, the strain will be distributed along the pipe, and not concentrated in a narrow, low strength weld. To manage this risk the designer must:

- Determine whether the defect acceptance criteria are to be based on Tier 1 or Tier 2 requirements.
- Identify locations along the pipeline route where weld strength matching must be achieved (land slip areas, areas at risk from large scale flotation, areas of potential settlement etc).
- Initiate weld procedure development and testing. Research undertaken in Australia has demonstrated that with appropriate steel:
- X80 pipe can be welded with full matching characteristics using GMAW techniques in all thicknesses.

- X80 pipe can be welded with adequate matching characteristics using Exx10 electrodes in thicknesses above about 7 mm.
- Below 7 mm, Exx10 electrodes will not produce full matching. This may be acceptable in locations where the pipeline route is known to be not subject to displacement controlled loading.

Where it is necessary to demonstrate weld metal matching it must use wide plate or full pipe section tensile testing. There are a limited number of laboratories that have the capability to undertake these tests – it is important that the project plan incorporate sufficient time for the welding procedure development and tensile testing. Some iteration of weld procedure development and testing may be required.

Where the welding procedure or electrode combinations require different processes from those "normally" used, it may be necessary to provide additional welder training prior to commencement of production welding. Some training is normally required, and this represents an extension of that process. It is worth noting at this point the subtle change in AS 2885.2 which requires "qualification of a welding procedure", not "welding procedure qualification". Pipeline welding contractors and where they exist, the designer's or the owner's welding engineer have shown no inclination over recent years to develop welding procedures that will deliver matching welds, even though the limitations of existing procedures for X70 line pipe based on combinations of E6010/E8010 electrode combination have been reported to the industry on many occasions as delivering potentially under matched welds. The approach to a new project has generally been to copy the last procedure and assume that it will work for the new project. Compliance with AS 2885.2 for all high strength steel grades requires development of a welding procedure and qualification of that procedure over the extremes of each combination of variables for which that procedure will be used. This requirement exists irrespective of the steel that is to be welded.

Additional effort, including specifying, sourcing and controlling higher strength electrodes may be required to achieve the performance characteristics necessary for welding X80 steel.
The cost saving associated with high strength pipe arise from a reduction in pipe wall thickness which reduces both required steel tonnage and also welding cost. In comparison with X70 grade pipe, X80 grade pipe represents approximately 12% reduction in total steel weight and about 25% less deposited weld metal. These benefits however are balanced by any increase in the pipe/weld consumable costs and require that field welding productivity is not compromised.

According to the project executed in Australia, maximum economic benefits have been obtained by the use of high strength line pipe up to an including x70 grade pipe. The continued use of conventional manual metal arc welding using cellulosic consumables for such pipe designs has enabled field construction rates.

The strength of X80 however, challenges the continued use of cellulosic welding consumables because of their limits in the strength and also high inherent hydrogen content. The main problems in the high strength line pipe are resistance to hydrogen assisted cold cracking and sufficient weld metal strength to match the pipe. Extensive investigation has ensured that under the normal field construction practice HACC can be avoided. The limited strength of cellulosic consumables is the major problem and has been shown to under match the yield strength of X80 grade pipe and even X70 grade pipe at the upper end of the normal strength range. From an economic point of view sufficient weld metal strength matching is required to ensure sufficient tolerance to the typical weld defect which occurs during pipeline construction in order to avoid unnecessary repairs. There is an important difference between weld metal yield strength matching and weld metal strength matching. The latter is directly related to weld defect tolerance, which not only depends on the actual yield strength of the weld metal and the pipe, but also the specified defect limits(mainly depth) and pipe wall thickness..Yield strength matching will provide maximum defect tolerance but it is difficult to determine, mainly where different yielding phenomena can occur in different suppliers of high strength pipe grades.

10.6 BENDING:

10.6.1 COLD FIELD BENDING:

Higher steel grades are expected to have some impact on the cold field bending performance of line pipe because the reduced wall thickness necessarily increases the D/t ratio of the pipe. In combination with the increased steel strength, increased care may be required to achieve the same bend radius in X80 compared with X70. However at the pressures and diameters where X80 grades will be effective the D/t ratio is relatively low AS 2885 Appendix J provides procedures for establishing an appropriate bending procedure, including provisions for accepting a procedure where small buckles are formed. Consequently it is not anticipated that there is any significant risk to the construction productivity as a result of field bending limitations imposed by X80 steel. Furthermore if there is any limitation, it will be established prior to construction commencing, (during qualification), enabling the construction practice to be modified to accommodate the qualified procedure.

10.6.2 INDUCTION BENDS:

Even though modern induction bending processes are able to process the high strength pipe with minimal change in the yield strength, it is common practice in major projects to fabricate induction bends from increased thickness pipe to provide a margin that allows for possible strength reduction. If increased wall thickness pipe is used, it seems unlikely that the use of X80 steel in induction bends would pose a risk to the project. It is usual to conduct procedure qualification trials to establish constraints and the properties of the bent pipe. Until such time as the induction bending performance of more complex steels such as grade X80 is better understood the risk should be managed by the specification of X70 or X65 pipe material of appropriate thickness for induction bending. The induction bending characteristics of these materials are well understood by competent manufacturers.

10.7 FIELD HYDROSTATIC TESTING:

Field hydrostatic testing represents the proof test of the pressure strength of the pipeline. AS 2885 has established that this test is undertaken at a pressure that is 1.25 times the maximum allowable operating pressure. There is no evidence that the use of X80 line pipe has any influence on the satisfactory completion of the hydrostatic test, and no additional provisions are required when the design factor is 0.72. If the design factor is raised to 0.80, then the minimum pressure strength test pressure will induce 100% of SMYS in the pipe at the high point in the test section, and a stress that exceeds 100% SMYS elsewhere. This is a constraint that applies to all steel grades where the pressure design thickness is determined using a design factor of 0.80.

11.0 CASE STUDY:

11.1 CHEYENNE PIPELINE:

The principals and executives of El Paso/Colorado Interstate Gas determined the viability of using X-80 line pipe for a 380 mile, 36 inch, high strength and high pressure natural gas pipeline. The cost of the pipeline was projected at $425 million and was 6 years in the making, from conception to completion. Construction was completed by two contractors employing 3 spreads within approximately 4 months of the construction start date. A number of key elements had to be considered for the successful implementation of such a pipeline, these included the metallurgical design of the X-80 line pipe, bending tolerances, weldability issues, welding procedure qualifications, toughness testing, NDT techniques, welder and welding inspector training programs and hydro testing. Over 181,000 tons of line pipe was manufactured and delivered to the project. The pipe was manufactured at two different pipe mills, one in Canada(80% of the entire order) and one in the USA(remaining 20%).In addition to the 380 miles of 36 inch diameter mainline pipe,4 miles of 30 inch X-80 pipe were manufactured and installed in a lateral pipeline near the Greenburg, compressor station. The project originated at the Cheyenne compressor station in Wyoming and was aligned in a south-Easterly direction across Colorado, through Western Kansas and finishing at the Greensburg, Kansas compressor station. Over 32000 additional HP of compressor was added to the pipeline to deliver up to 1.7 billion cubic feet per day of natural gas to the market place. During the summer and fall of 2004, the Cheyenne Plains Gas Pipeline Company (CIG, a subsidiary of El Paso) constructed a 380 mile long, high pressure natural gas pipeline through Colorado and Kansas. The pipeline became operational ahead of schedule in 2004 and was delivered under the initial approved budget. Two U.S.A pipeline contractors completed the project. Associated Pipe Line Construction Inc. with one spread of equipment completed approximately

125 miles of the X-80, 36" dia. pipeline in Colorado. U.S. Pipeline Inc completed the remainder of the 36" dia. pipeline in Colorado and Kansas and a 4 mile, X-80, 30" dia lateral in Kansas with two equipment spreads Over 180,000 tons of line pipe was required for the project Napa Pipe mill manufactured approximately 80 miles. of X-80, 36"/30" dia. DSAW straight seam pipe IPSCO pipe mill manufactured the remainder (~303 miles) of X-80, 36" dia. spiral seam welded. Wall thicknesses ranged from 0.464" to 0.667" for the X-80 line pipe. All pipe was shipped as 80 foot joints to minimize the amount of handling and the number of field welds The Cheyenne Plains Pipeline project represents the foresight and wisdom of the El Paso engineers and senior management to take advantage of new steel making, welding and non-destructive testing technologies to initiate the first X-80 pipeline project in the United States. As a result of the successful completion and implementation of the project, El Paso received the prestigious 'The Pipeline of the Year' award from the pipeliners Association of Houston in June 2005. The initiation of the project represented the move towards greater economical product throughput by increasing pressures and flow rates while ensuring reasonable construction costs. To accomplish this goal significant consideration was paid to environmental, constructability, and safety issues for the long term reliable operation of the pipeline.

11.2 RHURGAS

The first time X80 pipe was used in what could be termed a commercial pipeline construction project was in 1992-1993 by Rhurgas in Germany. This pipeline is the largest X80 (in terms of tonnage) pipeline that has been built to date. The pipeline which was constructed from Schluechtern to Werne has a total length of 250km, and was constructed from 48 Inch (DN1200) mm SAW pipe with 18.3 and 19.44 mm wall thicknesses The Rhurgas pipeline operates at a pressure of 10 MPa, and was constructed within a 20 meter ROW for the majority of its length. In contrast to the later Canadian and UK experience, the Rhurgas pipeline was constructed entirely using MMAW welding processes Like the other experience the pipe was pre-heated. The pre-heat temperature was 120° C The root and hot pass welds were completed using standard vertical down welding with E 7010 electrodes. The fill and cap passes were also completed using vertical down welding techniques with a Low Hydrogen E 10018-G electrode. Given the significant role that the welding speed has in governing overall construction rates and times, a comparison was made between the welding time for welds completed using all cellulosic welding procedures, and those completed with the combined cellulosic, low hydrogen procedure described above. The results of the tests demonstrated that when experienced welders were used, the welding deposition times were almost identical. The key difference in overall times was attributed to the difference in inter pass cleaning times. All cellulosic procedures were cleaned with wire brushing, and the low hydrogen electrodes required grinding. In spite of this difference in time, the project was able to achieve production rates of 30 welds per day with 25 welders. Interestingly the repair rates on the project were much lower than those quoted for the later mechanized welded pipelines, with an average repair rate of only 3%. The pipe had an average length of 17.3 meters, with each joint weighing up to 10.3 tones bending for the project was carried out at a central bending station using a 60 tonne bending machine with an internal mandrel. Bend angles of up to 0.5 degrees per 300 mm or 2 degrees per diameter were achieved. The ovality was limited to 4% which was easily achieved. Significantly, whilst all reports on this pipeline appear positive, there does not appear to have been any further pipelines constructed in continental Europe from X80 pipe since this project was completed. RuhrGas also successfully tested and evaluated a mechanized welding alternative using the CRC Evans GMAW technology. The test results were positive, however due to the rugged nature of the terrain this technology was not used.

11.3 TRANSCANADA PIPELINES

The use of X80 pipe in Pipeline construction in Canada appears to have developed more consistently following the initial trial. A number of Canadian pipe mills developed the capability to supply X80 pipe, with Ipsco Inc., Regina, being the first Canadian mill to achieve commercial production of Grade 550. The development of its Grade 550 was a co-operative effort between Ipsco, TransCanada Pipelines Ltd (TCPL), Canadian research laboratories universities, and government. In total TCPL (Which merged with Nova Gas Transmission in 1999) now has approximately 400 km of pipelines constructed from X80 material in their system, approximated 39 km of this is 42 Inch (DN 1050) with the balance being 48 Inch (DN 1200).

11.4 EASTERN ALBERTA SYSTEM

In 1994, the Matzhiwn pipeline in Eastern Alberta was constructed from spiral welded X80 material, this pipeline was 33km long 48 Inch, pipe with 12.1mm wall thickness. The pipe was welded using a mechanized gas-metal arc welding procedure identical to those used for X70 pipe. No welding problems were encountered that could be attributed to the process, the procedure, or the higher strength material being welded The Tie-ins were completed with a combination of cellulosic (E55010G) for the root and hot pass, with 100° C. preheat followed by self-shielded FCAW for all remaining passes. using an E9IT8-G wire. The particular self-shielded consumable selected was optimized in terms of deposit strength and toughness by the manufacturer for application to X 80 pipe, and the welds produced consistently met yield-strength requirements and exceeded the toughness requirements at the -5° C. design temperature.

11.5 CENTRAL MAIN LINE LOOP

Following the successful construction of the Eastern Alberta Pipeline the same internal external configuration for mechanized welding was also used for the 1997 91-km expansion of Nova's Central Alberta system 48 Inch (DN 1200) with 12.1 and 16 mm W.T.). The welding procedure was identical to that used on the previous project with additional fill passe for welds in the 16-mm W.T. pipe The spread of mechanized welding equipment involved an additional fill-pass shack; 130 joints/day were achieved at a repair rate of 7%.

Figure 4: construction of X80 line pipe

11.6 EASTERN MAIN LINE LOOP

Also in 1997, 127 km of the 1,219 mm OD Eastern Alberta system main line loop were designed and constructed with X80 Pipe. In this case, all-external mechanized welding was used to join the

12 mm and some 16-mm pipe One welding shack was used to complete the root pass, and three additional shacks would each complete the remaining hot, fill, and cap passes of a weld. Production rates of some 70 welds/day with repair rates of around 5% were achieved Low-hydrogen, vertical-down MMAW with cellulosic root and hot passes were used for tie-ins and repairs.

11.7 TRANSCO PIPELINE

Like Nova, Transco carried out an extensive development program prior to and as part of the introduction of X80 pipe. Including Parent pipe and seam weld property tests MMAW welding trials, GMAW welding trials, Validation of defect acceptance criteria – Wide plate tests Cold field bending trials Evaluation of Induction bends Damage tolerance – ring tension & full-scale tests hydrogen embrittlement tests, Risk assessment, hot tap welding trials.

It appears that the use of cellulose based electrodes were precluded during the development program, and Transco adopted a GMAW system which included internal welding heads to deposit the root pass, followed by conventional GMAW welding for the subsequent passes Transco also carried out an investigation into the bendability of X80 pipe. This trial was carried out using 48 In (DN 1200mm) 15.9 mm pipe in both X65 and X80 thicknesses. This provided for a D/t ratio of approximately 75. The test results indicated that it was more difficult to bend the X80 pipe compared with X65, and the X80 pipe could only be bent to 0.4 degrees per 12 Inch (300 mm) compared with the 0.5 degrees used for the lower strength X65 pipe. Additionally the tests demonstrated that using a hydraulic mandrel was preferred over a pneumatic mandrel as it reduced the propensity for the pipe to buckle. Using a hydraulic mandrel bend radii of 40D (or approx 1.5 degree per diameter) were achieved In UK X80 was first used in 1998 for a short section of X65 48 Inch DN1200mm pipeline from Peters Green to South Mimms in England Following this, in 2000, the 25 km Drointon to Sutton-on-the-Hill pipeline was built. This pipeline was constructed by Transco using 48 Inch DN1200mm pipe. No real difficulties were identified during the construction of either of these pipelines In 2001 Transco completed the construction of a further 112 km of 48 Inch (DN1200) X80 pipeline, and in 2002 a further 46 km 48 Inch of (DN1200) was completed. Though no details of these pipelines have been published, it is understood that Transco were planning to construct these pipelines using heavier wall thickness in order to allow operation at a pressure of up to 9.4MPa compared with the 7.5MPa at which the earlier pipelines were designed to operate.

Figure 5: Transco X80 pipeline construction

12.0 PROJECT COST SUMMARY:

POROJECT COST SUMMERY					
Sl No	DESCRIPTION	ALL COST IN Rs.LAKHS			
		Foreign currency	Indian Currency	Total	
		EQV.INR	INR		

1	PLANT & MACHINERY				EXCHANGE RATE CONSIDERED 1USD=Rs 45 Custom Duty 26% Port Handling 2.50% Excise duty 10.30% ST/VAT 4% Service Tax 10.30% Works Contract 4%
1.1	P/L-JETTY TO LPG	436	5052	5488	
1.2	RECEIPT STATION PLANT	0	3253	3253	
1.3	HPCL PLANT	0	628	628	
1.4	DESPATCH STATION(JETTY)1	1329	843	2172	
1.5	NO		7857	7857	
1.6	MOUNTED BULLETS	23	2043	2067	
	IBPS				
	SUB TOTAL(1)	1788	19676	21465	
2	ENGINEERING COST	EXCLUDED			
2.1	DETAIL ENGINEERING,PROCUREMENT, CONSTRUCTION		859	859	
2.2	SUPERVISION&PROJECT MANAGEMENT	EXCLUDED			
	SERVICE TAX				
	SUB TOTAL(2)	-	859	859	
3	SITE RELATED COST				
3.1	LAND FOR TERMINALS/STATIONS/SV		135	135	
	SUB TOTAL(3)	-	135	135	
4	OWNERS COST PERIOD				
4.1	EXPENCES		215	215	
	START UP & COMMISSIONING				
4.2	EXPENSES		429	429	
	OWNER'S CONST.PERIOD EXPENSES				
	SUB TOTAL (4)	-	644	644	
	SUB TOTAL(1+2+3+4)	1,788	21,314	23,103	
5	CONTIGENCY (5%)	89	1,066	1,155	
	SUB TOTAL(1+2+3+4+5)	1,877	22,380	24,258	
	TOTAL COST	1,877	22,380	24,258	

PLANT MACHINERY-CROSS COUNTRY PIPELINE						
Sl No	DESCRIPTION	ALL COST IN RS.LAKHS				
		Foreign currency EQV.INR	Indian Currency Ic	Sc	Total	

1	EQUIPMENT/SYSTEMS					
1.1	STATUTORY CHARGES			500	500	
1.2	R.O.U ACCQUISITION &CROP			968	968	
	COMPENSATION					
1.3	LINE PIPE,COATING &		1,626		1,626	
	TRANSPORTATION					
1.4	FFLOW TEES(3NOS)		6		6	
1.5	PIPELINE LAYING			881	881	
1.6	O.F BASED TELECOME SYSTEM		228	23	251	
1.7	SCADA AND APPLICATION	346		28	375	
1.8	SYATEM			0	-	
1.9	CATHODIC PROTECTION		204	195	399	
	SV STATION					
	SUB TOTAL(1.1 TO 1.9)	346	2064	2595	5005	
2	INDIRECT COST					
2.1	CUSTOM DUTY	79			79	
2.2	PORT HANDLING & INLAND	10	15		25	
2.3	FRIEGHT		297		297	
2.4	EXCISE DUTY&VAT(CST)			57	57	
2.5	WORKS CONTRACT TAX		25		25	
	INSURANCE					
	SUBTOTAL(2.1to2.5)	89	337	57	483	
	TOTAL COST	89	337	57	483	

PLANT & MACHINERY-RECEIPT STATION					
Sl No	DESCRIPTION	ALL COST IN Rs.LAKHS			
		Foreign currency	Indian Currency	Sc	Total
		EQV.INR	Ic		
1	EQUIPMENT/SYSTEMS/UNITS				
1.1	LPG LOADING PUMPS		113		113
1.2	TRUCK LOADING ARMS		78		78
1.3	BASKET FILTERS(12"x2)		29		29
1.4	SCRAPPER RECEIVER(12"x1)		14		14
1.5	FIRE FIGHTING			500	500
	SUB TOTAL(1)		234	500	734
2	BULK MATERIAL				
2.1	PIPING		103		103
2.2	ELECTRICAL		141	0	141
2.3	INSTRUMENTATION		804		804
2.4	VALVES		415		415
	SUB TOTAL(2)	-	1463		1463
3	SPARES		85		85
	SUB TOTAL(3)	-	85		85
4	ERRECTION				
4.1	MECHANICAL			70	70
4.2	ELECTRICAL			34	34
4.3	INSTRUMENTATION			40	40
	SUB TOTAL (4)	-		145	145
5	CIVIL,STRUCTURE,BUILDING &AIR CONDITIONING			460	460
	SUB TOTAL(5)	-	-	460	460
	SUB TOTAL DIRECT COST	0	1782	1105	2886
6	INDIRECT COST				
6.1	CUSTOM DUTY				0
6.2	PORT HANDLING AND INLAND FRIEGHT	-	72		72
6.3	EXCEISE DUTY & VAT(CST)		257		257
6.4	WORKS CONTRACT TAX			24	24
6.5	INSURANCE		14		14
	SUB TOTAL INDIRECT COST		343	24	367
	TOTAL COST	0	2125	1129	3253

PLANT & MACHINERY-PLANT					
Sl No	DESCRIPTION	ALL COST IN Rs.LAKHS			
		Foreign currency	Indian Currency	Sc	Total
		EQV.INR	Ic		

1 1.1	EQUIPMENT/SYSTEMS/UNITS BASKET FILTER(12"x2)		29		29	
	SUB TOTAL(1)		29	0	29	
2 2.1 2.2 2.3 2.4	BULK MATERIAL PIPING ELECTRICAL INSTRUMENTATION VALVES	0	8 205 4 208		8 205 4 208	
	SUB TOTAL(2)	-	425		425	
3	SPARES		23		23	
	SUB TOTAL(3)	-	85		85	
4 4.1 4.2 4.3	ERRECTION MECHANICAL ELECTRICAL INSTRUMENTATION			17 1 24	17 1 24	
	SUB TOTAL (4)	-		42	42	
5	CIVIL,STRUCTURE,BUILDING &AIR CONDITIONING			24	24	
	SUB TOTAL(5)	-	-	24	24	
	SUB TOTAL DIRECT COST	0	477	66	543	
6 6.1 6.2 6.3 6.4 6.5	INDIRECT COST CUSTOM DUTY PORT HANDLING AND INLAND FRIEGHT EXCEISE DUTY & VAT(CST) WORKS CONTRACT TAX INSURANCE	-	19 62 3	1	0 19 62 1 3	
	SUB TOTAL INDIRECT COST		84	1	85	
	TOTAL COST	0	560	67	628	

PLANT AND MACHINERY-IBPS

Sl No	DESCRIPTION	ALL COST IN Rs.LAKHS				
		Foreign currency EQV.INR	Indian Currency Ic	Sc	Total	
1 1.1 1.2 1.3 1.4	EQUIPMENT/SYSTEMS/UNITS LPG PUMPS EPT CRANE SCRAPPER LAUNCHER RECEIVER(12"x2) FIRE FIGHTING		346 32 27	500	346 32 27 500	

	SUB TOTAL(1)		405	500	905	
2	BULK MATERIALS					
2.1	PIPING		8		8	
2.2	ELECTRICAL		154		154	
2.3	INSTRUMENTATION	14	76		90	
2.4	VALVES		329		329	
	SUB TOTAL(2)	14	567	0	581	
3	SPARES	5	49	-	54	
	SUB TOTAL(3)	5	49	-	54	
4	ERRECTION					
4.1	MECHANICAL			48	48	
4.2	ELECTRICAL			23	23	
4.3	INSTRUMENTATION			10	10	
	SUB TOTAL (4)	-		82	82	
5	CIVIL STRUCTURAL, BUILDING &AIR CONDITIONING			242	242	
	SUB TOTAL(5)			242	242	
	SUB TOTAL-DIRECT COST	19	1021	824	1864	
6	INDIRECT COSTS					
6.1	CUSTOM DUTY	4			4	
6.2	PORT HANDLING & INLAND FRIEGHT	0	39		39	
6.3	EXCISE DUTY & VAT(CST)		133		133	
6.4	WORKS CONTRACT TAX			18	18	
6.5	INSURANCE		9		9	
	SUB TOTAL INDIRECT COST	4	181	18	203	
	TOTAL COST	23	1202	842	2067	

MOUNDED BULLETS-RECEIPT STATION

Sl No	DESCRIPTION	ALL COST IN Rs.LAKHS				
		Foreign currency EQV.INR	Indian Currency Ic	Sc	Total	
1	STORAGE UNITS					
1.1	4 BULLETS INCLUDING DESIGN,FABRICATION,ERRECTION &HYDROTESTING			2790	2790	
1.2	PLATES(3100MT)		2015		2015	

1.3	COST OF CP STATION		-			
1.4	INSTRUMENTATION ON 8 BULLETS		250		250	
	SUB TOTAL(1)		2265	2790	5055	
2	BULK MATERIALS	INCLUDED SEPARATELY				
2.1	PIPES		-		-	
2.2	ELECTRICAL		-		-	
2.3	INSTRUMENTATION				-	
2.4	VALVES		-		-	
2.5	PLATES					
	SUB TOTAL(2)		-	-	-	
3	SPARES	0	0		0	
	SUB TOTAL(3)	0	0		0	
4	ERRECTION	INCLUDED IN CLAUSE(1)				
4.1	MECHANICAL					
4.2	ELECTRICAL					
4.3	INSTRUMENTATION					
	SUB TOTAL (4)			0	0	
5	CIVIL STRUCTURAL, BUILDING &AIR CONDITIONING			2300	2300	
	SUB TOTAL(5)			2300	2300	
	SUB TOTAL-DIRECT COST	0	2265	5090	7355	
6	INDIRECT COSTS					
6.1	CUSTOM DUTY					
6.2	PORT HANDLING & INLAND				0	
	FRIEGHT				0	
6.3	EXCISE DUTY & VAT(CST)		255		255	
6.4	WORKS CONTRACT TAX			210	210	
6.5	INSURANCE		37		37	
	SUB TOTAL INDIRECT COST		292	210	502	
	TOTAL COST	0	2557	5300	7857	

PLANT & MACHINARY-DISPATCH STATION(JETTY)						
Sl No	DESCRIPTION	ALL COST IN Rs.LAKHS				
		Foreign currency EQV.INR	Indian Currency Ic	Sc	Total	
1	EQUIPMENT/SYSTEM/UNITS					
1.1	MARINE LOADING ARM	630			630	
1.2	SCRAPPER LAUNCHER(12")		14		14	
1.3	BASKET FILTERS(12"x2)		29		29	
1.4	MERCEPTAN DOZING		30		30	
1.5	CI DOZING SKID		25		25	
1.6	CORROSION MONITORING	14			14	
1.7	BLENDING SKID	379			379	
1.8	COMPRESSOR PAKAGES		60		60	
	SUB TOTAL(1)	1023	158	0	1181	
2	BULK MATERIALS					
2.1	PIPING		6		6	
2.2	ELECTRICAL		90		90	
2.3	INSTRUMENTATION		170		170	
2.4	VALVES	0	191		191	
	SUB TOTAL(2)	0	458	0	458	
3	SPARES	51	31		82	
	SUB TOTAL(3)	51	31		82	
4	ERRECTION					
4.1	MECHANICAL			30	30	
4.2	ELECTRICAL			22	22	
4.3	INSTRUMENTATION			8	8	
	SUB TOTAL (4)			60	60	
5	CIVIL STRUCTURAL, BUILDING &AIR CONDITIONING			23	23	
	SUB TOTAL(5)			23	23	
	SUB TOTAL-DIRECT COST	1074	647	83	1803	

6	INDIRECT COSTS					
6.1	CUSTOM DUTY	189	0		189	
6.2	PORT HANDLING & INLAND	61	21		82	
	FRIEGHT		81			
6.3	EXCISE DUTY & VAT(CST)				81	
6.4	WORKS CONTRACT TAX			3	3	
6.5	INSURANCE	5	9		14	
	SUB TOTAL INDIRECT COST	255	111	3	369	
	TOTAL COST	1329	758	86	2172	

ANNUAL OPERATING COST AT 100% CAPACITY									
Sl No	DESCRIPTION	QTY	KW	KW HR(PA)	UNIT RATE(Rs/KwHr)		ALL COST ARE IN Rs.LAKHS		
				IN 10^5		Ic		Ic	TOTAL
(A)VARIBLE OPERATING COST									
1	POWER								
1.1	IBPS BOOSTER PUMP	2	1060	76		6		456	456
1.2	PLANT LOADING PUMP	1	90	6		6		36	36
1.3	JETTY RENTAL 4KM(6 LAKHS PER KM)							24	24
SUB TOTAL OF POWER			1150					516	516

COST							
TOTAL VARIABLE OPERATING COST(A)						516	516
(B)FIXED OPERATING COST							
1	SALARY AND WAGES	NDS/ STN		RsLAKHS/ PA			
	OFFICER	4		20		80	80
	CLERICAL STAFF	2		8		16	16
	LABOUR STAFF	18		5		90	90
SUB TOTAL OF SALARY &WAGES		24				186	186
3	REPAIR & MAINTENANCE						
3.1	PIPELINE	@1% OF TOTAL INSTALLED COST OF PIPELINE			1% OF 7554	76	76
3.2	STATIONS(DESPATCH+RECEIPT)	@3% OF TOTAL INSTALLED OF STATIONS			3% OF 6053	182	182
SUB TOTAL OF REPAIR AND MAINTENANCE						257	257
4	ADMIN EXPENCES	50% OF SALARY AND WAGES				93	93
SUB TOTAL OF ADMIN EXPENCES						93	93
5	INSURANCE	@0.15%OF(PIPELINE+STATIONS)			0.15% OF 13607.35	20	20
	SUB TOTAL OF INSURANCE					20	20
	TOTAL FIXED OPERATING COST					557	557
	TOTAL COST					1073	1073

13.0 CALCULATION:

Diameter of the pipeline =16" (400mm) = D

Grade of the pipeline: X70

Wall thickness of the pipeline =8.1mm = t

Length of the pipeline = 100Km=L

Price of steel plate =Rs5040/ton (As per March 2011)

Volume of the steel used $= \pi \times D \times t \times L$

$=3.141 \times 400 \times 8.1 \times 100$

$=10173.6 \times 10^5\ m^3$

$= 10173.6 \times 10^5 kg$

$=10173.6 \times 10^2$ ton

Price of the steel used $=10173.6 \times 10^2 \times 5040$

= Rs512.74944 Cr

Grade of the pipeline:X80

Wall thickness of the pipeline =7.1mm = t

Length of the pipeline = 100Km=L

Price of steel plate = Rs5040/ton (As per March 2011)

Volume of the steel used $= \pi \times D \times t \times L$

$=3.141 \times 400 \times 7.1 \times 100$

$=8917.6 \times 10^5\ m^3$

$= 8917.6 \times 10^5 kg$

$=8917.6 \times 10^2$ ton

Price of the steel used $=8917.6 \times 10^2 \times 5040$

=Rs449.447Cr

Reduction in the steel cost =512.74944 -449.447

=Rs63.302 Cr

Reduction in weight = 12%

Laying cost = Rs881lacs per km

Total laying cost =Rs881 Cr per 100 km

Reduction in laying cost = Rs105.72Cr (Weight has reduced 12%)

Reduction in transportation and welding cost= 1 lakh per 1Cr budget

14.0 CONCLUSION & FUTURE SCOPE:

As we proceeded through the project, we concluded that the use of X80 will give abundance amount of profit to the project. The main thing we have to take care is to know the mitigation of the risk and the awareness of the X80 line pipe material. If we go for a long term project and we will use X80, it will create a new generation in the pipeline industry. The case studies we have discussed clearly indicates that if the existence of X80 is possible with excellent output outside India then there is no reason that it will be implemented in India. With proper accessories, proper welding methods and welding electrodes, we can set X80 as a future line pipe material.

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