"PIPELINE PROJECT MANAGEMENT"

A thesis submitted in partial fulfilment of the requirements for the
Degree of
Master of Technology
(Pipeline Engineering)

By

DEEPAK KUMAR JAISWAL
R160207020

Under the guidance of

Mr.................................
College of Engineering
UPES, Dehradun

Mr Avinash Kansal
Manager In Charge
HPCL
Ajmer

College of Engineering
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Approved

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Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2009

CERTIFICATE

UPES Guide has ascertained quality of the project – II, Anti Plag certification etc for asserting this high quality academic activity.

Signature..
Name ....P. K. BAHL..................
Pipeline Engineering
UPES Dehradun

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(भारत सरकार का उपक्रम) रजिस्टर्ड ऑफिस 17, जमशेदजी टाटा रोड, मुंबई – 400 020
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CERTIFICATE

This is to certify that the dissertation report titled " **Pipeline Project Managment** " is being submitted by **Mr. Deepak Kumar Jaiswal** , in partial fulfillment of the requirements for the award of the degree of MASTER OF TECHNOLOGY (Pipeline Engineering) of U.P.E.S. Dehradun. This is a bonafide record of the work carried out by him under our guidance and supervision. Further certified that this work has not been submitted for the award of any other degree or diploma.

Date 20/04/2009

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" Acknowledgement the kindness you receive

On your way up.

It is ironical that you meet the some people

On your way down."

I take this opportunity to express sense of gratitude and respect to all those who helped me throughout the duration of my training period.

I am very much thankful to almighty GOD that has given me the opportunity to stand here. I am also thankful to my respected teachers and parents for their support, without their cooperation this training not has been possible.

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I also don't want to miss the opportunity to express my thanks to **Er. Shailesh Kumar Singh** Operation Officer, **Er.R.K.Meena** Ex.Operation Officer, **Er.Ravi Kumar** Ex.Operation Officer, **Er.Nirmal Sharma** Operation Officer.

DEEPAK KUMAR JAISWAL

"PIPELINE PROJECT MANAGEMENT"

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ABSTRACT

A cross-country pipeline construction project is exposed to an uncertain environment due to its enormous size (physical, manpower requirement and financial value), complexity in design technology and involvement of external factors. These uncertainties can lead to several changes in project scope during the process of project execution. Unless the changes are properly controlled, the time, cost and quality goals of the project may never be achieved. A methodology is proposed for project control through risk analysis, contingency allocation and hierarchical planning models. Risk analysis is carried out through the analytic hierarchy process (AHP) due to the subjective nature of risks in construction projects. The results of risk analysis are used to determine the logical contingency for project control with the application of probability theory. Ultimate project control is carried out by hierarchical planning model which enables decision makers to take vital decisions during the changing environment of the construction period. Goal programming (GP), a multiple criteria decision-making technique, is proposed for model formulation because of its flexibility and priority-base structure. The project is planned hierarchically in three levels—project, work package and activity. GP is applied separately at each level. Decision variables of each model are different planning parameters of the project. In this study, models are formulated from the owner's perspective and its effectiveness in project control is demonstrated.

Keywords: project planning; project control; goal programming; pipeline construction.

COMPANY INTRODUCTION

MUNDRA-DELHI PIPELINE OVERVIEW:

M/S Hindustan Petroleum Corporation Limited (HPCL) has laid cross country multi-product pipeline from Mundra sea port location on west coast of Gujarat to Bahadurgarh in Haryana near Delhi crossing three states viz. Gujarat, Rajasthan and Haryana for transporting petroleum products from Mumbai refinery to northern India.

The petroleum products from the Mundra port is pumped through three 24 inch pipeline each dedicated for Motor spirit, High speed diesel and Superior Kerosene oil.

Mundra dispatch stations will ensure the supply of the products at normal operating conditions. The dispatch station (Mundra) shall make all necessary arrangements for the product dispatch and ensure proper lining up of the system in conjunction with receipt terminals.

Dispatch station at Mundra and Bahadurgarh (excluding marketing & storage Tanks at all Locations).

Cross-country main pipeline between Mundra Dispatch station and Bahadurgarh Receipt station.

Tap-in provision on Mundra-Palanpur pipeline section at Chasra for future connection from petronet's Vadinar-Kandla pipeline (PVKPL).

Cross country dedicated pipelines for ULMS,ULSHSD, and SKO Mundra to Bahadurgarh Receipt station.

Tap-off station at Palanpur, Ajmer, Jaipur, Rewari, Receipt station at Bahadurgarh.

Intermediate Booster pumping stations at Santalpur & Awa apart from Booster / pumping station at Mundra, Palanpur, Ajmer,Jaipur.

The pipeline facilities also include the Pump station, intermediate Pigging Stations, Sectionalizing Valves Stations, ect.

Corrosion Inhibitor dosing tank and pump is provided at all pumping station for dosing the corrosion inhibitor for pipeline internal corrosion protection. CP station is approximately located at 30 km along pipeline for pipeline external corrosion protection.

MDPL SPECIFIC CHARACTERISTICS :

Capacity: 5 MMTPA

Length:

Main pipeline Mundra to Bahadurgarh is 1048.6 km.

Three pipelines from Adani port to HPCL terminal is of 6.5 km.

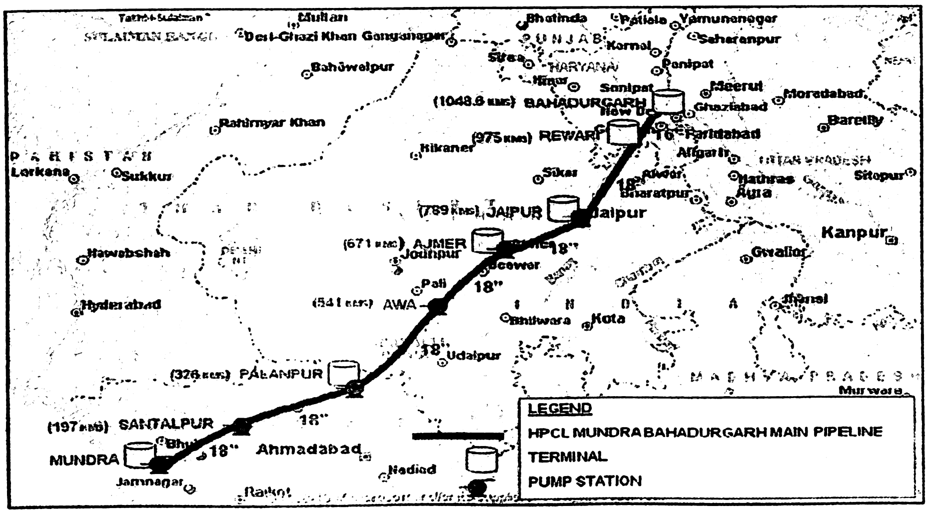
Line size (OD) and thickness:

Main pipeline from Mundra to Rewari is 18 inch, and from Rewari to Bahadurgarh is 16 inch.

Wall thickness 7.4 -7.8 mm.

Pipeline from Adani port to HPCL Mundra terminal is 24 inch.

MUNDRA BAHADURGARH MAIN PIPELINE



Transporting Products:

Motor Spirit (MS), Ultra low sulphur Motor spirit (ULSMS), Ultra low sulphur high speed diesel (ULSHSD), High speed diesel (HSD), Superior Kerosene oil (SKO).

Pipe material & Grade: Material: Carbon steel

Grade : API 5L X65, Grade B

Right of way: 20m

Pipeline design basis: ASME B31.4 & OISD -141

Methods of crossing:

Rail, NH, SH, major Road & lined canals by horizontal boring.

Road, canals & non-perennial rivers by open cut.

As per API 1102

CP & SV station:

32 cathodic protection (CP) stations at a distance of approximately 30 Km interval and 34 sectionalizing valves (SV) along pipeline.

1.PIPELINE PROJECT CONTROL

1.1 PROJECT MANAGEMENT :-

"A project is any undertaking with a defined starting point and defined objectives by which completion is identified. In practice, most projects depend on finite or limited resources by which the objectives are to be accomplished."

Project management is the art of directing and coordinating human and material resources through out the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, quality and participant satisfaction.

1.2 PIPELINE PROJECT MANAGEMENT:-

The length of an onshore cross country pipeline system may range between a few Kms to a 1000 Kms or more. Since a pipeline project is not confined to a particular site and spans cross country, the execution of a pipeline project becomes complex.

A cross country pipeline project involves procurement of line pipes, pumps, valves, Pig launchers & receivers, OFC, Density Meters, Turbine Meters, SCADA & APPS, HV/MV system package, Basket Filters etc. and pipeline coating works, pipeline laying works, construction of pumping stations, civil structural & mechanical works, telecom, instrumentation works etc. ROU needs to be acquired before the pipeline laying work can commence. Lands for pumping stations need to be acquired before station works could commence. Statutory approvals namely MOEF (Ministry of Environment & Forests) & PESO (Petroleum & Explosives Safety Organisation) to be obtained before actual works can commence. Surveys, Engineering studies and Environmental Impact Assessment & Risk Analysis studies are required to be carried for approval of the project by management and statutory bodies.
Hence a careful planning and effective control is required to complete a pipeline project successfully within the project schedule and cost.

2.PROJECT CONTROL CYCLE :-

The four sequential phases in time through which any project passes are namely: **Concept**; **Development**; **Execution** (implementation or operation); and **Finishing** (termination or close out).

The basic cycle of a project management control represented by **"C – D – E - F"** is presented in the figure below:

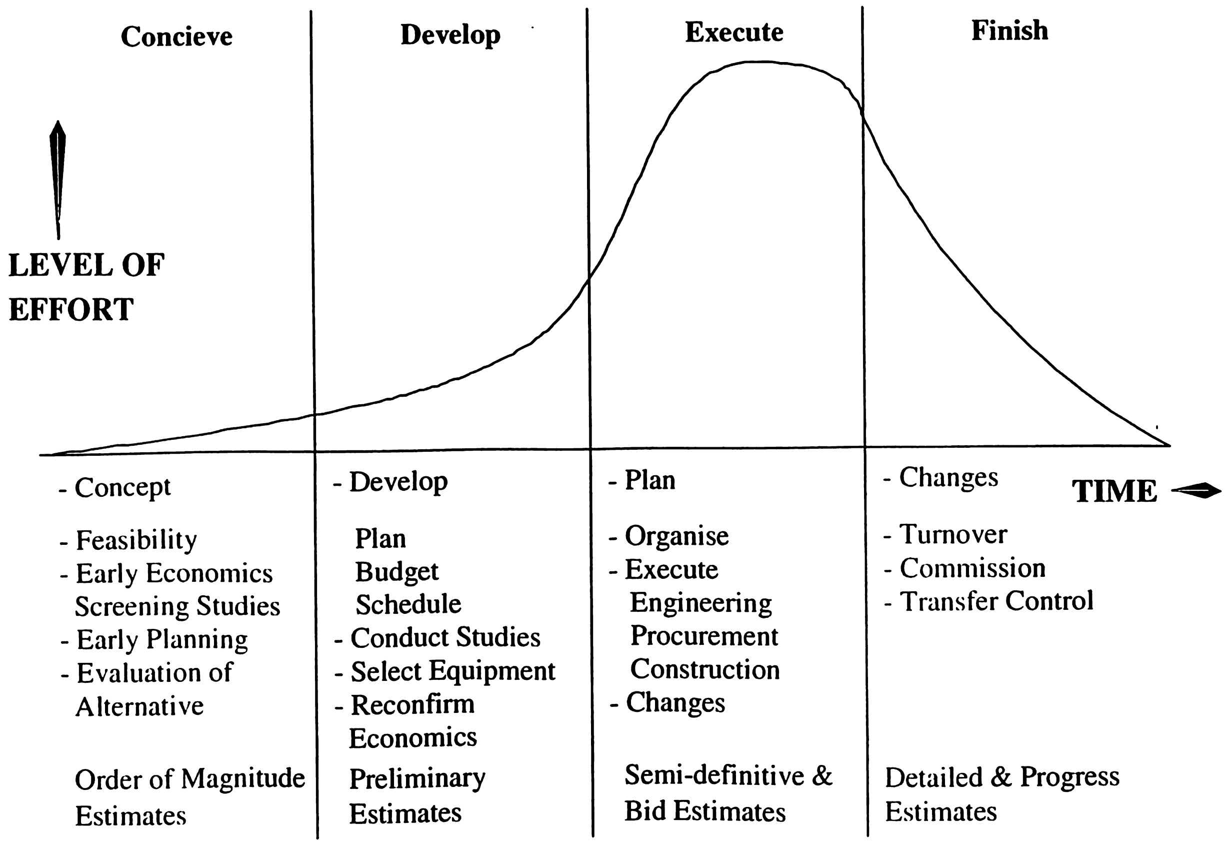


Fig.1 Dynamics of the Project Life Cycle

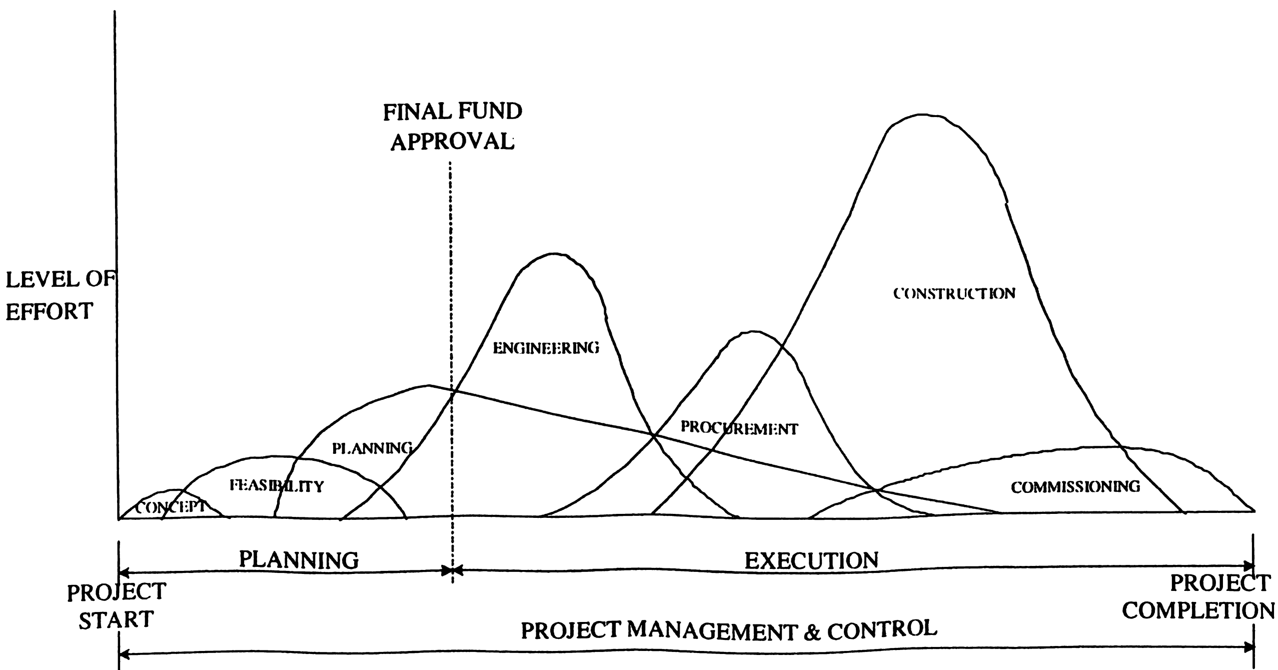


Fig.2 Project Management & control

During the Concept Phase, a need for the project is identified and the feasibility of the project is determined based on the Pre-Feasibility Studies. Alternatives are recognized and choices are made. Budgets, schedules and financing are established. Conceptual types of estimates form the basis for decisions regarding the capital cost of the project.

The level of effort increases during the **Development Phase**. Detailed Feasibility Study, Environmental studies and Financial Studies are carried out. The project execution plan is developed and the economics of a project are reconfirmed. Preliminary estimates used to develop the scope of the project, budgets and schedules are developed and the cash flow forecasted.

The project is planned with respect to scope, quality, time and cost. Project planning is the development of logical sequence for performing the work. Normally these sequences are shown with the help of pert schedules. Planning requires a total project concept, quantities or work, mobilisation details and duration estimates for various activities. The project schedule indicates the time frame in which slot the various activities are to be performed to complete the project within the schedule. Without a detailed plan, there is no baseline for comparison, no determination of deviation, and hence no satisfactory basis for corrective action during Execution Phase.

Project team is identified and the responsibilities and authorities for each team member for the project activities (e.g. estimating, design, planning, procurement, construction) are defined.

The **Execution Phase** requires a further level of effort and a considerable proportion of the Capital expenditure. The bulk of the engineering, procurement and construction effort is carried out.

Effective project execution requires efficient management of Design Consultants, Procurement and Contract Administration, Construction and Quality Control. It is important for the project manager and other members of the project team to understand the basic needs of human beings, their strengths and weaknesses, mental and social abilities, and how to weld a complex mixture of humans into a dynamic and productive team. One of the most important characteristic of a successful project is the project manager's ability to manage people.

Continued monitoring, reporting and forecasting must take place during project implementation, and the forecasts compared to the Plan. Deviations must immediately receive management attention, either by reallocation of resources or modifications to the Plan.

During the **Finish Phase**, transfer of control and responsibility passes from the contractor/ consultant to the owner. Startup / commissioning as well as training of personnel takes place and the economics of the project are finalized.

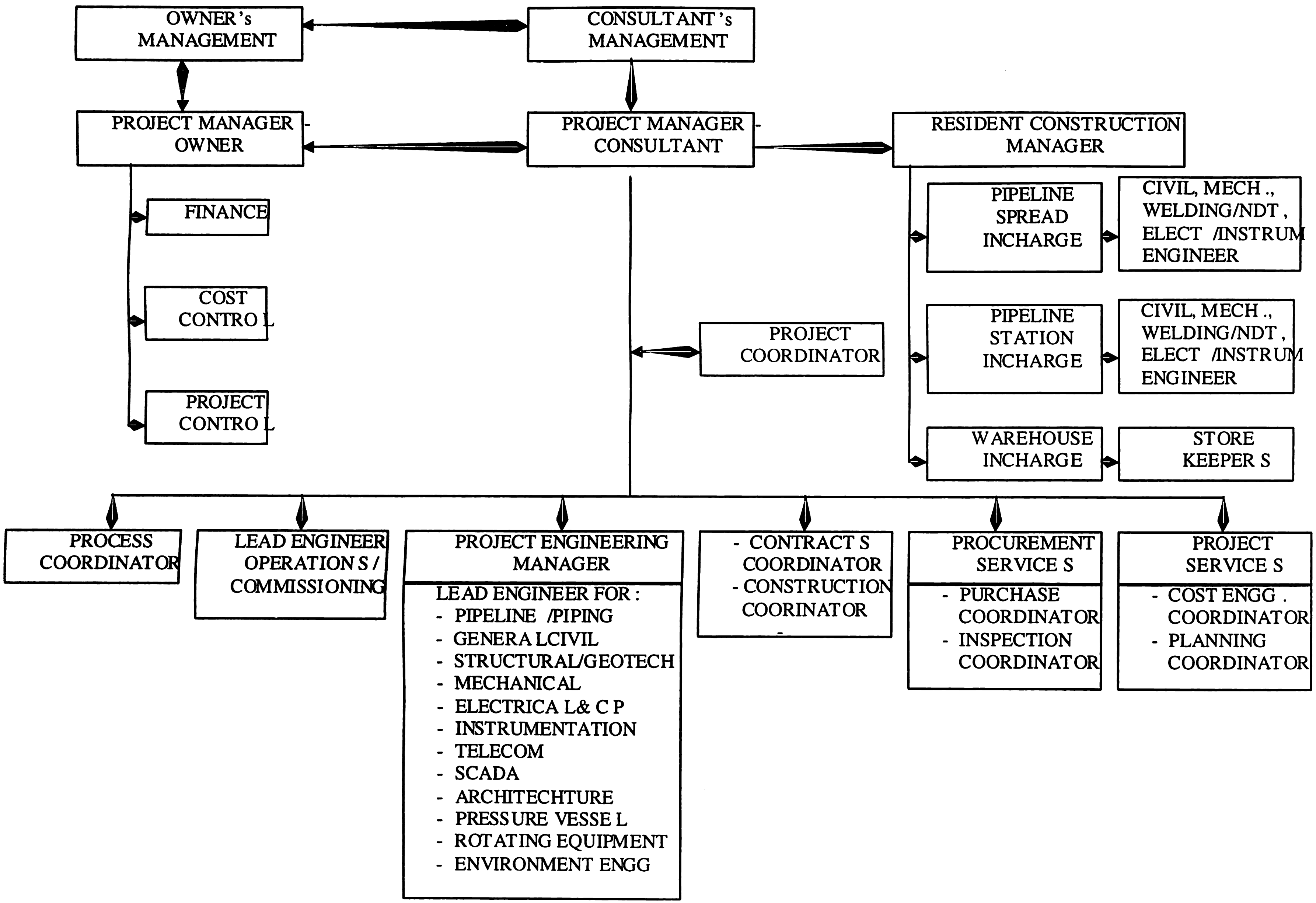


Table2. **TYPICAL PROJECT MANAGEMENT TEAM**

2.1 PROJECT PLANNING AND SCHEDULING

The project planning process consists of the following:

- Setting the project start date .
- Setting the project completion date/
- Selecting the project methodology or project life cycle to be used.
- Determining the scope of the project in terms of the phases of the selected project methodology or project life cycle .
- Identifying or selecting the project review methods to be used.
- Identifying any predetermined interim milestone or other critical dates which must be met.
- Listing tasks, by project phase, in the order in which they might be accomplished.
- Estimating the personnel necessary to accomplish each task.
- Estimating the personnel available to accomplish each task .
- Determining skill level necessary to perform each task.
- Determining task dependencies
  - Which tasks can be done in parallel
  - Which tasks require the completion of other tasks before they can start.
- Project control or review points Performing project cost estimation and cost-benefit analysis.

2.3 WORK BREAKDOWN STRUCTURES :-

The development of a project plan is based on having a clear and detailed understanding of both the tasks involved, the estimated length of time each task will take, the dependencies between those tasks, and the sequence in which those tasks have to be performed.

The method used to develop the list of tasks is to create a work breakdown structure. A ***work breakdown structure*** (WBS) is a hierarchic decomposition or breakdown of a project or major activity into successive levels, in which each level is a finer breakdown of the preceding one. In final form, a WBS is very similar in structure and layout to a document outline. Each item at a specific level of a WBS is numbered consecutively (e.g., 10, 10, 30, 40, 50). Each item at the next level is numbered within the number of its parent item (e.g., 10.1, 10.2, 10.3, 10.4). The WBS may be drawn in a diagrammatic form or in a chart resembling an outline.

The WBS begins with a single overall task representing the totality of work to be performed on the project. This becomes the name of the project plan WBS. Using a methodology or system life cycle (analysis, design and implementation) steps as a guide, the project is divided into its major steps. The first phase is project initiation; the second major phase is analysis, followed by design, construction, testing, implementation, and post-implementation follow-up. Each of these phases must be broken in their next level of detail, and each of those, into still finer levels of detail, until a manageable task size is arrived at. A ***manageable task*** is one in which the expected results can be easily identified; success, failure, or completion of the task can be easily ascertained; the time to complete the task can be easily estimated and the resource requirements of the task can be easily determined. A typical WBS for a pipeline project during Construction Phase is given below.

WBS number	Task Description
10.0	ROU Clearance
10.1	3(1) notifications
10.2	Objection hearings
10.3	6(1) notifications
20.0	ROU Dosing / Grading
30.0	Trenching
40.0	Stringing of Coated pipes on the ROU
40.1	Transportation
40.2	Stringing
50.0	Welding & NDT
60.0	Field joint coating
70.0	Lowering
80.0	Backfilling
90.0	Clearing
100.0	ROU restoration

Table.3

2.3 DEFINING PRECEDENCE RELATIONSHIPS AMONG ACTIVITIES :-

Once work breakdown structure has been defined, the relationships among the activities can be specified. *Precedence* relations between activities signify that the activities must take place in a particular sequence. Numerous natural sequences exist for construction activities due to requirements for structural integrity, regulations, and other technical requirements. For example, design drawings cannot be checked before they are drawn. Diagrammatically, precedence relationships can be illustrated by a *network* or *graph* in which the activities are represented by arrows. The arrows are called *branches* or *links* in the *activity network,* while the circles marking the beginning or end of each arrow are called *nodes* or *events.* Given below a figure illustrating typical set of activities with precedence at a pipeline project site:

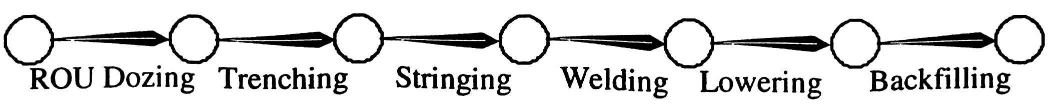


Fig.3 Activities at a pipeline project

3.0 FUNDAMENTAL SCHEDULING PROCEDURES :-

Project scheduling is used to assign dates to project activities and match the resources of equipment, materials and labor with project work tasks over time. Good scheduling can eliminate problems due to production bottlenecks, facilitate the timely procurement of necessary materials and ensure the completion of a project as soon as possible.

The actual work performed is compared to the schedule to determine if construction is proceeding satisfactorily. Suitable measures are adopted if the actual work at site is lagging behind the schedule to bring the project on track. After the completion of construction, comparisons between the planned schedule and the actual accomplishments may be performed to allocate the liability for project delays due to negligence on the part of contractor or changes requested by the owner or other unforeseen circumstances.

Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) are two closely related techniques for scheduling and monitoring the progress of a large project. A key part of PERT/CPM is to calculate the critical path. That is, identifying the subset of the activities that must be performed exactly as planned in order for the project to finish on time.

Scheduling and monitoring of project is done by using Scheduling & Monitoring softwares like Primavera, Microsoft Project etc. The fundamentals of scheduling methods are discussed below:

3.1 THE CRITICAL PATH METHOD :-

The most widely used scheduling technique is the **critical path method (CPM)** for scheduling, often referred to as *critical path scheduling*. This method calculates the minimum completion time for a project along with the possible start and finish times for the project activities.

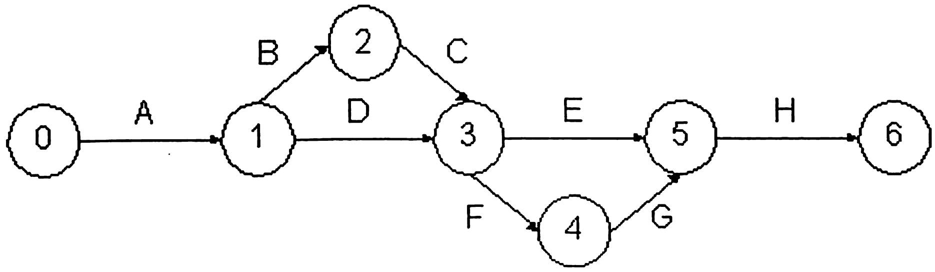
The ***critical path*** represents the set or sequence of predecessor/successor activities which will take the longest time to complete. The duration of the critical path is the sum of the activities' durations along the path. Thus, **the critical path can be defined as the longest possible path through the "network" of project activities. The duration of the critical path represents the minimum time required to complete a project**. Any delays along the critical path would imply that additional time would be required to complete the project.

There may be more than one critical path among all the project activities, so completion of the entire project could be delayed by delaying activities along any one of the critical paths.

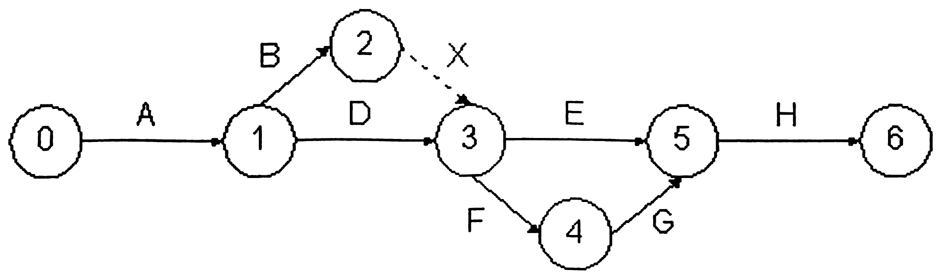
Critical path scheduling assumes that a project has been divided into activities of fixed duration and well defined predecessor relationships. A predecessor relationship implies that one activity must come before another in the schedule.

In critical path scheduling, a ***resource constraint*** is represented by a precedence relation. A ***constraint*** is simply a restriction on the options available to a manager, and a ***resource constraint*** is a constraint deriving from the limited availability of some resource of equipment, material, space or labor.

Dummy activities may be introduced for the purposes of providing unique activity designations and maintaining the correct sequence of activities. A ***dummy activity*** is assumed to have no time duration and can be graphically represented by a dashed line in a network. In figure given below, the elimination of activity C would mean that both activities B and D would be identified as being between nodes 1 and 3. However, if a dummy activity X is introduced, the unique designations for activity B (node 1 to 2) and D (node 1 to 3) will be preserved.



(a)



(b)

Fig.4 (a & b) Dummy Activies

3.1.1 Activity Float and Schedules :-

A number of different activity schedules can be developed from the critical path scheduling. An ***earliest time*** schedule would be developed by starting each activity as soon as possible. Similarly, a ***latest time*** schedule would delay the start of each activity as long as possible but still finish the project in the minimum possible time.

Activities that have different early and late start times can be scheduled to start anytime between earliest time schedule & latest time schedule. The concept of ***float*** is to use part or all of this allowable range to schedule an activity without delaying the completion of the project. An activity that has the earliest time for its predecessor and successor nodes differing by more than its duration possesses a window in which it can be scheduled.

Float is a very valuable concept since it represents the scheduling flexibility or "maneuvering room" available to complete particular tasks. Activities on the critical path do not provide any flexibility for scheduling nor leeway in case of problems. For activities with some float, the actual starting time might be chosen to balance work loads over time, to correspond with material deliveries, or to improve the project's cash flow.

3.2 PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT) :-

Program evaluation and review technique (PERT) charts depict task, duration, and dependency information. Each chart starts with an initiation node from which the first task, or tasks, originates. If multiple tasks begin at the same time, they are all started from the node or branch, or fork out from the starting point. Each task is represented by a line which states its name or other identifier, its duration, the number of people assigned to it, and in some cases the initials of the personnel assigned. The other end of the task line is terminated by another node which identifies the start of another task, or the beginning of any slack time, that is, waiting time between tasks.

Each task is connected to its successor tasks in this manner forming a network of nodes and connecting lines. The chart is complete when all final tasks come together at the completion node. When slack time exists between the end of one task and the start of another, the usual method is to draw a broken or dotted line between the end of the first task and the start of the next dependent task.

A PERT chart may have multiple parallel or interconnecting networks of tasks. If the scheduled project has milestones, checkpoints, or review points (all of which are highly recommended in any project schedule), the PERT chart will note that all tasks up to that point terminate at the review node.

3.2.1 GANTT CHART :-

A Gantt chart is a matrix which lists on the vertical axis all the tasks to be performed. Each row contains a single task identification which usually consists of a number and name. The horizontal axis is headed by columns indicating estimated task duration, skill level needed to perform the task, and the name of the person assigned to the task, followed by one column for each period in the project's duration. Each period may be expressed in hours, days, weeks, months, and other time units. In some cases it may be necessary to label the period columns as period 1, period 2, and so on.

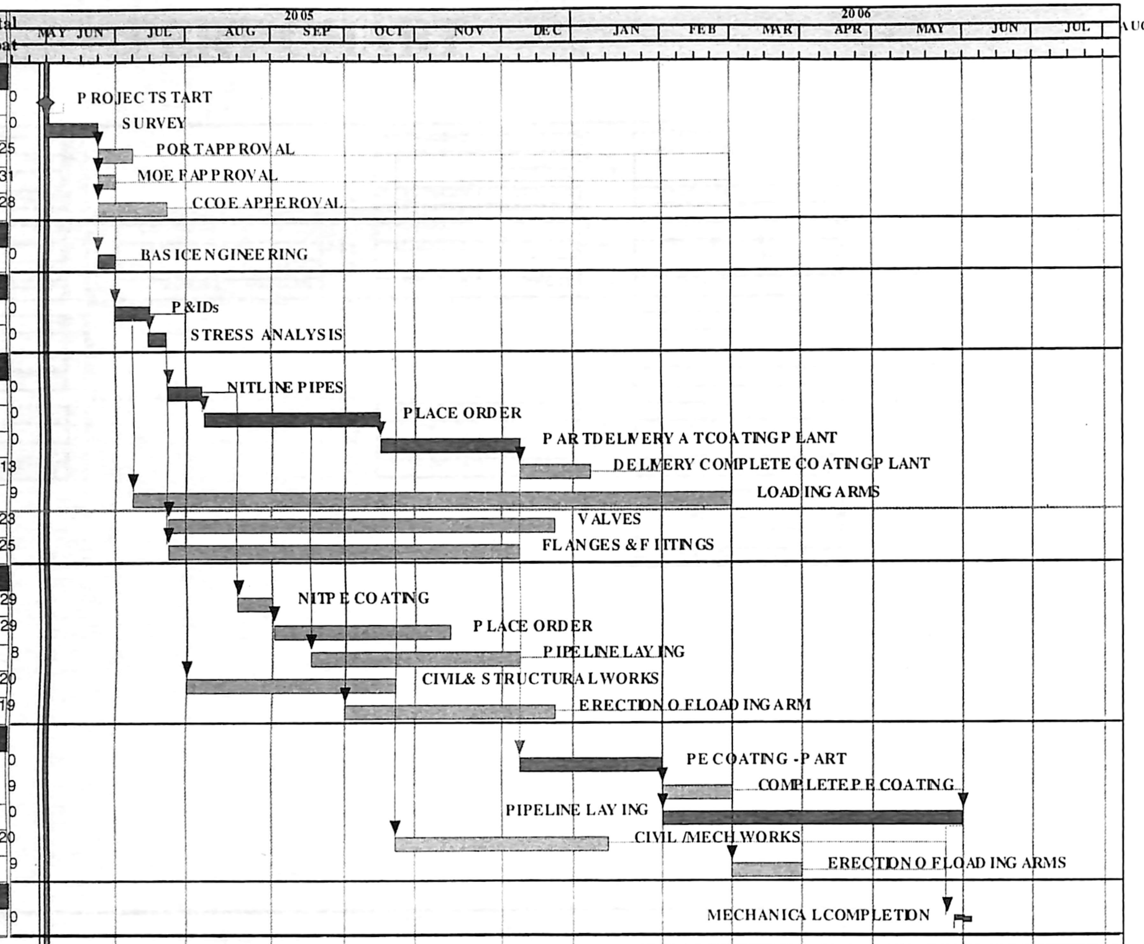
The graphics portion of the Gantt chart consists of a horizontal bar for each task connecting the period start and period ending columns. A set of markers is usually used to indicate estimated and actual start and end. Each bar on a separate line, and the name of each person assigned to the task is on a separate line. In many cases when this type of project plan is used, a blank row is left between tasks. When the project is under way, this row is used to indicate progress, indicated by a second bar which starts in the period column when the task is actually started and continues until the task is actually completed. Comparison between estimated start and end and actual start and end should indicate project status on a task-by-task basis.

Gantt & Pert Charts created in Primavera for a dummy pipeline project are given below. This pipeline project is scheduled to be completed in 1 year. The project start date is 1st June, 05 and the project must finish by 30th May, 2006. The activities that are critical are shown in red colour and activities that have float are shown in green colour.

Cross Country Petroleum Pipelines *Pipeline Project Control*

GANTT CHART

Activity ID	Orig Dur	Early Start	Early Finish	Late Start	Late Finish	Total Float
PRE PROJECT ACTIVITIES						
PP000010	0	01JUN05		01JUN05		0
PP010010	3	01JUN05	21JUN05	01JUN05	21JUN05	0
PP020010	3	22JUN05	05JUL05	14DEC05	27DEC05	25
PP020020	5	22JUN05	28JUN05	25JAN06	31JAN06	31
PP020030	4	22JUN05	19JUL05	04JAN06	31JAN06	28
BASIC ENGINEERING						
BE140010	1	22JUN05	28JUN05	22JUN05	28JUN05	0
DETAILED ENGINEERING						
DE030010	2	29JUN05	12JUL05	29JUN05	12JUL05	0
DE040010	1	13JUL05	19JUL05	13JUL05	19JUL05	0
PROCUREMENT						
PR050010	2	20JUL05	02AUG05	20JUL05	02AUG05	0
PR050020	10	03AUG05	11OCT05	03AUG05	11OCT05	0
PR050030	8	12OCT05	06DEC05	12OCT05	06DEC05	0
PR050040	4	07DEC05	03JAN06	08MAR06	04APR06	13
PR060010	34	06JUL05	28FEB06	07SEP05	02MAY06	9
PR070010	22	20JUL05	20DEC05	28DEC05	30MAY06	23
PR080010	20	20JUL05	06DEC05	11JAN06	30MAY06	25
TENDERING						
TT090010	2	17AUG05	30AUG05	08MAR06	21MAR06	29
TT090020	10	31AUG05	08NOV05	22MAR06	30MAY06	29
TT100010	12	14SEP05	06DEC05	09NOV05	31JAN06	8
TT110010	12	27JUL05	18OCT05	14DEC05	07MAR06	20
TT120010	12	28SEP05	20DEC05	08FEB06	02MAY06	19
CONSTRUCTION						
CC090010	8	07DEC05	31JAN06	07DEC05	31JAN06	0
CC090020	4	01FEB06	28FEB06	05APR06	02MAY06	9
CC100010	17	01FEB06	30MAY06	01FEB06	30MAY06	0
CC110010	12	19OCT05	10JAN06	08MAR06	30MAY06	20
CC120010	4	01MAR06	28MAR06	03MAY06	30MAY06	9
MECHANICAL COMPLETION						
ME130010	0		30MAY06		30MAY06	0



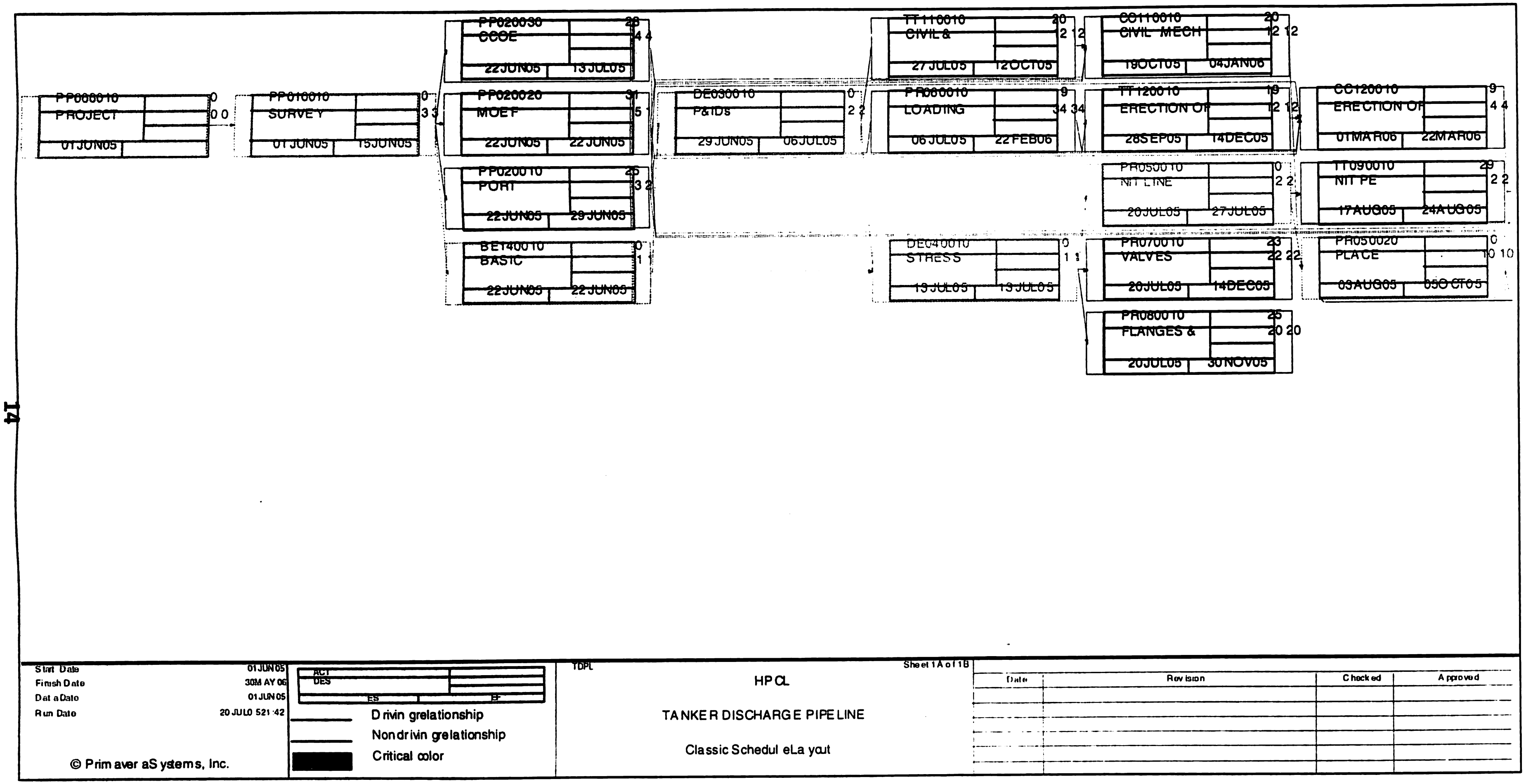
Start Date	01JUN05	Early Bar	TDPL
Finish Date	30MAY06	Progress Bar	HPCL
Data Date	01JUN05	Critical Activity	TANKER DISCHARGE PIPELINE
Run Date	19JUL05 21:19		Classic Schedule Layout

Sheet 1 of 1

Date	Revision	Checked	Approved

Based on the actual requirements of a pipeline project and its completion schedule, the activities and the critical nature of these activities will vary.

PERT CHART


PP000010
PROJECT
01JUN05
PP010010
SURVEY
01JUN05
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PP020030
CCOE
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MOEF
22JUN05
22JUN05
PP020010
PORT
22JUN05
29JUN05
BET40010
BASIC
22JUN05
22JUN05
DE030010
P&IDs
29JUN05
06JUL05
TT110010
CIVIL &
27JUL05
12OCT05
PR060010
LOADING
06JUL05
22FEB06
DE040010
STRESS
13JUL05
13JUL05
CC110010
CIVIL MECH
19OCT05
04JAN06
TT120010
ERECTION OF
28SEP05
14DEC05
PR050010
NIT LINE
20JUL05
27JUL05
PR070010
VALVES
20JUL05
14DEC05
PR080010
FLANGES &
20JUL05
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TANKER DISCHARGE PIPELINE
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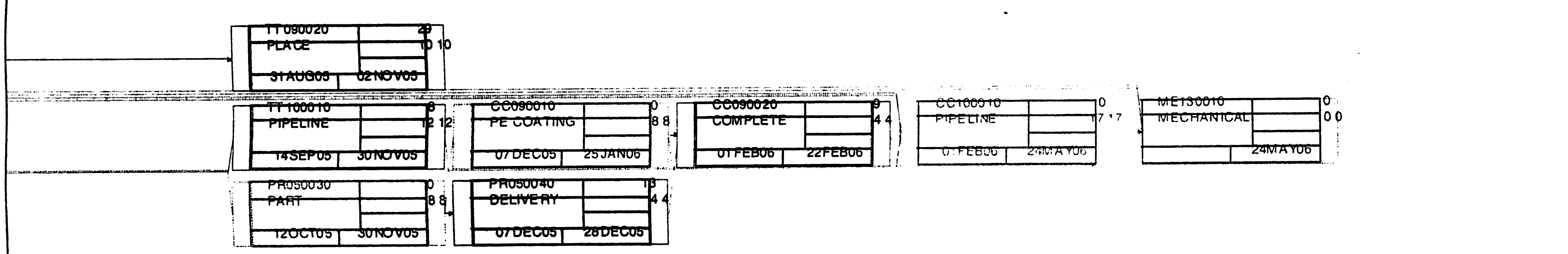

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Sheet 1B of 1B

HPCL

TANKER DISCHARGE PIPELINE

Classic Schedule Layout

Date	Revision	Checked	Approved

4.0 PROJECT MONITORING & CONTROL

4.1 MONITORING PHYSICAL PROGRESS OF THE PROJECT

Correct evaluation of project status with respect to planned progress depends primarily on the accuracy of measurement of progress. Progress should not only indicate the present state of work achievement, but also give a true indication of the time required for completion of the remaining work.

The basis measure for plotting planned progress and actual progress could be:

a) **The cost basis**

The method consists of first evaluating the value of job actually done. The percentage progress is then computed from the total contract value. However, the progress should be calculated from the amount billed and not from the amount paid since there is always a time lag between the actual payments and the progress of work.

b) **The quantum of work basis**

It is direct method of measurement of progress as it is the actual physical quantum of work which is taken for computation of progress. This method involves ascertaining the quantum of work done in some unit / units. The total quantum of work involved is calculated in the same unit / units.

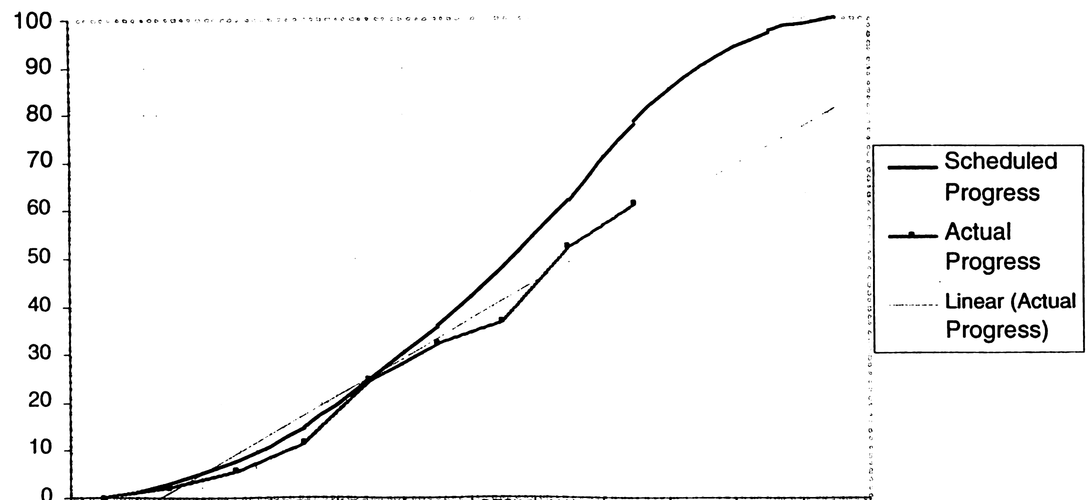
(c) **Man-hours basis**

It requires ascertaining the norms of productivity from past experience and data from similar projects elsewhere. Total requirement of man-hours for the work is first calculated from the drawings and bill of materials. Progress at a specific point of time is determined from the man-hours consumed vis-à-vis the total man-hours required. Precaution should, however be taken not to compute the progress from actual man-hours consumed. Instead man-hours, as calculated from the norms known as 'equivalent man-hours' should be used for computation, since actual consumption of man-hours will vary from place to place and from person to person depending upon the individual's skill level, working environments, motivation, etc.

4.2 Physical Progress "S" Curves

Planned progress curve is drawn on the basis of quantum of work involved and /or the deployment of resources as planned and / or cost basis. Actual progress curve is a plot of the actual progress information based on the same parameters used for plotting the Planned Progress Curves. The dotted portion of the curve is the trendline (based on linear extrapolation). The trendline reflects the anticipated completion based on the actual progress achieved at any given point of time and is suggestive of any changes required in the resource mobilization to progress as per schedule. Slippage at a point of time is determined by measuring the actual progress and then reading the time from the corresponding point in the planned progress curve. A typical actual progress v/s planned progress curve is shown in the figure below:

TANKER DISCHARGE PIPELINE
Actual Progress v/s Scheduled progress



	JUN'05	JUL'05	AUG'05	SEP'05	OCT'05	NOV'05	DEC'05	JAN'06	FEB'06	MAR'06	APR'06	MAY'06
Scheduled Progress	0.0	3.0	8.0	15.0	25.0	36.0	48.0	62.0	78.0	90.0	97.0	100.0
Actual Progress	0.0	2.2	5.6	11.6	24.8	32.4	36.8	52.4	61.2			

Months

Fig.5 Actual Progress v/s Scheduled Progress

It can be seen that after 9 months from the start of the project, the project is lagging by nearly 17% with respect to its scheduled progress and the trendline suggests that only 81% progress will be achieved by the scheduled completion date of May'06.

MONITORING FINANCIAL PROGRESS OF THE PROJECT

BUDGETING & ESTIMATING

At the earliest possible time, an acceptable project breakdown must be established, which properly reflects the best estimate of the work required to achieve the overall project objectives. This forms the basis for regular cost monitoring and reporting. The main Estimate Categories are given below:

A. Order of Magnitude Estimates

These are produced during the concept phase for screening studies, feasibility studies, choosing between alternatives, for budgeting and early economic evaluations of a Project. Approximate methods such as cost capacity curves, cost indices and cost capacity ratios are used. Because these are approximate methods

Cost Influence v/s Time :-

The ability to influence cost is directly related to the control of the project. The ability to influence costs is greater at the earlier stages of a project and diminishes with time. Expenditures during the early phases are comparatively small but the decisions made during the early period have a great influence on what later expenditures will be.

The early stages are the "on paper" stages which lend themselves to a value engineering approach. As expenditures and commitments increase with time the ability to influence costs lessens and changes become more difficult and costly to implement.

4.7 Cost Control During the Execution Phase :-

During the execution of any project, there are three broad areas that require control, namely:

Detail Engineering	- Working drawings, specifications, samples and prototypes
Procurement	- Contracts, supplies and services
Construction	- Site activities.

Cost control of quantities begins with accurate and complete material quantity take-offs. Deviations from estimated costs can be analysed using variance analysis to determine the cause. Material variances are due to quantity and price deviations.

Competitive bids from specialty vendors are generally solicited for the purchase of equipment. The selection and constant monitoring of vendors progress for a purchase is necessary in order to avoid delays in delivery, especially the last minute surprises. Most major pieces of equipment are on the critical path or near critical and any delays in delivery of these items will require a schedule change. These changes cause disruptions and extension in schedules, both of which are potentially costly.

Considering the financing of purchases, i.e.; the cash flow requirements and cost of money, 'just-in-time' technique of material supply is a common sense approach which requires astute and alert management. Many in the construction industry have experienced the situation where a piece of material of equipment is later or when the delivery of materials does not support the construction schedule. Often the technique used to overcome these potential material problems is that all required material be on site before starting a particular item of work. The "feedforward" approach is perhaps the insurance required to avoid construction delays. The sensitivity of a delay should be considered before postponing expenditures for deliveries that otherwise appear to be too early. The areas of cost control during the construction are direct labour and materials.

4.8 Reporting for Cost Control :-

For effective cost control, progress must be accurately measured and compared to the expected progress. The productivity or efficiency is determined by the "earned value concept". The three basic indicators are:

ACWP = Actual Cost of Work Performed
BCWP = Budgeted Cost of Work Performed
BCWS = Budgeted Cost of Work Scheduled

Credit is taken for completion of tasks within a package of work. The ACWP is determined and compared to the BCWP. Cost Variance (CV) and schedule variance (SV) analyses are now possible.

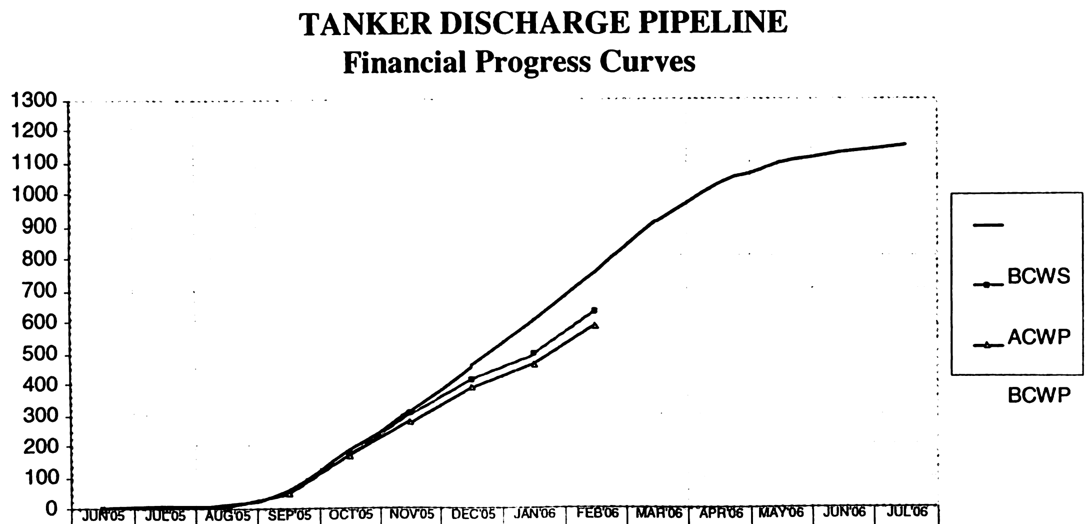
$$CV = BCWP - ACWP$$

A positive CV indicates an under run whereas negative CV indicates that the project or work package is over budget.

$$SV = BCWP - BCWS$$

A positive SV shows the project ahead of schedule; a negative SV means the project is behind schedule.

Financial "S" curves showing ACWP, BCWP and BCWS for the Tanker Discharge Pipeline project are shown in the graph given below. It can be seen that CV is negative, implying that the project has grown over budget. Further it can be seen that SV is also negative implying that the project is behind schedule.



	JUN'05	JUL'05	AUG'05	SEP'05	OCT'05	NOV'05	DEC'05	JAN'06	FEB'06	MAR'06	APR'06	MAY'06	JUN'06	JUL'06
BCWS	0.0	5.8	11.5	57.5	184.0	310.5	448.5	598.0	747.5	908.5	1023.5	1092.5	1127.0	1150.0
ACWP	0	0	9.2	50.6	169.05	297.85	409.4	487.6	623.3					
BCWP	0	0	9.2	49.45	164.45	270.25	381 8	456 55	577.3					

Months

Fig.7 Financial Progress Curve

Trends and Change Orders :-

Inevitably changes will occur on a project and the control of changes is a high priority for project management. There are two elements of cost resulting from changes. One is apparent, the other is unseen. The unseen impact is due to the lost time caused by stopping and starting an activity that requires change. Restarting usually requires relearning and therefore additional man-hours are consumed. The problem is aggravated further if more than one discipline or trade is involved.

Changes are also disruptive to supporting disciplines such as costing, scheduling and procurement. Changes require additional recycle of information and therefore the added probability of mistakes.

Hence a structured method to control change must be instituted; otherwise project control will be lost.

5.0 PIPELINE PROJECT EXECUTION :-

5.1 Management of Engineering & Project Management (EPM) Consultants :-

Management of EPM Consultant is a critical aspect in order to ensure project execution as per the time & cost schedule. This function ensures that the design, engineering and site work proceeds in a timely manner and that the output of this work is within the constraints of the project's scope and budget. The job may include:

- **Preparing a design brief outlining the project requirements to form the basis of consultant selection.**
- Including pre-qualification based on capability and staffing.
- Selection recommendations.
- Negotiating fee structures, terms of reference and responsibilities with the respect to the project ream.
- Award recommendations.
- Briefing, expediting and ensuring regulatory and user input coordination.
- Finalisation of the detailed project schedule and project curves for monitoring the project progress along with the consultant.
- Coordination and follow up with the EPM consultant for finalizing design basis, specifications, contracting strategies, tenders, evaluation of tenders and PO placement for procurement and works contracts.
- **Overseeing the site activities managed by the EPM consultant at stations and pipeline laying along the ROU.**
- **Monitoring and review of the progress and deployment of manpower on regular basis and expediting.**
- **Ensuring the mechanical completion of the project as per the approved design basis and project parameters.**

5.2 Quality Assurance and Control :-

Quality itself is the composite of materials attributes, including performance features and characteristics, of the product or service required to satisfy the need to meet project objectives.

A quality assurance program, therefore, identifies these objectives and establishes a strategy for organizing and coordination planned and systematic controls for maintaining established standards right from early design work through to commissioning.

A quality control program is necessary to exercise direct influence on results by the collection of specific technical data for analysis and decision as to acceptance or rejection.

5.3 Safety, Health and Environment:-

In a pipeline project, multifarious activities are involved during construction, erection, testing and commissioning and the men, materials and machines are the basic inputs. It is therefore required to properly plan and take the steps to ensure safety of the personnel, materials and machines and to minimize the impacts of occupational hazards on health of the personnel.

Since the pipeline project is not confined to any enclosed site and spans cross country, it becomes extremely important to study probable impacts of the project on the environment and prepare and follow an Environment Management plan.

5.4 Expediting :-

Expediting is essential to determine whether schedule objectives will be met and what corrective action will be necessary to protect against unexpected developments with regard to deliveries. This applies to all materials, equipment and services needed for the project, whether procured externally or provided internally by the owner.

5.5 Procurement :-

Procurement involves the systematic execution of procedures for purchasing all materials, equipment and services needed for the pipeline project, in good time and in a manner which is cost effective. This process includes:

- Establishing procurement criteria, methodology and procedures based on good commercial practice.
- Interaction with the project scheduling and budgeting activities.
- Pre-qualification of suppliers of goods and services, including sourcing, availability and market conditions.
- Establishing suitable standard documents for proposals, tender calls, contract general and special conditions, and purchase orders.
- Issue, receipt, assessment and recommendations for award in respect of proposals / bids / quotes.
- Establishing a material management and control system, including verification of materials and equipment received.
- Administration of contracts.

5.6 Construction Management :-

Construction management includes the setting of a strategy, followed by its implementation, for the procurement of constructed work. Therefore, it is important that the project manager ensures that the consultant oversees the following, to the extent that they are not incorporated into individual contract documents:

- Provides input to the design and reviews contract documents as to constructability and cost.
- Provides input to the project schedule with respect to construction activities and logic.
- Recommends tendering strategies and procedures for the selection of tenderer, including tenders for pre-purchased equipment.
- Has responsibility for ċalling, receiving, evaluation and comparing tenders, and recommending contract awards.
- Mobilizing and managing the construction site, including temporary facilities, site logistics, storage on and off site for pre-purchased materials and equipment and general site conduct.
- Mobilizing contractors, reviewing their schedules, manpower and methodology.
- General day-to-day scheduling, coordination and supervision
- Expending submission and review of drawings and samples
- Field contract administration, distribution of field clarifications, special work authorization, and distribution of any change orders.
- Claim avoidance measures.
- Harmonious contractor and labour relations.
- Monitors construction progress and cost.
- Calls for inspection and reinspection of defective work.
- Certification of contractor's physical progress.
- Submission of required as-built drawing, operating manuals and instructions and similar contract completion documentation.
- Ensuring the mechanical completion of the project as per the approved design basis and project parameters.
- Administering the correction of faults during the warranty period.

5.7 Payment Certification :-

Payment certification involves verifying interim and final payment entitlement for every consultant, supplier and contractor engaged on the project in accordance with the terms of the respective contracts. However, in respect of suppliers and contractors, much of this work is delegated to the respective consultants who have a professional responsibility to ensure that the work conforms to their technical requirements.

5.8 Regular Status Reporting :-

Reporting on a regular basis, of timely up-to-date information, is essential to keep the client and other informed of the status of the project and to permit all necessary decisions and action to be taken promptly. Typical reports includes:

- General Project status
- Progress compared to schedule
- Cost compared to budget
- Activity status of consultants, contractors and management
- Permits, agreements and contract negotiations
- Construction status

5.9 Commissioning :-

Typically, commissioning and start-up is carried out by the owner's users or operational staff who actually run the facility. However, prior to start-up, every system and every part of the project must be brought into operational mode ready for formal handover. The whole project team is therefore required to assist by organizing and managing the transition from construction / installation to operation. A carefully developed set of commissioning procedures is necessary to ensure orderly and successful project completion, including:

- Responsibilities and organization
- Detailed equipment and systems commissioning and start-up sequence, including check-out, static tests, operational tests' performance tests, etc.
- Client acceptance, including equipment and systems tagging, opportunities for training and general familiarization, designation of temporary working and storage areas for operations staff, etc.
- Deficiency lists, and their progressive correction.
- Ensuring completion of all final contract documentation.

6.0 CONTRACTING STRATEGIES :-

1) Lumpsum Turnkey (LSTK) Contract
2) Project Management through Engineering & Project Management (EPM) Consultant
3) Project Management by the Owner

6.1 Lumpsum Turnkey (LSTK) Contract :-

In turnkey project management, the owner specifies the Scope, Time, Cost and Quality requirements of the project to the Turnkey Contractor / Consultant. The contract is awarded on lump sum basis to the Turnkey contractor for carrying out the entire scope of the project including cost of design, materials, works and manpower. Upon mechanical completion of the project, commissioning and start-up is carried out by the contractor's personnel in coordination with owner's operational staff. The contractor is required to run the pipeline operations successfully till certain cutoff period and handover the pipeline to the owner.

Turnkey work represents the following major areas of operation in totality to be handled by one contractor or consultant for the owner:

- Design basis for the pipeline.
- Layout design of pump stations, CP/SV/Telelcom Stations
- Scope of process equipment design/selection
- Process description and specifications
- Manufacturing/procurement of items for the project
- Selecting Contractors and carrying out Pipeline laying, Civil, Mechanical, Instrumentation, telecom works etc.
- Transport, storing, laying, installation and commissioning of the pipeline.
- Hand over / handle spare, supply responsibility till certain cut off period covering guarantee as contracted/stipulated.

LSTK contract is adopted where in-house expertise is not available with the owner or there is a shortage of manpower or the time available for project completion is short. The advantage of LSTK contract is that the pipeline is made available to the owner without owner's much involvement. The major disadvantage is that the LSTK contract is awarded on a lumpsum value basis estimated cost of the materials & works which might be on higher side.

6.2 Project Management through Engineering & Project Management (EPM) Consultant :-

When handling a mega scale project, it is a common practice to engage an Engineering & Project Management Consultant by the owner. The scope of the EPM Consultant can be any combination out of the above responsibility list. The owner specifies the Scope, Time and Quality requirements of the project to the EPM Consultant. The cost is controlled by the owner.

The design basis, process design, specifications, layouts, tendering, procurement and construction is carried out by the Consultant and overseen by the owner's personnel. All purchase orders are placed by the owner and payments are made by the owner.

EPM consultancy is adopted where in-house expertise is not available with the owner or there is a shortage of manpower, but reasonable time is available for project completion.

The advantage of EPM consultancy is that throughout the duration of the pipeline project, owner can keep control on the project expenditure, progress and quality of work.

6.3 Project Management by the Owner :-

In small scale projects or where in-house expertise is available, owner may decide to execute the project on their own. Where in-house expertise for design and engineering is not available, consultant can be appointed for design and engineering only. Balance activities like tendering, procurement, contracting and site supervision are carried out by the owner. The entire responsibility of controlling time, cost and quality lies with the owner. Third party inspection services may be utilized during procurement and construction for certifying the quality of the materials and works.

7.0 Details Activities in Pipeline Project Execution :-

7.1 GENERAL

This section describes the main activities and processes involved in constructing a large diameter onshore pipeline.

7.2 PRINCIPLES OF PIPELINE CONSTRUCTION

A pipeline can be broken down into three basic elements where different forms of pipeline construction method are used. They are:

(i) Open cross-country areas, where the spread technique is used
(ii) Crossings, where specialist crews and civil engineering techniques are used
(iii) Special sections such as built up urban areas, restricted working areas, difficult terrain sections and environmentally sensitive areas

7.3 SPREAD TECHNIQUE AS USED IN OPEN CROSS COUNTRY AREAS :-

The basic method of constructing steel, welded oil and gas onshore pipelines i open cross country areas is generally known as the spread technique. The spread technique utilizes the principles of the production line system, but in the case of a pipeline the product (the pipeline) is static and the individual work force, (crews) move along the pipeline track (right-of way/spread). The implementation of the spread technique is conditional on the pipeline being welded above ground in maximum possible continuous lengths between obstructions/crossings (which can extend to lengths in excess of 10 kilometers). These welded pipe lengths are then immediately installed into unsupported/unobstructed trenches gradually in one continuous length utilising multiple (three or more) mobile lifting tractors (side -booms) in unison.

The breaks in the continuous main spread method of working result from the location of existing services, roads, railways, tracks, ditches, streams and river crossings, and are also dependent upon restricted working, time constraints and physical features/obstructions. These breaks in the main pipeline spread activities are undertaken by dedicated specialist crews utilising a variety of special construction techniques and are generally undertaken after the main pipeline sections have been installed.

The main pipeline spread installation is undertaken by dedicated crews undertaking one operation at a time commencing at one end of the pipeline and travelling forward to the other end at anything from 500m to 1,500m per day depending on the diameter of the pipe, terrain, soils, etc. There are a total of some 40 separate operations carried out in 7 main activity groups, as described in Sections A.5.1 to A.5.7 inclusive. The programme of activities and the start-up of the crews is dependent on available resources and the risk of one crew having an impact upon the following activities.

Because a pipeline is a production line, it is essential that the time periods between crews is such that there is no risk of one crew causing stoppage or disruption on the preceding or subsequent crew. If the float between crews is not managed on a continuous basis, with the emphasis placed on the daily moving, then a concertina effect will result with substantial disruption and standby costs. Effectively, there can be up to a 4-week delay between crews to ensure that the concertina bunching effect of crews does not occur. Consequently, there are in the programme extended periods of time when there are no activities taking place along large sections of the pipeline route. The average time from start of ROW to commencement of land reinstatement is, typically, in the order of 10 to 15 weeks.

7.4 PRE-CONSTRUCTION ACTIVITIES :-

Pre-construction activities need to be carried out by the Installation Contractor prior to the start of the main pipeline installation activities. These activities include finalizing the pipeline route, detailed design finalization, mobilization, notification of entry to landowners, setting-up of pipe yards and base camps, establishing temporary works requirements, setting-up of geographic positioning stations, design of land drainage in agricultural areas and reinstatement works, construction of temporary access roads, pre-environmental mitigation works, and agreeing with landowners any special requirements prior to entry onto their properties.

The Installation Contractor will carry out pre-entry surveys as-and-where required so as to record the condition of the land prior to the start of any work.

7.5 MAIN PIPELINE CONSTRUCTION ACTIVITIES :-

Once the pre-construction activities have been completed, then the main construction works can commence. Generally, operations are carried out in seven main activities groups, as described in the following sections:

1.5.1 Construction Activity Group 1 - Preparing Work Area
1.5.2 Construction Activity Group 2 - Layout Pipe and Weld above Ground
1.5.3 Construction Activity Group 3 - Excavate Trench and Installation of Pipe
1.5.4 Construction Activity Group 4 - Pipeline Crossings, Special Sections and Tie -Ins
1.5.5 Construction Activity Group 5 - Final Backfill and Reinstatement Works
1.5.6 Construction Activity Group 6 - Facilities and Pipeline Control
1.5.7 Construction Activity Group 7 - Testing and Commissioning General details are shown in Figure 1.

7.5.1 Construction Activity Group 1 - Preparing work area

The pipeline operations consist of :-

1.Setting-out :-

The setting-out crews are the first personnel from the construction contractor's workforce to enter the site to commence the main construction activities. The setting out of the works should be scheduled to commence at least four weeks prior to the remainder of the construction activity group 1 activities. This work will be carried out with small four man crews using GPS and surveying instruments. Setting-out pegs will be placed at all boundaries, changes in direction and intermediate sightings on the proposed centre line and the extremities of the working easement.

In areas of open country where good and level access is available along the pipeline route and it is anticipated the rock or ground is of sufficient strength that it could impede progress of the trench excavation, then initial ground investigations works will be carried out directly behind the setting-out crew.

Part of the setting-out crew's duties is to identify any existing services that crosser are in close proximity to the pipeline and supervise the trial hole crew. The trial hole crew will hand excavate to expose, identify and determine the exact location of all existing services. This data will be recorded and transferred to the engineers for incorporation into the final pipeline design.

2.Advanced archaeology major works :-

This applies to locations where there are substantial/concentrated archaeology remains, which could involve extensive excavations. Provided access is available or requires minimal work along the ROW from an established entry point, a separate advanced ROW and topsoil/top cover crew will be mobilised to enable the archaeology works to commence in advance of the mainline and be completed before front-end crews pass. The topsoil/top cover at archaeology locations will be stripped by back-actors to avoid any disturbance to the stripped subsoil.

3. Right of Way/easement boundary demarcation - secondary ground investigation option 1 :-

This will commence after the setting-out. A crew o personnel and equipment comprising mainly large heavy tracked plant will form the right of way access onto the land. The operations will include the removal of all hedging for disposal off site, bridge or flume pipe access across field ditches, protectio n of existing services by protection mattresses, re-grading of existing ground contours to assist access, the erection of goalpost and safety signs at overhead electric power lines and telecommunication cables, the placement of hard standings as required for car parking and the blasting/removal and re-grading of rock areas or outcrops to provide a level and safe excavation line/running track along the entire pipeline route.

Additional crews will be provided to install offsite ROW accesses along the pipeline route to enable the ROW crew to gain access to the working areas, where access from the public road is not available or would cause a safety risk, or as a result of locked out locations or environmental concerns. Agreement with the landowners involved in any offsite access must be finalised prior to pipeline commencement.

Where temporary ROW fencing is required then additional crews will be required to erect this fencing to delineate the working area.

During the ROW and fencing operation it will be possible to undertake ground investigation works by the excavation of trial pits at 100 metre intervals to determine actual ground substrata, trench stability, ground water levels and seepage. These investigations, however, can only take place at this time on open areas where restrictions due to land use (agricultural) and environment do not exist.

4. Pre-construction terrain and ground stability (excluding dewatering) :-

At locations where there is a risk of ground movement that could result in safety risks to the construction activities and/or undermine the pipe during installation and the period prior to final reinstatement then permanent stability of the affected terrain needs to be undertaken. This work can be separated into two elements:

- Removal of material such as the overburden at the top of ravines and the removal of

loose material that could move during the installation works.

- Addition of material such as Bentonite, which is injected under pressure into gravels with high and fast water tables and deep mning areas to provide a protective curtain around the pipe. It also includes the adding (placement) of boulders/ground at the toe of steep gradients on forwarded and side slopes in the second element.

5.Trench excavation in rock areas :-

In areas where rock is confirmed as such by the initial ground investigation works then the trench is excavated ahead of any pipe operations. This sequence of working is undertaken to ensure that the excavation of the trench cannot cause any damage to the pipe and/or pipe coating and provide an extended safe working width for the excavation crews allowing double -sided trench working by excavators/ breakers.

Following the review of the data from the initial ripper and trial hole surveys, the ground will be classified in ease of excavation into five groups defined by the method of removal. These are (i) utilising standard excavation, (ii) larger more powerful excavators (face shovels converted to back-actors), (iii) ripping/hydraulic hammer and excavation, (iv) blasting/hydraulic hammer and excavation and (v) rock trenchers (saw and blade). The finished trench should be to the correct depth and width to suite the pipe diameter, plus any bedding and pipe cover. The trench should also be in a straight line so that the pipe can la y central in the trench without coming into contact with the trench sides. All loose and jagged outcrops, which could come in contact with the pipe during lay operations, will be removed.

The excavation will commence with dedicated crews immediately following the ROW operation. The forward progress will be dependent upon the ground strength, grain structure, terrain, access, method of removal and number of crews/equipment employed.

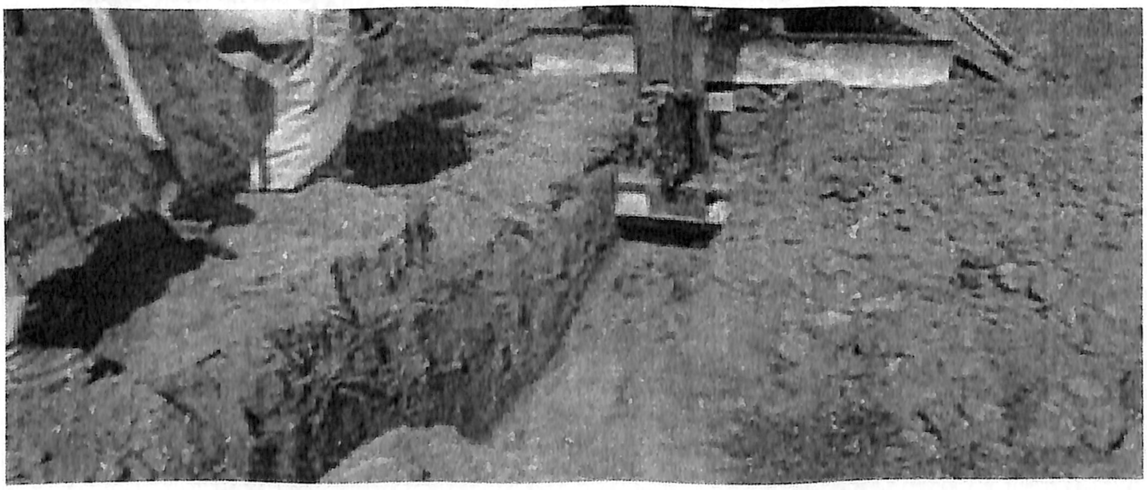


Fig.8 Trenching

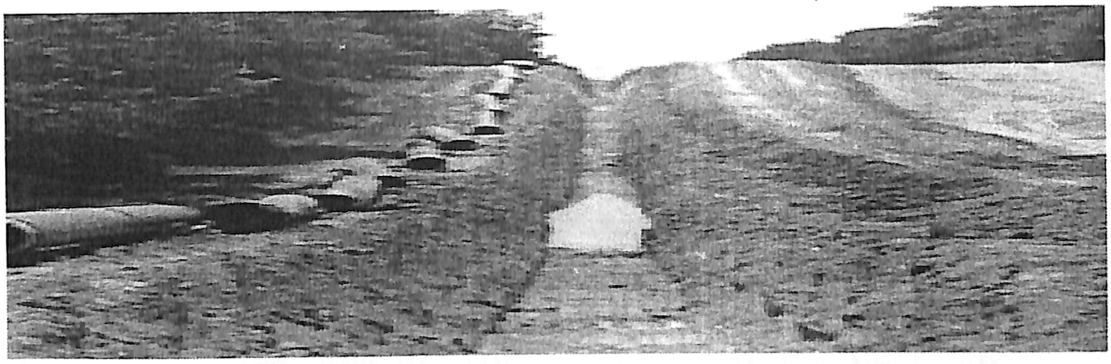


Fig.9 Trenching & Stringing

6. Pre-construction cut-off drains :-

All cut-off drainage works, which comprise the connection of existing drains to a new header pipe, will commence immediately after the right of way and fencing operations.

Cut-off drainage works will be undertaken at locations where there are existing concentrated drainage schemes on agricultural land and where agreement is reached with the landowners and/or occupiers to their installation. This work will be resourced taking account of the scope of work and the requirement to achieve pipeline installation progress of, say, 500 to 1,500 metres per day along the pipeline route.

7. Top soil strip -secondary ground investigation Option 2 :-

Topsoil strip operations commences after cut-off drainage operations and is scheduled to allow adequate time for completion of the drainage works in the event that unforeseen obstacles or circumstances are highlighted during the execution of the drainage installation operations.

The topsoil operation consists of 1 crew with plant comprising up to 8 excavators/ bulldozers removing the topsoil to its full depth (typically, = 300mm) and storing in a single stack on the opposite side of the easement to the trench excavation material. The topsoil is stripped with 2 to 3 excavators along the easement boundary on the opposite side to the topsoil stack area. This provides a subsoil interface/cutting edge for the dozers to work from in pushing the topsoil across the easement.

In areas where topsoil removal is required then the ground investigation works are undertaken following the removal of the topsoil as this avoids any risk of topsoil contamination with the subsoil. The investigation works are as those detailed in the ROW section and comprise the excavation of trial pits at 100 metre centres to determine actual ground sub-strata, trench stability, ground water levels and seepage.

Fig.10 Top Soil Stripping

7.5.2 Construction Activity Group 2 - Layout pipe and weld above ground

The pipeline operations consist of: -

1.Project mechanical procedures/testing of welders :-

Prior to the start of any mechanical works the Contractor will issue for Client approval a full set of mechanical procedures for bending, welding, x-ray and coating. These procedures will address how the Contractor intends to undertake the work in accordance with the project specifications detailing equipment and specific mandatory requirements. The procedures, particularly with regard to welding and x-ray will be sufficient to cover the full ranges of the various parameters characteristic of the project in terms of diameter, wall thickness and technique. Once the documented procedures are approved then full trials for each element of the works will be carried out, fully inspected and witnessed by the Client. The welding will include non-and full destructive testing to ensure that the procedure welds are undertaken in strict compliance with the contract requirements and fully comply with the minimum strength, hardness and quality requirements of the relevant specifications.

Once the procedures have been approved then the welders will be tested to ensure that they can comply with the requirements of the procedure welds. A register will be maintained of the welders employed on the project with the various welding techniques they are approved to work on.

2. Double –jointing :-

Double -jointing of the single approximately 12 metre long pipes into 24 metre lengths will, if considered economically viable by the project, be carried out in the pipe yards prior to pipeline stringing. Double -jointing permits the doubling of the welding progress with the same basic welding resources or allows the same production with a much smaller crew.

In considering double -joints due consideration needs to be given to the use of specialist pipe bogies for the moving of the 24 metre pipes, the capability of the local road system to accommodate the vehicles and the requirement for special road movement permits. The double jointing can be placed on the easement but this results in additional cost due to double handling of the pipe and the need to continually move the double joint equipment, which can offset any savings from increased welding production.

3.Pipe stringing :-

The pipes and pre-formed bends will be scheduled to be delivered to, and stock piled at, the proposed pipeline pipe yards some 4 to 8 weeks in advance of stringing operations. The pipe supply should ensure that the various grades, wall thicknesses and coatings are supplied in sufficient and correct quantities to meet the programme.

Immediately following ROW or topsoil strip or excavation in rock areas, the pipe stringing operations will commence, which involves laying the pipe lengths along the easement length using pipe trailers. A typical crew will consist of two cranes - one at the base camp loading the pipe trailers and the other on the pipeline easement off-loading the pipe trailers.

In the event that ground conditions do not permit travel down the easement with standard or special heavy-duty pipe trailers then the pipes will be loaded on to tracked pipe carriers at the public roads or at a point where the change in ground conditions occurs and permits the turning of the wheeled pipe trailers.

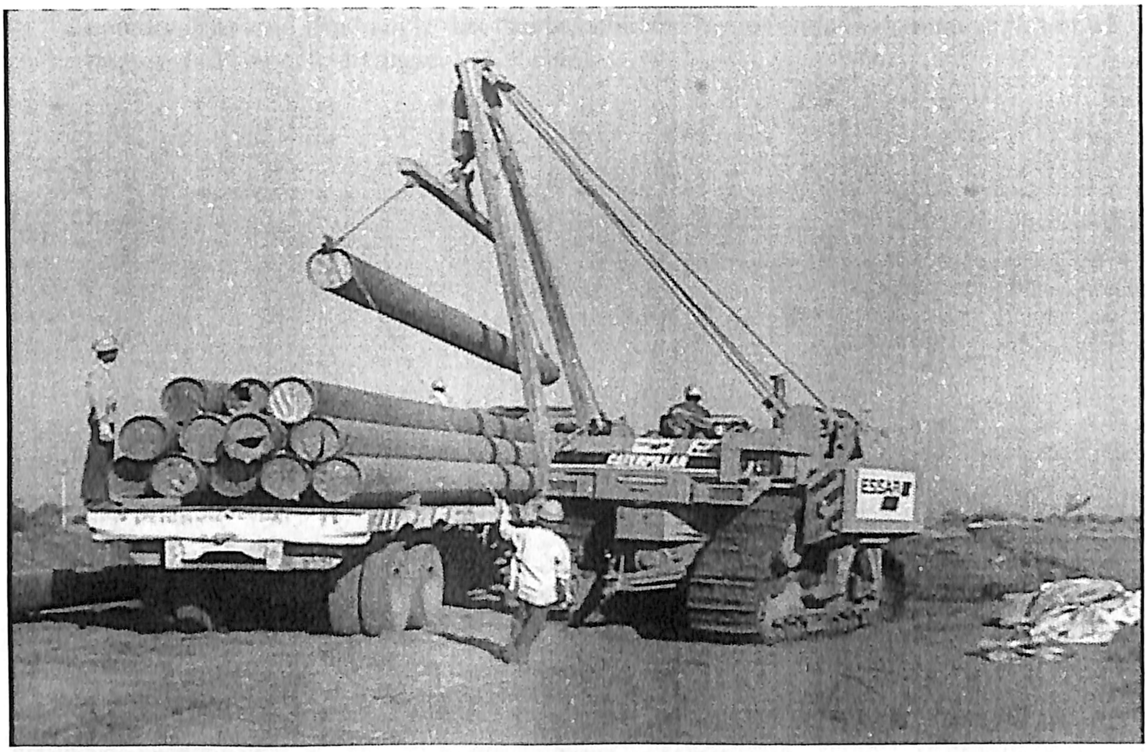


Fig.11 Pipe stringing

4.Forming field bends (cold bending) :-

Once the pipe has been strung along the easement, engineers will follow to determine the location of all bends required in order that the pipeline can follow the contours of the land and the required line and level as detailed on the drawings. There are two types of bends normally used ie hot pre-formed or forged bends which are manufactured off site in a factory and are to a radius of 5 or 3 times the pipe diameter and cold bends which are to a radius of 40 times the pipe diameter and are formed in the field.

A typical cold bending crew consists of a four -man team together with a bending machine and a side boom tractor. The bending machine is towed along the pipeline route by the side boom and includes "formers" consisting of 20 - 150 ton hydraulic rams, which bend the pipe to the required radius and angle. The side boom acts as a lifting device and has a fixed jib attached to a tracked dozer with a capability of lifting between 15 to 120 tons, dependent upon the size of the machine used.

The number of cold bends required depends on the route and contours of the pipeline. Typically, they can range from 1 pipe in 10 in developed regions to 1 pipe in 50 in open country. The cold bend angle that can be achieved ranges from maximum angles of 12 degrees (42" pipe) to 40 degrees (12" pipe).

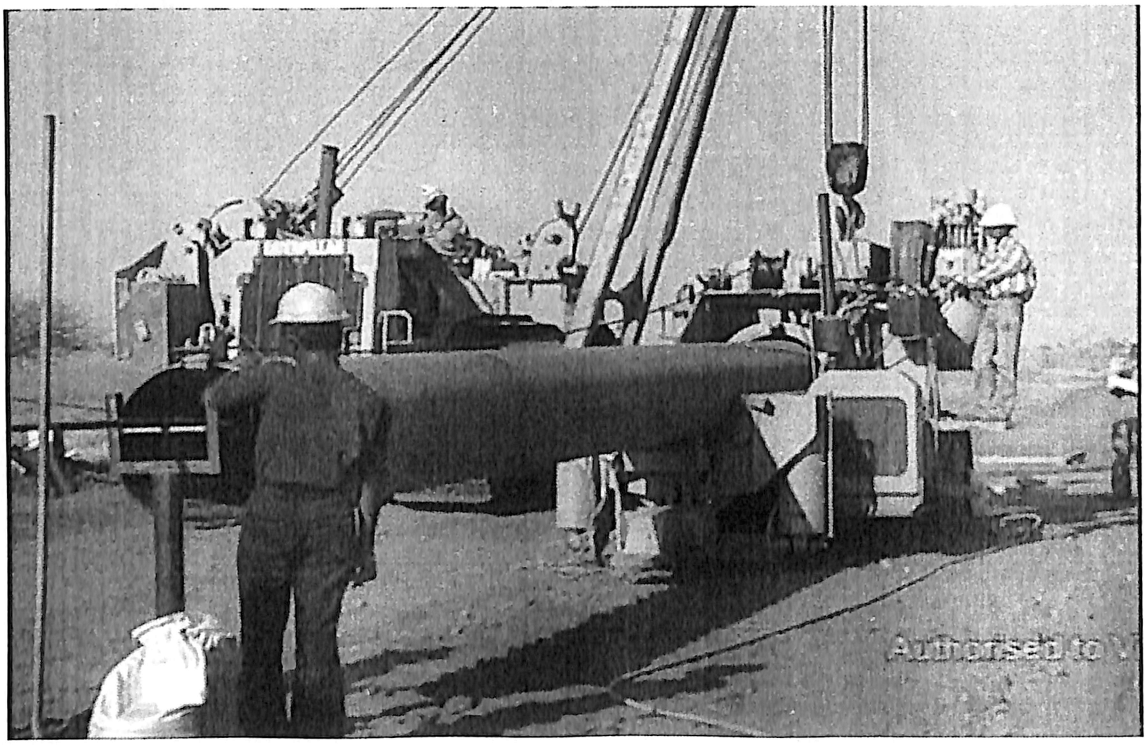


Fig.12 Cold bending

5. Welding of the line pipe :-

The welding of the pipeline will commence a few days after the cold bending crew. The welding crew will weld the pipeline in continuous lengths between features such as roads, watercourses, tracks, railways, services and other underground obstacles that prevent the line pipe being continuously installed in the trench.

There are primarily two methods of welding which are manual or automatic. As the names imply manual welding involves the welding of the pipe by welders and automatic involves a semi-automatic system. At present, and with the correct welding experience, there is no substantial difference in quality or production.

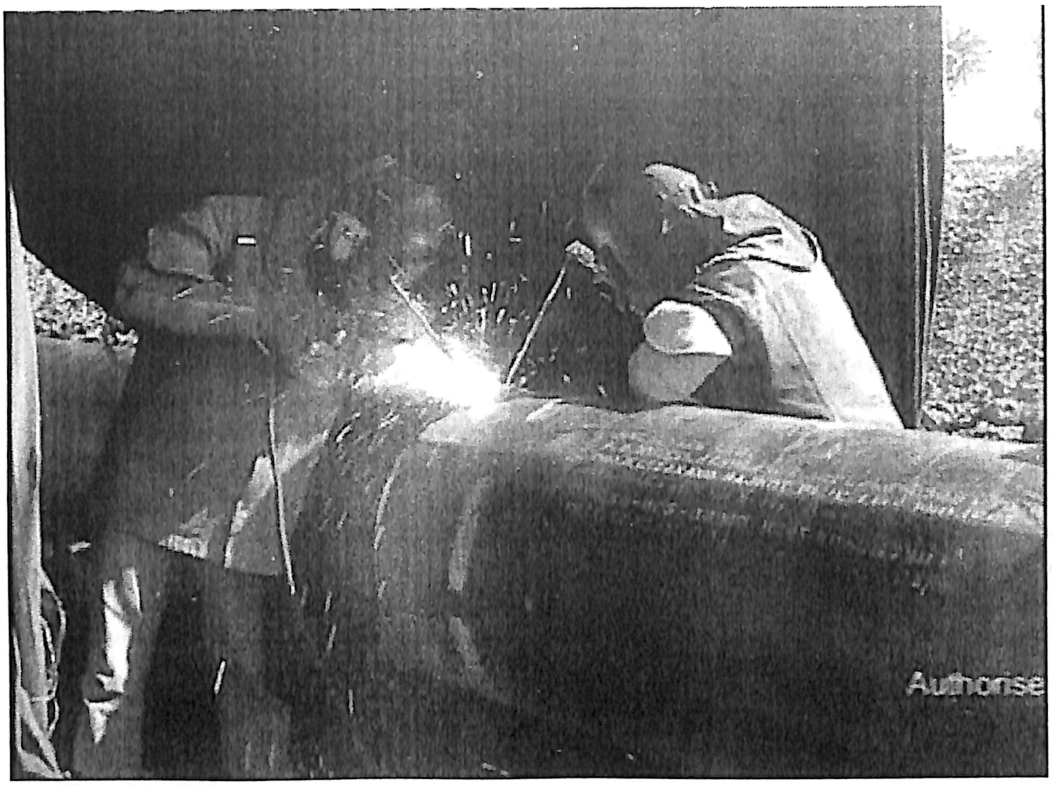


Fig.13 Welding of the line pipe

Automatic welding is used primarily for three main reasons: -

- Ensure welding quality
- Increase/sustain a high daily production rate
- Reduce the overall manpower requirements

Manual welding is used where: -

- A supply of experienced welders is readily available.
- Difficult terrain, weather and site conditions exist.
- Special sections and areas with a high percentage of tie -ins
- High production rates cannot be achieved.

Both systems generally (although certain automatic systems can now do single pass complete welds) operate on a front-end/back-end principle. The front-end consists in a manual operation with, say, 3 separate welding stations placed on CAT D6 carriage consisting of a HIAB for the welding shelter (used in inclement weather or windy conditions), 4 welding bullets and a compressor. The welding stations work on 3 separate joints and complete one pass before moving on with the sequence being the bead (2 - 4 welders), immediately followed by the hot pass (2 - 3 welders) and then hot fill (2 welders). With the automatic process, 1 machine deposits sufficient weld metal equivalent to the 3 manual passes. The weld is allowed to cool after the front-end passes and then sufficient welders working in pairs or multiple automatic machines follow on to fill and cap that day's production.

The crew will achieve progress in the order of one weld approximately every 3 to 5 minutes or up to 90 to 150 welds per day, which is equivalent to 1,000 to 1,500 meters of line pipe on 12 meter pipes and up to twice that if double -jointed pipes are used.

6.Welding of fabrication pipe work :-

As the mainline welding crew is set up for speed and any reduction in the speed will increase costs and could cause delays to following operations then any fabrications or pipe work involving bends or difficult set-ups or welds that require more than the bead before lowering off (creating cracks) will be left out. These fabrications are welded together by a small dedicated crew who complete these welds prior to the field joint coating crew.

7. NDT Inspection :-

All welds on the pipeline are generally subjected to inspection by radiography. This is achieved on the main pipeline by an internal x-ray tube travelling along the inside of the pipe carrying out x-rays at each weld for approximately 2 minutes per weld. On completion of the x-ray the film is taken to a dark room and processed in time for the results to be available for inspection at the end of the day or early the next day. Welds, which do not meet the required acceptance criteria, are either repaired or cut out and re-welded.

Experienced and qualified x-ray specialists undertake the radiography under controlled conditions. Before the operation is started, the section of pipeline is cordoned off by marker tape to stop entry by non x-ray personnel and audio/flashing warning alarms are activated during all times when the x-ray tube is energised. The x ray personnel are on constant surveillance to ensure that the workforce and members of the public are aware of the x-ray activities and only authorised access is permitted.

Welds completed by semi-automatic welding processes are examined using automatic ultrasonic testing (AUT) techniques. This consists of an assembly that traverses the circumference of each completed weld in order to detect any defects . The results of each ultrasonically inspected weld are automatically recorded and are used to determine whether a weld repair is required and if so what type.

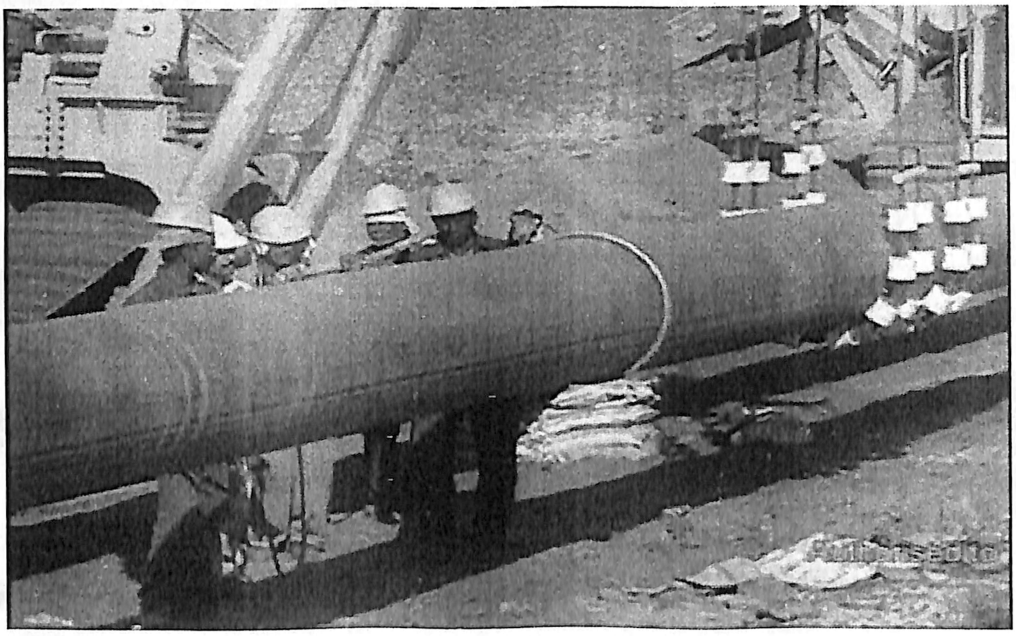


Fig.14 NDT Inspection by Holiday Detector

8. Weld rectification (repairs) :-

A weld rectification (repair) crew follows immediately behind the NDT inspection activities to either carry out repairs to or cut out any defective weld. On completion of all repairs a further xray is carried out on the weld to ensure that the finished weld conforms to the standard required. The x-ray of repair welds is usually carried out from the outside of the weld by a two-man crew.

9. Field joint coating :-

The coating of the pipeline field joints to prevent corrosion starts a few days after the welding. This extended period is to allow for any repairs or cut-outs to be completed without prejudicing the coating crew's operations.

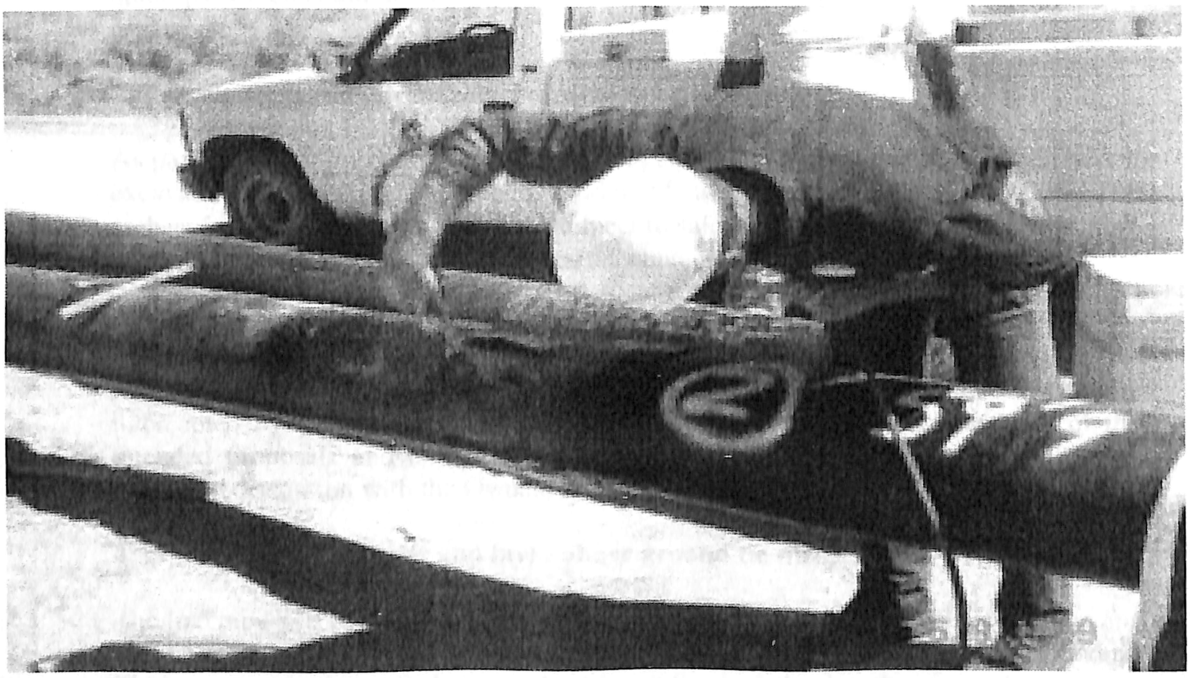


Fig.15 Field joint coating

7.5.3 Construction Activity Group 3 - Excavate Trench and Installation of pipe

The pipeline activities consist of :-

1. Trench Excavation :-

In areas other than rock, trench excavation commences a few days after the field joint coating operation. A typical trench excavation crew consists of 5 - 8 excavators working in line. This operation only excavates the length of open cut trench sufficient to install the main line welded pipe; it does not excavate any roads, ditches, services or obstacles. The number of excavators employed will be such that the amount of trench excavated in a single day matches the rate of progress of the welding crew. The spoil from the trench will be stored adjacent to the trench on the opposite side of the ROW from the topsoil stack.

The finished trench will be to the correct depth and width to suit the pipe diameter, plus any bedding and pipe cover. As far as possible, the trench should also be in a straight line so that the pipe can lay central in the trench without touching the trench sides. All loose and jagged outcrops, which could come into contact with the pipe during laying operations, will be removed.

2. Trench excavation archaeology watching brief :-

As part of normal good practice an archaeologist will be present during the main trench excavation undertaking a watching brief of the material being excavated. The archaeologist will have the authority (subject to safety constraints) to stop the trenching works if he considers the excavation has encountered a major archaeological find.

3. Finalise drainage design :-

In agricultural land, the Contractor will record the existing drainage system actually intercepted by the pipeline. The information will be reviewed taking account of the intended proposals and any final amendments to the system finalised at this stage following discussion with the Owners or Occupiers.

4. Pipe installation (lower and lay) - above ground tie -in sections :-

The line pipe will be positioned approximately 5 meters from the trench centre-line and will be installed into the open unobstructed trench utilizing a number of side -booms. This operation will usually be carried out immediately following the excavation crew.

As the line pipe is being installed a coating crew will be present who will holiday detect the pipe to detect any damage to the pipe coating just prior to the pipe entering the trench. Any holidays (damage) detected will be repaired by a fast setting repair coating.

In areas of rock, the pipe installation will commence anything from 5 to 15 days after the welding crew.

If there are any above ground breaks in the mainline due to access openings across the ROW, expansion breaks or bend breaks, then these will be welded above ground, x-rayed and coated during the excavation and lowered-in as part of the mainline lower & lay operation. This will optimise the use of the side -booms within the lower & lay crew and reduce the number of below ground tie -ins.

5. Cross trench drainage connections :-

In agricultural land, the permanent reinstatement of the existing land drains to be replaced across the pipeline trench is carried out prior to the trench backfill operations. The replacement drains extend for a short distance into undisturbed ground.

On completion of inspection of the reinstatement works, the trench is backfilled and compacted in layers to the underside of the drain. This work is only undertaken in extreme locations to supplement the main pre- and post-drainage schemes.

6. Installation of permanent cathodic protection system test posts :-

Either as part of the fabrication welding crew activities (if the location of the CP test posts are known) or as the pipe is being installed Cathodic Protection lugs are welded to the pipe. These lugs which can be 50mm square plate are welded on the pipeline using low hydrogen welding rods where test posts will be installed to check the ground/pipe to soil potential. The test posts are placed at about 1km distances along the pipeline and located at fixed boundarie s such as road crossings or other locations, which have relatively easy access. Cables are attached to the lugs the whole area coated, checked for holidays and the cables brought to ground level during backfilling and left. During the reinstatement activit ies the Cathodic Protection test posts are installed with the cable running up through a duct in the test post and tied off. The test post is then concreted into the ground directly above the pipeline.

IMPRESSED CURRENT SYSTEMS:-

The use and design of impressed current systems are more flexible than galvanic anode systems. Design requirements are determined by a survey of the structure to be protected.

The principle is the same for both systems except impressed current systems energize anodes by use of an external energy source. A rectifier is used to convert available AC to DC. The direct current is then introduced into the electrolyte by an anode (or anode bed) especially designed to have a long life under relatively high current, high voltage conditions.

Many different types and sizes of anodes are available for use in impressed current systems. These are graphite, high silicon cast iron, lead-silver alloy, platinum, and even scrap steel rails. Each anode has special design, installation, and operating characteristics.

Impressed current systems are advantageous when:

1. Current requirements are high.
2. Electrolyte resistivity is high, requiring higher voltage than is available from galvanic anodes.
3. Long life protective systems are required.
4. Fluctuation in current requirements is encountered (systems can be controlled and adjusted automatically).

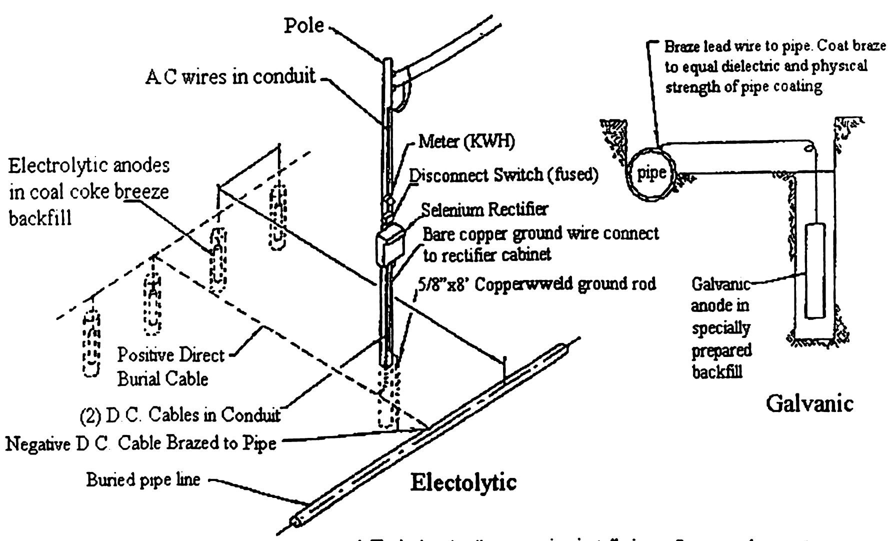


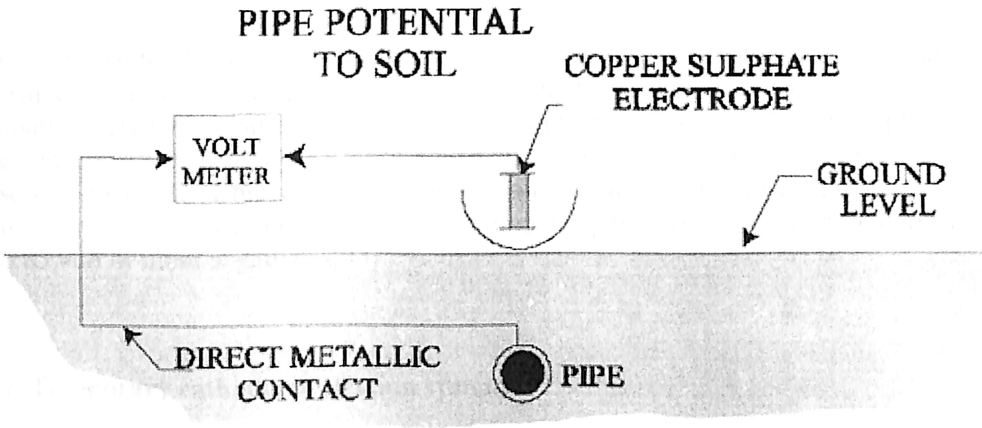
Figure 4: Typical cathodic protection installations. Impressed current (rectifier) system is shown at left and application of a galvanic anode for protection of pipelines at right.

Fig.16 Typical impressed current cathodic protection system

Protection of pipe involves installation of a transformer rectifier control unit and several anodes (graphite or silicon cast iron rods) wired in parallel. The positive terminal of the rectifier is connected to the anode bed, and the negative terminal is connected to the structure to be protected. In addition, the power unit is usually equipped with indicating ammeter, voltmeter, and overload circuit breaker. Current output of the unit is adjusted by the taps on the secondary winding of the transformer which vary the AC voltage to the rectifier stacks.

PIPE TO SOIL POTENTIAL (PSP) :-

Pipe-to-soil potential is the potential difference (voltage reading) between a buried metallic structure (pipeline) and the soil surface. The difference is measured with a half-cell **reference electrode** in contact with the soil.



1. INVESTIGATE CORROSIVE CONDITIONS.
2. EVALUATE THE EXTENT OF CATHODIC PROTECTION

Fig.17 PIPE TO SOIL POTENTIAL (PSP)

The half-cell is an electrode made up of copper immersed in copper-copper sulphate (Cu-CuSO4).

STANDARD REFERENCE HALF CELL
($Cu-CuSO_4$ ELECTRODE)

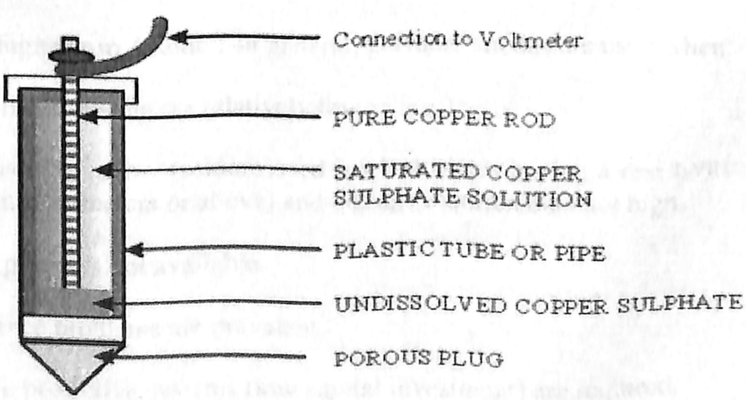


Fig.18 Half Cell

Design and Criteria for Cathodic Protection: -

The cathodic protection system is designed basis current requirement. Corrosion of steel (or iron) stops when PSP is – 0.85 volt or more electronegative with the reference electrode placed close to the electrolyte / structure interface and the pipeline is considered cathodically protected. This potential value is the most significant measurement with respect to corrosion control. It actually is the measurement of voltage drop at the interface of the metallic surface and the electrolyte, the reference cell being on a contact terminal and the structure being protected is the other terminal.

Current required to raise the structure's potential to protected values is a function of the structure's electrical resistance to the electrolyte. On pipelines, this is a combination of coating resistance and soil resistivity (or "contact" resistance). For example, a well coated pipeline in high resistance soil may require as little as 50 microamperes per square meter to achieve cathodic protection; a bare or poorly coated pipe in low resistivity clay may require 15 to 20 milli amperes per square meter to be polarized to – 0.85 volt or more negative.

7. Temporary cathodic protection system :-

As the pipeline may be buried for the full construction period before the permanent Impressed Current Cathodic Protection (CP) System is activated, then some form of temporary system needs to be installed prior to the backfilling of the pipe. The temporary system, typically,comprises a number of zinc anodes attached to the pipeline at regular intervals. These are buried parallel to and at a distance of, say, 3 meters from the pipe.

SACRIFICIAL ANODE SYSTEM :-

Galvanic systems produce the required protective current by an electrochemical reaction. A metal less noble than the metal to be protected is selected for the sacrificial anode. When protecting steel or cast iron, the anode material can be magnesium or zinc. Zinc and magnesium being more anodic than steel, will corrode to provide cathodic protection for steel pipe. The number, size, type, and location are determined by a detailed survey of the structure to be protected. Factors such as coating resistance, soil resistivity, and interference effects are considered.

Typical Magnesium Anode :-In general, galvanic anodes are used when:

1. Current requirements are relatively low.

2. Soil resistivity is low (seldom used in electrolytes having a resistivity of 10,000 to 15,000 ohm-centimeters or above) and voltage requirements not high.

3. Electric power is not available.

4. Interference problems are prevalent.

5. Short life protective systems (low capital investment) are required.

In most applications the anode is a cylinder or rod connected electrically by a wire to the structure to be protected. Sometimes a calibrated resistor is installed in the anode lead wire to control current output.

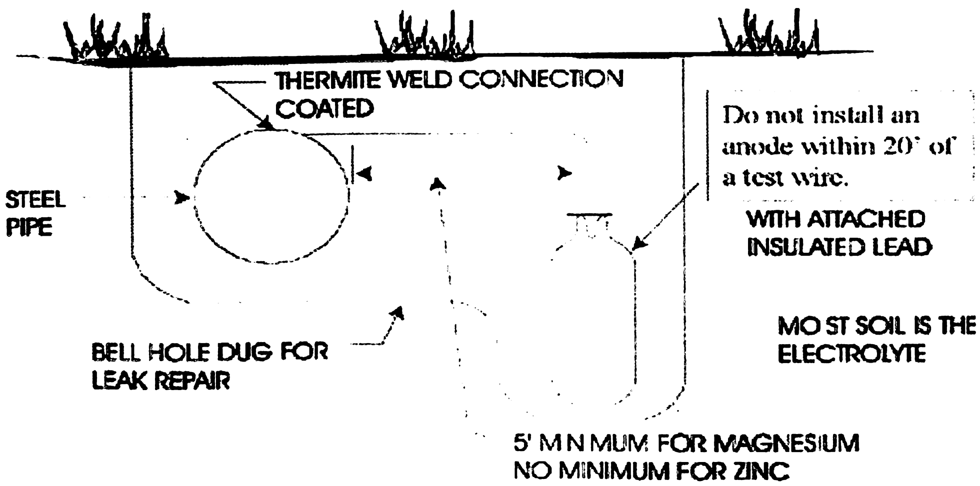


Fig.19 Typical Magnesium Anode

Under the same conditions, cylinder type anodes have a longer life but lower current output than rod type anodes.

8. Backfill of the pipeline Trench :-

Trench backfill starts immediately following the placement of the line pipe in the trench and the undertaking of a survey of the pipe levels by the engineers to confirm that the required pipe cover has been achieved. There is a requirement that the initial backfill around the pipe and to 300mm above the crown be of loose and relatively fine particles, which can be readily compacted and do not damage the pipe coating. In areas of rock it will be necessary to place the pipe on a 150mm bed of similar material. In order to provide this material it may be necessary to import sand/soft material offsite, sieve the excavated material or crush the excavated material. The sieve and crusher equipment will be portable machines, which will be transported along the pipeline ROW.

The pipe is backfilled over the entire length except for, say, 30 meters at each end of the pipeline work section, which is left free to facilitate the tie -in to the crossing/line break pipe work.

7.5.4 Construction Activity Group 4 - Pipeline crossings, special sections and tie-ins.

<u>**The pipeline operations consist of:**</u>

1. Crossings :-

The crossings are carried out by a number of different and dedicated crews simultaneous with the main trench excavation works and final tie -in to the main pipe installation being carried out by subsequent tie -in crews following completion of the crossings and main pipeline installation works. The crossings are undertaken by two distinct methods of construction consisting of either:

- Open cut
- No dig technique

There are various options to the two methods of working and the actual method employed at any given location will be dependent upon the ground conditions, pipe diameter, local environment, third party restrictions and the type of obstruction being crossed.

The extent of a crossing in design terms is normally defined from fixed locations, which extends either side of the crossing land take or boundary fencing. However, the length of a crossing in terms of construction includes the crossing plus any temporary works to facilitate the installation, the swan neck offsets to bring the pipe back to normal cover and the tie -in pipes to connect the crossing to the mainline.

A key aspect in the determination of the method of construction that will be used at any crossing will be the requirements of the regulatory authority/owner that has jurisdiction over the crossing. Part of the approval process with the regulating authority will be the issue of detailed plans and calculations of the design, which will be supported by fully detailed construction method statements.

Details of the various crossing methods are described herewith and are taken in the order of ease of construction and cost.

Open cut :-

Open cut is generally by far the most cost effective way of crossing obstacles that cause breaks in the mainline and is undertaken by crossing the obstruction by means of an open excavation. The trench excavation at the obstruction, whether it be a ditch, a road, a railway, a river, or a service is excavated for the full length of the crossing prior to the installation of the pipe. Accordingly, in order to minimise the time for which the crossing trench is open, the welding, NDT inspection and field joint coating of the section of pipe required for the crossing is completed in advance of excavating the trench. An open cut crossing can very often be installed in one working day and the road or ditch temporary reinstated sufficiently to fulfil the function for which it is required prior to the crew-leaving site for the day.

No-dig technique :-

At locations where open cut methods are impractical or not permitted for whatever reason, then no-dig techniques have to be implemented. No-dig techniques can be classified into two main groups - sleeve or 'bare' line pipe. The actual method that will be used is determined by the ground conditions, third party restrictions, length of crossing, diameter, and design/safety requirements.

The different options available for no-dig techniques are described briefly below:

- Auger Bore is a term used to define a method where the pipe is supported by cranes/side -booms in a pit and a cutting head removes the spoil at the face, this is transported by flights down the pipe and is discharged into the pit through the auger machine which is positioned at the rear of the pipe being bored

- Thrust Bore is a term used to define the installation of pipes by the manual excavation of the face with the pipe pushed forward from a thrust pit with hydraulic rams off a thrust wall at the back of the pit. Due to the risk of a potential face collapse upon the miners,the face has to be self-supporting. Accordingly, this method is used primarily in stable/hard ground conditions where the strata or strength precludes auger bore. As labour has to work at the face then the minimum pipe diameter normally considered is 36".

  There are two options with the thrust bore method of working:-

  – **Concrete Sleeve.**:- This method comprises the pre-installation of concrete sleeve pipes, which are typically 2.5 meters in length. Following installation of the concrete sleeve, line pipe in lowered into the thrust pi and pushed/pulled along the sleeve to a point where the next pipe can be lowered, welded, x-rayed, coated and then pushed/pulled along the sleeve.

  – **'Bare' Line pipe :-** This method comprises the installation of similar equipment to that for the concrete sleeve except that the line pipe is used for the thrust pipe rather than a concrete sleeve.

- Tunnels are not expected to be used on this project and, as such, are not discussed further.

- Horizontal Directional Drill (HDD) is a term used to define the method of installing a pipeline in long sections without taking entry onto the land. The method involves the welding of the pipeline into a continuous string above ground on one side of the crossing and pulling this string through a pre-drilled hole to the other side. The pipe will be welded, inspected, coated, tested and sitting on heavy-duty rollers prior to the drill operation commencing on site. Normally, a pre-installation hydrostatic test of, say, 4 hours duration, is carried out on the completed string to confirm the pipe integrity.

  – The drilling machine will be positioned on the opposite side to the welded pipe string. The profile of the crossing will consist of five main elements - the entry angle, the radius of the sag bends, any side bend configuration, the exit angle and the intended reamer size. The accuracy of the drill can be maintained within a tolerance of 0.1% of the proposed profile at any point during the drilling process. The drill machine will be positioned at the drill entry point and at an angle from the horizontal of around 5 degrees for a 42" pipe).

  – The drill will then commence with a 3 or 5-inch drill rod installed in 3 or 5 meters sections to drill a pilot hole along the proposed drill profile. The position of the drill head will be continually monitored via the on site computer system. Bentonite under pressure (20 bar) is forced out at the drill head to make a route through the ground, allow steering and to support the annulus walls. Once the pilot hole is complete further passes are then carried out with reamer heads which increase the hole size to around 150% of the pipe diameter to allow pipe installation.

  – On completion of the reaming the leading pipe of the weld string (to which a swivel pull head has been welded) is connected to the drill rods and the process of pulling the pipe into the annulus begins. During this operation the drill rods are removed as the pipe progresses forward towards the drill side. Ideally, the pipe pull is carried out in one continuous operation without any delays. When the pipe pull is complete the pipe coating integrity is checked by placing an electric current down the pipe to ensure that it is within the required limits and the equipment then removed from site with the Bentonite disposed of in an approved manner.

2. Special sections :-

A special section is a term used to define any section of the pipeline that (i) cannot be undertaken by the spread technique, (ii) is a break in the mainline that does not conform to the definition of a crossing as described above, (iii) locations where time restrictions apply, (iv) environmentally sensitive areas where third party specific constraints apply, (v) restricted working, (vi) difficult directional drills or (vi) urban areas. By designating a section of the pipeline as a special section it highlights the fact that the section is more complicated than the mainline and will involve unique methods of working, generally low production and higher than average project costs.

There are four basic forms of construction methods that are used in special sections:

- Pull/Push Method of Construction is mainly used in unstable ground areas where the ground would not support the construction traffic and/or where the batter angle of repose of the excavated trench is below 25 degrees. The method involves installing the pipeline across an obstacle by welding the pipe which has concrete weight coating on heavy duty rollers in a continuous length and pulling the pipe with winches at one end, whilst at the same time side -booms/excavators push the weld string along the rollers into

- Horizontal Directional Drill (HDD) is a term used to define the method of installing a pipeline in long sections without taking entry onto the land. The method involves the welding of the pipeline into a continuous string above ground on one side of the crossing and pulling this string through a pre-drilled hole to the other side. The pipe will be welded, inspected, coated, tested and sitting on heavy-duty rollers prior to the drill operation commencing on site. Normally, a pre-installation hydrostatic test of, say, 4 hours duration, is carried out on the completed string to confirm the pipe integrity.

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- Mainly Operation which involves the installation of the pipeline in the trench one pipe (single or double -jointed) at a time. This method of pipe installation is used in locations of narrow ROW, unstable ground and/or urban areas and utilises a single, complete crew which carries out all operations including excavation, pipe installation, welding, NDT inspection, coating and backfilling. Mainly techniques are used at locations where the spread method cannot be employed.

- Above Ground Pipe work is not expected to be used on this project and, as such, is not discussed further.

3. Tie –ins :-

Tie-ins are the welds generally undertaken in the trench that connect two sections of pipeline together. Once the crossing/special sections and the main pipeline either side are installed, tie -in crews are then employed to tie the crossing and special sections to the main line. The tie -in crews consist of excavators to prepare the trench for entry by the welders, side -booms to lift and set up the pipe for welding, mobile welding crews, mobile NDT inspection crews and mobile coating crews.

7.5.5 Construction Activity Group 5 - Final backfill and Reinstatement works :-

<u>**The pipeline operations consist of: -**</u>

1. Special backfill requirements for washout, stabilisation, geotechnical protection. These are needed at locations to ensure long-term trench stability, or where it is considered that additional stability is required following trench excavation. Special backfill requirements are essential to control the effects of water on a trench line and mitigate against natural hazards that could result in pipeline failure or extensive operational remedial costs due to exposure and movement such as seismic conditions, erosion, mining subsidence. In order to deliver a full lifecycle cost effective pipeline system due allowance must be made to ensure those elements that could result in extensive pipeline operational costs are addressed and the necessary permanent works undertaken as part of the pipeline construction activities.

2.Final backfill and clean up :-

On completion of the tie -in work activities on the mainline, a final backfill and grade crew will progress along the pipeline. This crew will inspect the coating of the exposed pipe and any holidays (coating defect) will be repaired as necessary and the section of exposed pipe backfilled to ground level. All temporary materials, trench supports including piles, surplus excavations, rubbish, etc will be systematically removed from the construction easement area and then the sub soil levelled to its original contour or as determined by operational requirements.

3. Post construction lateral drains :-

In areas where pre construction header drains have been installed or where additional drainage is required following trench excavation, then lateral drains will be installed either side of the pipeline to collect and remove surface water from the pipeline ROW area.

4. Subsoil cultivation :-

In agricultural land, the subsoil cultivation involves the final surface preparation of the subsoil including reforming of open cut ditch banks and other features which may have inadvertently been affected by the right of way operation in gaining access.

Once all the features have been returned to their original condition and the surface re - levelled, the subsoil over the whole working area will be broken up into a fibrous condition. Any shallow land drains will be marked and the subsoil carefully "ripped" parallel to those drains to avoid any damage to the shallow drainage installation. Having broken up the subsoil into a fibrous condition the entire area is then worked and levelled with bulldozers without inducing any unnecessary compaction.

5. Permanent works for post construction terrain stabilisation :-

At locations where a risk is considered to exist then additional works will be undertaken immediately following ground final backfill and clean up. For example, surface ditches will be dug parallel to the pipeline with outfalls to existing surface water systems in areas where the backfill is susceptible to water disintegration or can become air blown in heavy winds it will be encased within stone paving. Final ground and/or trench stabilisation will be addressed with the final grading/ reshaping of forward and side slopes and smoothing out any ground removal undertaken on the initial ROW operations in order to provide protection against run off water into the trench.

6. Reinstate offsite roads and provide operational access :-

There will be a general commitment to either leave the temporary roads or remove them with a provision for retaining sufficient temporary roads to ensure safe operation. The road crew will commence out of sequence with the main operations working as and when required in removing/upgrading/reinstating existing and temporary roads that are to be retained, also, as part of the operation, reinstating as much as possible of the route but permitting access to the final reinstatement crews. New roads in ecologically - sensitive areas will be removed.

7. Top soil replacement and final reinstatement :-

The top soil replacement and final reinstatement of the pipeline easement area immediately follows the subsoil preparation and cultivation activities. This operation consists of a number of activities, which have to be carefully monitored to avoid unnecessary compaction of the soil strata, and includes:

- Removal of all temporary access equipment
- Final formation of ditch banks
- Clean up/patch up any damage to highways
- Replacement of top soil.
- Final level on open country.
- Erection of new permanent replacement boundary fencing and new hedging.
- Erection of marker, aerial and Cathodic Protection posts

Wherever possible, the final reinstatement will be undertaken in dry conditions.

On completion of final reinstatement the easement land will be brought back to its original condition, as follows:

- Open country - Any fencing will be removed and the land left for immediate occupation
- Special sections/isolated areas - Any fencing removed, access roads reinstated to the agreed level with security barriers erected if required/agreed and the land left for immediate occupation
- Arable land -Fencing will be removed and the land fit for immediate planting
- Grassland - The temporary easement fencing will remain erected and the ground left ready for re-seeding at the earliest growing season. The temporary easement fencing will then be removed.

7.5.6 Construction Activity Group 6 - Facilities and Pipeline control :-

The main items consist of:

- Block valve sites
- Pumping stations
- Offtake facilities
- Cathodic protection system
- SCADA and leak detection system
- Electrical power supply
- Telecommunications system
- Control centers.

The work associated with these facilities and systems will, in the main, be carried out by separate contractors to the Pipeline Installation Contractor. However, all work involved with these facilities will be co-ordinated with main pipeline construction to ensure that the overall schedule for the project is achieved whilst optimising in-country logistics and ensuring that the requisite HSE standards are maintained.

It is not considered necessary to discuss these activities in detail as, to a large extent, they are carried out independently of the main pipeline construction.

7.5.7 Construction Activity Group 7 - Testing and Commissioning :-

The pipeline operations consist of hydrostatic testing, pre-commissioning and commissioning of the pipeline. The last two activities are considered outside the scope of main pipeline construction activities and, as such, are not discussed further.

1. Hydrostatic testing :-

The post-pipeline construction testing operations are carried out to ensure that the installed pipeline complies with the appropriate regulations and can be declared fit for its intended use. The testing of the pipeline is undertaken on completion of all pipeline construction work including if possible final reinstatement, which is weather dependent.

First of all, the pipeline is cleaned and filled with fresh water by the use of internal pigs. The use of the pigs ensures that all air is removed from the pipe. The pipeline is then tested, depending on the code and type of pipeline (oil, gas, etc), to, say, 125% of the maximum operating pressure for a continuous period of 24 hours. On acceptance of the pressure test the water will be removed by the use of the internal pigs propelled by air.

The first task in testing is to establish the number of test sections required for the pipeline. This is determined based on :-

- Availability of suitable water and location of sources.
- Location of suitable disposal sites for test water.
- Variation in altitude which affects the actual test pressure and allowable hoop stress.
- Length of section, which should be based on a risk assessment on the effect the considerable volumes of water, following a failure, could have on the local environment at any sensitive area.

Under normal circumstances, test sections are limited by 100-metre change in altitude and 100km in length.

It may be that, due to conservation or supply difficulties, water will have to be transferred from one test section to another along the pipeline. If this is the case then careful consideration of the installation programme should be undertaken with completion taking full account of water supply and disposal requirements. The transfer of test water from one section to another will be via hard (steel) pipe work so that no water is lost or spilled. As the water is transferred from one section to the next, it will be filtered and its chemical composition checked and modified as necessary.

In addition, it may be necessary to chemically treat the water to prevent biological growth in the water or inhibit oxidation of the internal pipe surface (rusting). The selection of chemicals will be subject to very strict evaluation prior to the start of the hydrostatic testing and will be based on chemical and physical analysis of the water at the actual sources. The addition of the chemicals to the test water will be subject to close scrutiny and control and the water will be checked periodically to ensure that it remains within the specified compositional limits. An environmental permit will be obtained for all water abstraction and discharge associated with the hydrostatic test(s).

Temporary pig traps will be installed at both ends of the pipeline section to be tested. These traps will be fully certified for the proposed test pressures. The temporary equipment at the 'upstream' end of the test section (where the water will be introduced into the pipeline) includes, large volume/low pressure filling pumps, break or settling tank(s), low volume/high pressure testing pumps, chemical injection tanks and pumps, hard (steel) pipework, compressors, temperature, pressure and volumetric flow instrumentation, pig traps, testing cabins, power supply generators, filters/filtration units, office and telecommunications facilities. Similar equipment will also be installed at the 'downstream' end although the type and amount will depend on whether the test water is being disposed of transferred to the next pipeline section.

All the temporary equipment needed for the hydrostatic testing operation will be fully certified for the test pressure(s) concerned and copies of the certificates will be available onsite for inspection prior to the start of the programme.

Normally, the block valves will be tested in -line with the valves 'locked' open and any instrumentation disconnected for the testing operation.

Once a test section has been completed mechanically and is declared ready for testing, the temporary equipment will be installed at both ends of the section. The section will initially be pigged with a bi-directional swabbing pig propelled by air to ensure that all debris is removed from the line. The pipeline will then be filled with water utilizing a 2 possibly 3-pig train with, typically, a 500 meter long slug of water between the 1st, 2nd and 3rd pigs. The high volume/low pressure pumps will be used for this activity and the volume of water entering the pipeline will be controlled and measured to give a line fill rate of, say, 1km per hour.

It is normal practice (and sometimes a requirement of the relevant code) for one of the pigs to have an aluminum gauge plate attached to check for pipe ovality/dents. The gauge plate is circular and has a diameter equal to 95% of the internal pipe diameter (bore).

Once the line is filled it will be left to stand to allow the water temperature to equalize to the surrounding ground conditions; this is typically 3 to 5 days but, as expected, is extremely variable. Once the temperature is stable the test will commence with an initial rise in pressure to 35 bar to ensure that the air content is less then that required by the design code (normally 0.2%). The low volume/high pressure pumps are used to add this water into the pipeline.

With the air content confirmed, the test pressurisation continues to the test pressure at a steady rate of, typically, no faster than 1 bar per minute. Once the test pressure is reached it shall be held for the required time, which for this Project is likely to be 24 hours. During this 'hold' period, the pressure and temperature will be measured, monitored and recorded continuously.

Small leaks during the testing operation can be difficult to detect and locate. A change in the water/pipe temperature may give the appearance of a leak. If the temperature of the pipe/water decreases, the test pressure decreases and vice versa for a rise in pie/water temperature. To prevent unnecessary concerns in this respect, the effects of temperature change on pressure can and will be pre-determined so that the integrity of the pipeline can be confirmed during the testing period.

On completion of the 'hold' period and successful acceptance of the test the water is removed from the pipeline by swabbing pigs propelled by dry/oil free compressed air. The water will either be sent an approved disposal site (evaporation pond/lagoon or river depending on water quality and chemical composition) or into the next test section via solid cross-over piping.

On completion of the initial de -watering, additional pigging runs will be carried out using a combination of swabbing and foam pigs to remove as much free water as possible from the pipeline. This sequence will continue with all other test sections.

Once the dryness of two adjacent sections has been accepted, these sections will be tied-in by welding a short section of line pipe between them to form a complete pipeline between permanent pig trap sites.

CAPITAL COST

Basics of Estimation:

The project cost has been estimated on the basis of requirements using following basis of estimation

- Cost actually incurred in the past appropriate escalation
- Establishing physical requirements, preliminary specifications and in house cost data.
- Experience of virtually identical projects elsewhere to establish physically requirements and cost.
- Experience of slightly different projects estimated approximately to established physical requirements, and budgetary quotations.
- Experience of similar projects in value/terms adjusted for price difference by past experience and escalation data.

Survey and Field Engg:

The cost includes the cost of mainline survey, population density survey, cadastral survey and soil resistivity survey at the proposed new station locations and field engineering.

Land Acquisition, ROW, and Crop Compensation:

Land for the stations has been considered to be available within the existing marketing installations (bottling plants). Right-of-way compensation has been considered for the new ROW. Crop Compensation has been considered for the entire route of the pipeline.

Project Management and Engg:

The cost of project management and engineering is estimated on the basis envisaged time schedule.

Mainline pipes & Materials:

The cost of pipes has been considered as per the latest data available. The cost of materials required such as casing pipe, coating and wrapping materials, valves etc. has been estimated on the basis of budgetary offers and cost actually incurred in recent past on these items.

Mainline Construction:

The cost of mainline construction has been estimated on the basis of cost of similar projects being executed.

Compressor Stations and Terminals:

The cost under this head includes mainly the cost of mainline pumping units including valves, electrical and instrumentation items, civil and mechanical works including the erection and installation of requisite facilities. Cost estimates are based on the budgetary offers/earlier purchase orders.

Cathodic Protection:

The cost towards cathodic protection includes the material required for temporary and permanent cathodic protection, installation and commissioning of equipment, CP rectifier units, ground beds, cables etc. Estimates are based on budgetary offers and rates from similar projects executed in recent past.

Telecommunication and Telesupervisory System:

A dedicated telecommunication and Telesupervisory System has been envisaged for the complete pipeline system. Cost estimated are based on budgetary offers/earlier purchase orders, adjusted suitably

Capital Cost

(May 2007 price level)

(Rs.in Lakh)

S.No.	DESCRIPTION OF ITEM	FE	Rupee	Total
1	Survey & Field Engineering	0	17	17
2	ROW & Crop Compensation	0	168	168
3	Project management and Engineering, Insurance	0	352	352
4	Mainline Pipes	1712	1404	3116
5	Mainline Materials	0	44	44
6	Mainline Construction	216	1211	1427
7	Pump Station and Terminal	7	561	568
8	Cathodic Protection	8	56	64
9	Telecommunication & Telesupervisory	0	413	413
10	Line Balancing Tank at Terminal station	0	339	339
	Grand Total	1943	4565	6508

Exchange Rate: 1 US $ = Rs. 40.71, 1 UK £ = Rs. 81.01 , 1 Eu ro =Rs.54.96

OPERATING COST:-

The operating cost of the pipeline system includes the cost of utilities like power and water, consumables, salaries and wages, administrative overheads, repair & maintenance etc.

Basis of Estimation:

Power(electricity):

The project has been conceived based on on the electric motor driven compressing units at stations, requirement of power is planned to be drawn from the respective State Electricity Boards/ marketing installation.

Utilities:

Power - Electrical power is required for auxiliaries and controls etc. and for illumination at the stations. Requirement of power is planned to be drawn from the respective State Electricity Boards/ marketing installation.

Water – while there is no major requirement of water for operation of the pipeline system the water for fire-fighting would be drawn from marketing installation.

Manpower: The cost towards salaries and wages is based on the estimated manpower requirement on the existing scales of pay and allowances.

Repair and Maintenance: Repair and maintenance of the mainline has been considered @ 1% of the investment in the mainline. Similarly repair and maintenance of the stations has been considered @ 2% of the investment on stations and telecommunication and telesupervisory system.

General administration expenses: The cost under this head includes management expenses including allocation of head office services, security services and insurance of facilities being proposed in the pipeline system etc.

Operating Cost

(May 2007 price level)

(Rs.in Lakks)

S.No.	DESCRIPTION OF ITEM	COST PER ANNUM
1	Electricity(for prime movers)	252
2	Utilities	
	Power & Water	5
3	Manpower	0
4	Repair & Maintenance	
	(a) Mainline	48
	(b) Pump Station and others	26
5	Other Expenses	
	(a)General Administration Expenses	1
	Total	332

LAWS OF PROJECT MANAGEMENT

The cardinal laws that are to be kept in mind while implementing any project are:

"Projects do not get into trouble, they start in trouble"

"Any spare time in the project schedule is used up at the start"

MURPHY`S LAW

Nothing is as easy as it looks;
Everything takes longer than you expect;
And if anything can go wrong,
It will and at the worst possible moment.

CHISOHN's LAW

Any time things appear to be going better,
You have overlooked something.

9.0 CONCLUSION:

High levels of construction activity are presenting numerous challenges to the industry in reliably progressing projects from the drawing board to commission and operations. Project management and engineering talent are in limited supply, construction spread availability is limited and raw materials are in high demand. In addition, the increase in construction work in a resource constrained market has resulted in an upward trend in prices and steady shift of project risk from the EPCM contractor to the asset owner.

Summing up my work is necessary there, as to present clearly the task covered by me.
To ensure high quality work only competent and skilled operators should be permitted to work on the job. They shall be qualified. They should work only as per the qualified procedure specification.
Following are the results associated with the work completed by me:

10.0 REFERENCES

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