Chapter 2

Project Description

2.1 Type of Project

Cairn Energy India Pty Ltd. (CEIL) proposes to start production of oil and gas from discovered fields in the state of Rajasthan. In order to start early production, CEIL intend to lay an onshore oil evacuation pipeline with associated facilities from Mangala terminal in Barmer district, Rajasthan to Salaya terminal in Jamnagar district via Viramgam. Total length of pipeline will be about 600 km. The pipeline has been divided in two phases / stretches viz. Mangala to Viramagam and Viramgam to Salaya terminal. The length of pipeline from Mangala to Viramagam terminal will be approximately 340 km, whereas pipeline between Viramgam and Salaya terminal shall have length of approximately 260 km.

Skin Effect Heat Tracing System and / or contingency gas fired indirect heating system and blending of diluents will be established to overcome waxy nature of crude oil and to achieve the continuous flow of liquids. The crude oil pipeline will be insulated with 90 mm Poly Urethane Foam (PUF) and 8 mm HDPE jacket to arrest the heat loss from pipeline to the surrounding soil. The heating stations with maximum 1.0 MW power generating units will be installed at every 18 km interval. Thus a total of 32 heating stations cumulating to 32 MW electricity capacities will be installed along the pipeline route.

Storage, handling, pumping and diluent's mixing facilities will be established at Viramgam and Salaya terminals. Two tanks of each 5,000 m^3 capacity (total 10,000 m^3) for crude oil storage will be installed at Viramgam terminal. Six tanks of each 50,000 m^3 for storage of crude oil and diluents (total 300,000 m^3) will be installed at Salaya terminal near Jamnagar. Viramgam and Salaya terminals require 8 MW and 10 MW power respectively for heating, diluents mixing and pumping the crude accumulating to the total energy of 50 MW spread across several locations. Power requirement will be met by captive generating sources of dual fired generators based on gas and / or oil.

A parallel gas pipeline of 8" diameter from Raageshwari gas terminal will be laid along the main crude oil pipeline corridor for supply of natural gas for heating and pumping stations.

Currently, developing countries, like India, which are signatories to various international treaties, do not have any commitment to reduce emission of greenhouse gases. However, in the near future, when India among other developing countries may have to show reduced greenhouse gas emissions intensity per unit of GDP than in the past, any environment-friendly project would be encouraged. At any rate, even without global pressures, local environmental considerations would favour a move towards projects that would contribute to reducing environment pollution. This pipeline and associated facilities project is a step forward in achieving this objective.

The pipeline will result in decongestion of roads, eventually minimizing road accidents and environmental pollution that are generated by other means of transport. This includes both air as well as noise pollution. The pipeline, being underground, will also provide lesser direct contact with the populace thereby reducing its impact as well as provide better overall security.

2.2 Need for the Project

India has been witnessing rapid urban and industrial growth in the past two decades, and with the country's current liberalization policy this growth is expected to accelerate and need additional energy for development. CEIL proposes to start production of oil / gas from discovered fields (Mainly Mangala and Bhagyam fields) in year 2009. The crude oil thus produced from these fields needs to be evacuated to the nearby refineries for processing into petroleum products. Mangalore Refinery and Petrochemicals Ltd. (MRPL), Indian Oil Corporation (IOC) and other refineries are potential buyers of the crude.

There is a large demand for natural gas / hydrocarbons in Western parts of Gujarat which is presently being catered to by means of road and rail transport. These modes, apart from being susceptible to the vagaries of poor roads, traffic congestion, shortage of tankers / rakes, and accidents can carry only small quantities of the products. This generally results in interrupted / intermittent supplies of the hydrocarbons to the consumers. The pipeline will ensure an uninterrupted availability of these products to the industrial and domestic consumers in this region in the required quantity at the required place and at the required time. The reliability of supply is thus extremely high. In order to facilitate the early production from these discovered fields, CEIL in partnership with ONGC propose to lay an onshore oil evacuation pipeline of approximately. 600 Km length with associated facilities from Mangala Terminal, Barmer District, Rajasthan to Salaya Terminal in Jamnagar District via Viramgam (Ahmedabad district) in Gujarat.

The road and rail transportation systems, at present, have to share the load of transporting raw material and finished products from the supply centers to the demand / consumer centers. Rail transport is utilized for carrying bulk of the petroleum products throughout the country and the balance quantity is transported by road. This is stretching the transport sector capacity and hindering the movement of other essential raw materials and products.

Transportation of crude oil by pipeline is comparatively less expensive than the other modes of transport both in the capital and operating costs. If a good network of pipelines is implemented throughout the country, this will ensure that the pipeline transported products will be available to the consumers at a lower cost than alternate modes of transport.

The environmental impact of crude transportation is the minimum for the pipeline mode of transportation. There is virtually no adverse impact on the existing road infrastructure as there is no additional load on the road network due to tanker movement. One of the additional advantages of pipeline transportation is that the scope of economic offences like theft / pilferage and adulteration of products is almost negligible

2.3 Location of the Project

The proposed insulated buried oil evacuation pipeline connecting Mangala terminal in Rajasthan to Salaya terminal in Jamnagar district through Viramgam station in Ahmedabad district, Gujarat will pass through parts of eight districts in both

the states. Out of the total 600 km pipeline length, the pipeline will traverse 150 km in Rajasthan and 450 km in Gujarat. Storage, heating, pigging, pumping and diluent's mixing facilities will be established at Viramgam and Salaya terminals.

The approximate route of the proposed pipeline is as under;

Sr. No.	Route	Approx. Length	Districts Covered
1	Mangala terminal to Raageshwari gas terminal	80 km	Barmer, Rajasthan
2	Raageshwari gas terminal to Sanchor	70 km	Barmer and Jalore, Rajasthan
3	Sanchor to near IOC terminal, Viramgam	190 km	Sanchor in Rajasthan and Banaskantha and Ahmedabad in Gujarat
4	Viramgam to Salaya terminal	260 km	Ahmedabad, Patan, Rajkot, Surendranagar and Jamnagar

Mangala terminal is located at 25º 55' 16" North latitude and 71° 30' 25" East longitude. Based on the preliminary survey, the tentative locations for Viramgam terminal (23º 05' 51" N and 72º 01' 51" E) and Salaya terminal (22° 19' 21" N and 69° 47' 27" E) have been finalized and shown in **Fig 1.1**. However, the final locations of terminals may change or shift within radius of 5 km from the proposed locations depending upon the land availability and local environmental considerations. The present route has been finalized based on least disturbance to the environment, human habitations, forest, aquatic bodies and avoid sanctuary, archaeological monuments and other sensitive locations.

The pipeline route in Rajasthan falls within the Thar Desert region with vast expanses of sandy soils with minimal vegetation. From the land use pattern, it can be observed that most of the land is barren and covered under sand dunes. The region does not have any natural forest and is characterized by rolling sand plains and scattered thorny trees (Babool). The area as a whole is sparsely populated with isolated pockets of habitation. The entire stretch of the block is covered by sandy soils with golden colored sandy dunes. There are rivers in the area. The area is characterized by scanty vegetative cover and is represented by xerophytic plants

The pipeline route in Gujarat would not pass through any environmental sensitive and reserved forest areas. Major land use along the proposed pipeline is agricultural / barren land. There are no established breeding grounds and migratory routes along the pipeline route and in the proposed storage terminals. No major hills and valley systems, archeologically important monuments, ecologically sensitive zones are observed.

The Desert National Park in Rajasthan is at a distance of more than 100 kms from the periphery of the Mangala terminal in Jaisalmer district. Utterlai airbase is located about 15 kms from the Mangala terminal in northern direction. The Wild Ass Wildlife sanctuary located in Little Rann of Kachchh, Gujarat is about 15 km away from the pipeline route and related facilities near Viramgam terminal. The Marine National Park, which is located along the coastal area between Jamnagar and Salaya, is approximately 30 km from the pipeline route. Jamnagar Airbase is about 15 kms north of the pipeline route.

2.4 Size of the Project

The proposed insulated buried crude oil pipeline extends from Mangala terminal of Barmer district in Rajasthan state to Salaya terminal near Jamnagar in Gujarat state. The pipeline has been divided in two phases stretches viz. Mangala to Viramagam and Viramgam to Salaya terminal. The length of pipeline from Mangala to Viramagam terminal will be approximately 340 km, whereas pipeline between Viramgam and Salaya terminal shall have length of approximately 260 km. Total length of pipeline will be about 600 km. The diameter of proposed crude pipeline is 24” and is designed with associated facilities for evacuation of 150,000 BOPD of crude oil.

Schematic showings of pipeline and related facilities from Mangala to Viramgam and Viramgam to Salaya terminals are shown in **Fig. 2.1 to Fig. 2.2** respectively.

Viramgam and Salaya terminals require 8 MW and 10 MW power respectively for heating, diluents mixing and pumping the crude. Thus the total energy requirement for the evacuation pipeline project is estimated as 50 MW spread across several location. Power requirement will be met by captive generating sources of dual fired generators based on gas and / or oil.

A parallel gas pipeline of 8“ diameter from Raageshwari gas terminal will be laid along the main crude oil pipeline corridor for supply of natural gas for heating

and pumping stations. Two tanks of each 5,000 m^3 capacity (Total storage capacity 10,000 m^3) for crude oil storage will be installed at Viramgam terminal. Six tanks of each 50,000 m^3 (total cumulative storage is 300,000 m^3) capacity for storage of crude oil and diluents will be installed at Salaya terminal near Jamnagar. The total estimated cost for the development of pipeline project including associated facilities is about Rs. 3500 Crores. Plot plan of Mangala terminal is shown in **Fig. 2.3**.

Gate valves and Motor operated Valves with controls shall be provided on the pipeline to regulate the flow as well as for isolation purpose and shall be capable of both remote and local operation. At least ninety numbers of motor operated valves (MOV) shall be provided at critical locations along the pipeline some of which are connected to the interlock system. These valves can also be operated from remote location. This will ensure quick isolation of the pipeline during emergency. The flow meters or metering station will have indicator, controllers, transmitters, and integrator with low and high flow alarms for custody transfer as well as part of the leak detection system.

2.5 Proposed Schedule for Approval and Implementation

CEIL intend to start production of oil and gas from Mangala field in Rajasthan by Q2, 2009. CEIL proposes to commence the pipeline laying in Q2, 2008 and complete the construction and testing operations of crude oil pipeline and associated facilities from Mangala to Salaya terminal by April, 2009.

2.6 Technology and Process Description

2.6.1 Crude Oil Pipeline Transport

The proposed insulated buried crude oil pipeline connecting Mangala terminal in Rajasthan to Salaya terminal in Gujarat will have total length of 600 km. The pipeline will traverse two districts of Rajasthan state and six districts of Gujarat state. The total length of the pipeline through various districts of Rajasthan and Gujarat is given in **Table 2.1**. It is proposed to transfer crude oil with maximum flow rate of about 150,000 BOPD and minimum of 30,000 BOPD.

Number of Tehsils and villages through which pipeline traverse are presented in **Table 2.2**.

The crude oil pipeline proposed routing tries to avoiding the following as far as possible.

- Built-up areas

- Proposed development areas based on the Information available
- Rugged Terrain
- Forest areas, water bodies and other environmentally sensitive areas

The proposed pipeline crosses network of National Highways, State Highways, Village Roads, Canals, Railway Lines and Rivers. Details of crossings are furnished in **Table 2.3**. The insulated pipeline will be laid with a minimum cover of 1.0 m below the ground level and the land will be reinstated to its almost original landuse after completion of laying the pipeline. In general, the pipeline and its associated facilities have been kept at a minimum distance of 100 m from any organized habitat as per Oil Industries Safety Directorate (OISD) guidelines. Therefore, Rehabilitation and Resettlement (R and R) issues will not be associated with the project. The storage locations at Viramgam and Salaya are located at safe distance from public utilities such as national and state highways, settlements, etc.

The evacuation pipeline facilities will be designed and constructed to meet the National and International standards and complies with HSE and legislation requirements. The integrity and safety of the pipeline will be monitored through computerized Supervisory Control and Data Acquisition (SCADA) and leak detection systems.

2.6.1.1 Pipeline Optimization / Sizing

The pipeline optimization study was carried out to develop the most economical configuration of the pipeline in terms of pipeline diameter, grade and wall thickness as well as the pumping requirements. The pipeline specifications are as follows:

Crude Oil Pipe

- Pipeline diameter : 24 "
- Wall thickness : 10.6 /11.1/12.7 mm
- Pipeline grade : API-5L-X65
- Material of Construction : Carbon Steel
- Insulation (PUF) : 90 mm
- Outer Jacket (HDPE) : 8.0 mm

Gas Pipeline

- Pipeline diameter : 8 "
- Wall thickness : 6.4 /7.1 mm
- Pipeline grade : API-5L-X56
- Material of Construction : Carbon Steel
- Coating : Three layer polyethylene (3LPE)

2.6.1.2 Operating Parameters

Crude Oil Pipe

- Line operating pressure : 90 bar
- Line Design pressure : 93 bar
- Maximum Temperature of product : 90°C
- Temperature to be maintained : 65°C
- Flow rate of Crude Oil : Maximum 1,50,000 BOPD and Minimum of 30,000 BOPD

Gas Pipeline

- Line operating pressure : 41 bar
- Line Design pressure : 49 bar
- Maximum design Temperature : 60°C
- Design Flow : 6.63 mmscsd

2.6.2 Associated Facilities Description

2.6.2.1 Viramgam Terminal

Viramgam terminal will primarily consist of storage, handling and pumping stations. The terminal will have 10,000 m^3 storage capacity of crude oil. The terminal will have two crude oil receipt tanks of 5,000 m^3 capacity each along with intermediate pumping stations. Adequate storage facilities with fire fighting and waste disposal facilities along with dyke and bunds for crude oil, fuel oil, chemicals and water will be planned as per the OISD guidelines. The land area required at this terminal is 25 ha. Viramgam terminal requires 8 MW power for heating and pumping

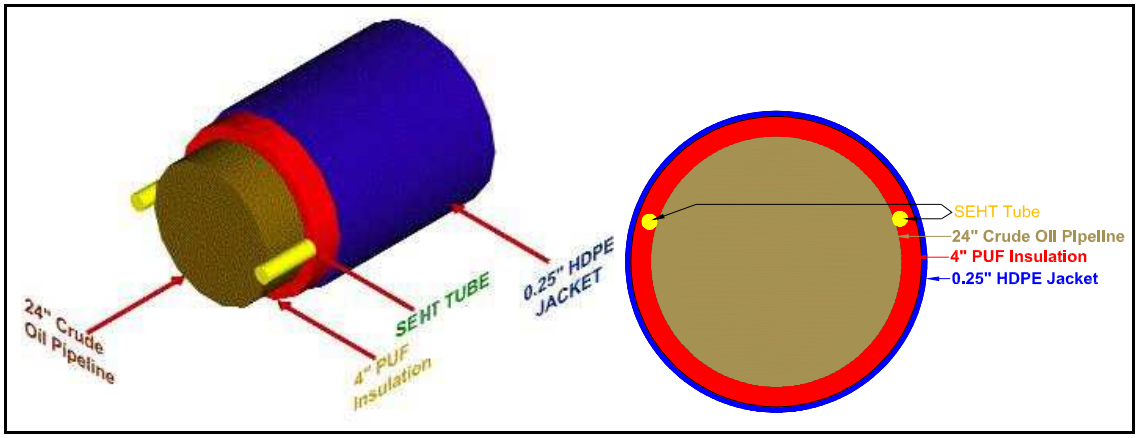
the crude oil. Power requirement will be met by establishing captive power generating facility based on gas and / or oil. This terminal will be having electrical sub-stations, metering facilities, telecom system and control room. Fuel gas and sewage treatment package units will be installed at this terminal. Plot plan of Viramgam terminal is shown in **Fig. 2.4**.

2.6.2.2 Salaya Terminal

Salaya terminal is located near Jamnagar in Gujarat state having 300,000 m^3 storage capacities of crude oil and diluents. The capacity will be spread into six storage tanks of 50,000 m^3 each. The facilities at Salaya terminal will primarily consist of storage tanks, blending facilities, crude oil pumps to consumers, utilities, power generators, control systems and terminal buildings. OISD guidelines will be followed for establishment of storage facilities. The land area required at this terminal is 100 ha. Salaya terminal requires 10 MW power for heating, diluents mixing and pumping the crude oil. Plot plan of Salaya terminal is shown in **Fig. 2.5**.

2.6.2.3 Skin Effect Heat Tracing System

As the crude is highly waxy and viscous, to assure continuous flow in the buried pipeline, Skin Effect Heat Tracing (SEHT) system will be installed. Heat tube duct of 1'', which may be one or more in numbers, will run along the entire length on the 24'' pipeline for running the cables of Skin Effect Heat Tracing System and for monitoring important parameters for the pipeline healthiness. The crude oil pipeline will be insulated with 90 mm Poly Urethane Foam (PUF) and 8 mm HDPE jacket and buried to arrest the heat loss from pipeline to the surrounding environment. The proposed heat insulation is shown in below figure.



Pictorial Representation of Pipeline with Heat Insulation System

2.6.2.4 Heating and Pigging Stations

Heating and pigging stations will be installed along the pipeline route. Captive power generating facilities will be established at all heating stations and Viramgam and Salaya terminals. Gas and / or diesel based Generators of 1.0 MW rating will be established at every 18 km interval along the pipeline route to supply power for these heating and pumping stations. A parallel gas pipeline of 8"diameter from Raageshwari gas terminal will be laid along the main crude oil pipeline corridor for supply of natural gas. Power requirement will be met by captive generating sources of dual fired generators based on gas and / or oil.

Suitable systems shall be provided for emergency power, DC power systems, and uninterrupted power supply. The system shall meet DGMS, Hazardous Area Classification and other standards applicable.

Heating / Tracing System

- Minimum temperature to be maintained : 65℃
- Insulation material : 90 mm PU foam
- Soil thermal conductivity : 1.80 W/m-K
- Number of heating sections : 32
- Length of heating section : 18 km
- Source of Power supply : DG / GG / State Power Supply

Power supply at middle of each section of the heat tracing system

- Heat output : 40 W/m (at 65℃)
- Overall effective heat transfer coefficient : 0.654 W/m-K

A 1" heat tube / duct, which may be one or more in numbers will run along the entire length on the 24 " pipeline (will be stitch welded) for running the cables for the Skin Effect Tracing System and for monitoring important parameters for the pipeline healthiness.

2.6.3 Operating Strategy

Gate valves and Motor operated Valves with controls shall be provided on the pipeline to regulate the flow as well as for isolation purpose and shall be capable of both remote and local operation. At least 90 numbers of Motor Operated Valves (MOV) shall be provided at critical locations along the pipeline some of which are

connected to the interlock system. These valves can also be operated from remote location. This will ensure quick isolation of the pipeline during emergency.

The flow meters or metering station will have indicator, controllers, transmitters, and integrator with low and high flow alarms for custody transfer as well as part of the leak detection system.

2.6.4 Pipeline Route Selection

The proposed evacuation pipeline route has been finalized based on the least disturbance to the environment and would not pass through any environmentally sensitive areas, human habitations, coastal and estuarine areas, archeological monuments nor reserved forests. The major land use along the proposed pipeline is agricultural / barren land. There are no established breeding grounds and migratory routes along the pipeline route and in the proposed storage terminals. In addition to above, the pipeline route has been selected to avoid the following.

- Mining areas
- Rugged and intricate grounds with hard strata, exposed rocks, boulders and quarries
- Built-up areas
- Places of worship
- Steep rising and falling ground, hills and valleys having sloping right of way

Efforts have been made to select the shortest possible route and to have minimum crossings of roads, rails, rivers and canals. Pipeline route has been selected to meet the requirements of economics, safety, constructability and availability of ROU including scope for further expansion.

2.6.5 Construction Methodology

2.6.5.1 Burial Depth of the Pipeline

General burial depth of the pipeline along the route will be with a minimum 1.0 m cover. Burial cover will be compacted to avoid future erosion by all weathers. Top soil replacement is seen as an important requirement in keeping the land uniform with the surrounding. Top soil, which will have been segregated and

protected along the RoU (Right of Use), will be back filled during the re-instatement activity phase.

Replacement of scrub and trees will also be made where possible that are without affect on the future of the pipeline. Site specific restoration and conservation plans will be developed. Topography in terms of Elevation versus Chainage for Mangala to Viramgam and Viramgam to Salaya terminals is shown in **Fig. 2.6**.

2.6.5.2 Pipeline Traverse at Crossings

The proposed pipeline crosses network of National Highways, State Highways, Village Roads, Canals, Railway Lines and Rivers. The rivers that encountered along the pipeline route are Luni, Sukri and Banas, Mahanadi, Brahmani and, however they are seasonal rivers and water flow can be found only during rainy season. The major irrigation canals include Narmada Canal and Sujlam Suphlam.

Auger boring method will be used to cross National highway and State Highways and major irrigation canals. Auger-Bore methodology will be used in accordance with statutory authorities and project specification and procedures.

Rivers crossings will be crossed using 'Open Cut' procedure where feasible to a depth 1.5 m pipeline cover below the estimated scour of river bed deemed for the foreseeable future. The buried pipeline will be concrete coated for anti-buoyancy and the coating will run the length of the river flood plain plus a minimum of 1 random pipe length beyond on each side, where the river is above the normal lie of the land it will be crossed using Auger Bore methodology. Drive and reception pits will be at least 2 m beyond the lowest landside of the dykes. Sheet piling will be used to keep the drive and reception pit walls in tack till back filling. Care will be taken of these dykes at all times

Before start of construction works for river crossings, a detailed procedure and method statement for the execution of river crossings shall be prepared, outlining the method of work, ecological aspects of river crossings, testing, execution of concrete coating, placing and lowering in , reinstatement, protection of river banks and river bed and the equipment used. During the construction of the river crossing, it is ensured that the water will be diverted around the construction site so that the downstream section of the river will not fall dry. In the case of crossing irrigation canals, it is ensured that the irrigation will not be interrupted during the construction works.

The excavation works in the river have to be done with the utmost care to avoid turbidity of the water as far as possible. The concrete coating has to be executed on lengths as indicated in the alignment sheets and other documents determining the concrete coating length. In case no protection of the riverbed is foreseen, the stratum of the riverbed has to be reinstated according to the natural conditions found in the riverbed (granulometry)

Any damaged banks to their previous slope shall be restored, cover with erosion protection material as required and provide adequate protection to the bank that might be eroded by the action of flood waters. Changes to width-depth ratio of watercourses and changes to natural substrate material at crossings shall be avoided. The stability of the channel at the crossings shall be monitored and remedial actions implemented if signs of instability such as erosion, sedimentation or other indicators of channel instability are noted by CEIL. Un-lined canals will be crossed with the buried pipeline using Auger boring / Open Cut method as per statutory approval.

Lined canals will be crossed using Auger boring below the canal concrete lining to a minimum of 1.5 m clearance. Railways will be crossed using cased pipe and auger-bored methodology. This will be done in accordance with railway authorities and project specification, procedures and specific approved method statements. Permissions shall be obtained from respective statutory authorities (railways, irrigation, highways, etc) prior to the commencement of work.

Method of pipeline crossing shall be as per table given below with approval from Statutory Authorities;

Sr. No.	Type of Crossings	Method of crossings
1	National highway	Auger Boring with Casing pipe.
2	State Highway	Auger Boring with Casing pipe.
3.	Other Roads	Conventional Trenching.
4.	Railway crossings	Auger Boring with Casing pipe.
5.	River Crossings	Conventional Trenching with concrete coating.
6.	Major Lined Canal	Auger Boring with Casing pipe.
7.	Unlined canal	Auger Boring with Casing pipe/ Conventional Trenching with concrete coating as per statutory requirements.

2.6.5.3 Pipeline Construction Method

The pipeline construction is proposed to be carried out through deployment of 4 to 5 spreads. Pump / storage terminals would be constructed through separate contractors. Critical lined canals are proposed to be crossed making use of Auger boring technique. It is proposed to lay pipeline using casing pipes at all railway and highway crossings.

The soil cover at critical locations will be increased as per the design code requirements. The optical fibre cable required for telecommunication system is also proposed to be laid in the same trench. During construction it will be ensured that

- Minimum number of trees are cut
- Inconvenience is minimised to the public
- Irrigation channel, fencing etc., affected during construction, is restored back ensuring that no damage is done to the landowners.
- Hydrostatic test water will be properly treated and disposed
- Trenches shall be backfilled and restored to original condition after the pipeline construction is over.

During construction, the following activities will be carried out:

Clearing and Grading

A 30 m wide Right of Use (RoU) area will be cleared off vegetation and other obstacles such as boulders. Critical areas will be marked on map before commencing the field activities. RoU boundaries will be clearly delineated and the site inspector will ensure that no clearing or encroachment occurs beyond these boundaries. Trees to be saved will be marked by flagging, fencing or any other appropriate method before clearing. Felling of trees will be restricted to the RoU, and will not affect the non-targeted tree population. In forest areas and scrubland, vegetation will be stockpiled for re-spreading as part of the restoration process. The Right of Use area will then be levelled to the required gradient. Earth movement resulting from grading of the ROW shall be minimized as far as practicable; however, the following shall be assured:

- The top soil shall be carefully removed and stockpiled along the edge of the temporary working strip, unless otherwise required by the land-owner or land-tenant.

- The access of vehicles along the RoU for the execution of each stage of the work.
- Rock outcrops and any other material, which may damage the pipeline or adversely affect trenching, shall be removed.

Stringing

Pipe transported to the site on trucks will be offloaded using side booms. The pipe then will be strung adjacent to the trench. Trailers and cranes will be used for the manoeuvring of pipes.

No pipe or other material shall be strung along the RoU before all clearing and grading operations have been carried out. In general, stringing may be performed before trench opening. In sections where blasting will be necessary for trench opening, stringing shall be done after trench excavation. Preferably it is expected that in normal soils conditions stringing be undertaken prior to trench opening.

The pipes shall be strung in such a way that normal use of the surrounding area is disturbed as little as possible.

Trenching

Trenchers and backhoe type excavators will be used to dig the trench for laying the pipeline. The topsoil will be removed segregating the remaining backfill material. The topsoil will be replaced in its position during the backfilling operation.

Blasting

The rock to a sufficient depth to accommodate the pipe will constitute trenching in rock. The storage, handling and use of explosives will be complied with necessary statutory requirements. Blasts will be blanketed as required to prevent damage to nearby structures, telephone lines, power lines or buried cables. Warning on the blast will be given to local inhabitants well in advance.

Every possible precaution shall be taken to prevent injuries and damage to persons, property and wildlife. No blasting will be allowed without prior written approval from regulating authorities and as well, written notice given to affected land owners, adjacent land owners, property occupants and any other affected parties.

Bending

The pipe will be bent using a bending machine to the appropriate angle to match the vertical and horizontal alignment of the trench.

Welding

Welding will be done using conventional manual/ Semi automatic welding involving a crew of welders and fitters. Once the pipe is strung a line-up crew will position the pipe using side booms in preparation for welding.

Pipe strings to be welded shall be effectively earthed. During welding, at least one end of the pipe string shall be closed to prevent a forced draught effect. Construction crews will always have the approved welding procedure at the site location where the procedure is being used. The ends of pipe strings shall be ensured by plastic or metal end caps bonded into place using a material fit for the purpose.

Following the completion of each working day or pipeline section, open pipe ends shall be effectively closed and shall not be opened until work restarts. Caps or plugs used for sealing pipe ends shall not be welded to the pipes or otherwise attached in any way, which could damage the pipes or the pipe coating.

Sufficient cross boards shall be provided to prevent pipe strings from slipping off skids. The length of the pipe string has to be limited to ensure integrity and safety due to thermal expansion effects. The maximum length of any welded out pipe string shall not exceed 1 km.

Non-Destructive Inspection

Mechanized Ultrasonic Testing (MUT) is the specified method to be applied for the execution of NDT. Each field weld will be 100% radiographed to test for soundness of the weld in compliance with specifications. NDT and its evaluation shall be performed in accordance with API Standard 1104.

Coating: After welding at each weld joint, coating of field joints of bare pipes and the repair of FBE coating shall be done by site application of High built liquid epoxy coating.

Required pre-heating shall be done with induction heating according to the approved coating application procedure. The ambient humidity may not exceed 85%. The humidity has to be proven by hygrometers and recorded. In case the mechanized spray coating is not applicable the coating shall be done by spray application by hand.

A holiday test shall be carried out, using an adjustable high voltage holiday tester having an audible and visual alarm. The scanning electrode shall consist of a

metal brush or coil spring, fitting the diameter of the coated pipes. The earth connection shall be made directly on the pipe without causing any coating damage. The test voltage shall be calibrated at least once per shift using a special high voltage meter.

When the holiday test is carried out, the external pipe surface shall be free of moisture. Following coating make-up the Joint will be covered with a HDPE Sleeve, overlapping the on pipe HDPE cover and through holes in the sleeve, PU foam will be poured and allowed to cure. Following curing, the sleeve will be sealed to keep the cover and insulation integrity.

The gas pipeline field joints will be coated with heat shrinkable sleeves.

Backfilling

The excavated soil will be returned to the trench. The topsoil, which has been preserved on the side of the Right of Use, will be spread over the filled up trench. Excavated and blast rock may be used as backfill above the layer of padding in agriculture, marshy and close to residential areas, up to the level of bedrock. A crown of soil will be kept on top of the trenched portion to allow for future settlement. Excess or unsuitable material will be cleared from the site and disposed of at a suitable site.

Backfilling will be managed so that damage from sizable rocks is not used or any other materials that may damage the pipeline insulation and jacket. The SECHT pipeline heating system is also prone to damage from bad handling and backfilling. Robust procedures are being drawn up to minimize any foreseeable back problems.

Fabrications and Tie-ins

Pipe fabrications include fittings, valves and connections that are welded to the pipe. These installations are usually prefabricated and then installed after the main construction crew finishes their work. The tie-in crews cut and weld the sections of the pipeline not constructed by the main crew.

Crossings

The method used for the crossing of waterways and other infrastructure facilities will vary from place to place depending on the environmental setting and the geo-technical features of the area. The detail method of various types of crossings is specified in clause 2.6.5.2.

Restoration

Restoration of the ROU will be conducted progressively following the completion of construction work. This will involve removal of foreign materials such as construction debris. The construction crew shall remove wastes, wrappers, packages daily. The terrain will be returned to its original condition by spreading the topsoil over the ROU and agriculture activities will be restored to original.

Pipeline Warning Markers

As the construction proceeds and the area are made good warning marker posts will be erected indicating the location of the pipeline and the crossing of other pipelines, cables and features. A marker tape will be placed in the trench 500 mm above the pipeline to indicate to future excavators that a pipeline is below and that they are nearing it.

2.6.6 Design and Safety Criteria

Design Considerations

The pipeline will be designed based on the most stringent international requirements and confirm to the Oil Industry Safety Directorate's (OISD) Standard # 141. Some of the considerations are described below:

Pipeline Thickness: Pipeline will be provided with extra thickness depending upon the land use and in conformity with ASME, ANSI and OISD requirements. Extra pipeline thickness will be provided at crossings near the populated areas and water bodies.

Pipeline Coating: The crude oil pipeline is proposed to be coated with FBE/ High Build Liquid epoxy and Gas pipeline is proposed to be coated with 3 layer polyethylene or equivalent high integrity coating for protection against external corrosion. Additionally an impressed current cathodic protection system will also be provided for Gas pipeline. The Crude oil pipeline will be provided with 90 mm thick insulation and 8.0 mm thick HDPE jacket.

Sectionalisation Valve Stations: Remotely operated sectionalising valves will be provided in line with the ASME B31.4 / B31.8 code and OISD requirements to isolate the pipeline sections during emergency or maintenance.

Pipeline Burial: Minimum depth of burial of the pipeline will be 1 metre below the ground level all along the route. This depth will be increased keeping in

view the sensitivity of the location. The OISD standards shall be followed for burial depth of pipeline.

All major Road, Railway and Canal crossings, the pipeline will be laid utilising Auger boring method.

Corrosion Inhibitor Injection: In order to protect the internal surfaces of the pipeline against the internal corrosion, corrosion inhibitor dosing at the originating pump station is proposed. To monitor the health of the pipeline, a corrosion monitoring system shall be installed.

Leak Detection: In order to avoid / minimise the hazards due to any leak in the pipeline, a leak detection system shall be provided along with SCADA system. By providing this system, it will be possible to detect the leak from the Master Control Station and thereafter, necessary measures to repair this leak can be undertaken.

Fire Fighting and Fire Alarm Systems: Adequate fire fighting facilities along with fire alarm and leak detection system shall be provided at all the pump stations.

Telecommunication and SCADA Systems: In order to monitor and control the pipeline operation an optical fibre cable based telecommunication system with SCADA facilities will be installed. The Master Control Station is planned to be located at Mangala and workstations at pump / SEHTS stations. Sectionalising valve stations will be remotely operated through the SCADA system.

Cathodic Protection System: The 3-layer polyethylene coating of the pipeline will be supplemented with Impressed Current Cathodic Protection System to protect the Gas pipeline against the corrosion. During construction of the pipeline, temporary catholic protection will also be provided.

Pigging of the Pipeline: For monitoring the internal condition of the pipeline, pig launching and receiving facilities will be provided at the beginning, end and at intermediate locations. The launchers and receivers will be designed for use of “intelligent” pigs to measure internal geometry and any corrosion.

Pipeline Materials: The pipeline will be fabricated from mild steel plates conforming to the American Petroleum Institute (API) Specification 5 L. The grade of steel will be X65. The minimum allowable yield stress will be 65,000 pounds per square inch. Pipeline material grade and final wall thickness will be selected based on design conditions defined in the Basic Engineering / FEED Package and

classification of locations and type of construction. All the pipeline material like valves, fittings and flanges etc. will be of ANSI class 600.

Block Valve Stations and Pig Traps: Block Valve stations will be provided in accordance with the requirements of ANSI / ASME Code B31.8/31.4 at intervals corresponding to location classes.

There is currently no compressor anticipated for the natural gas operations. At each block valve site there will be a total flow control valve that is capable of closing the flow of the pipeline gas under pressure in the manner of a “double block”. There will be a bypass facility to this valve, in case of its need, together with a vent pipe, which could be used to vent down a section of the pipeline, if this were ever required. It would not be required for normal operation. These block valve sites will be small fenced areas of approximate dimensions of 40 m x 50 m.

For pipeline safety the potential adverse impacts will be avoided by the use of standard for environmental protection and prevention measures during construction and operation as recommended by Oil Industries Safety Directorate (OISD).

2.7 Mitigation Measures and Environmental Standards

CEIL has adopted procedures in internalizing the environmental and safety parameters into the design of the project. Mainly the project design is based on the safety and environmental considerations. The components are route selection based on extensive survey, design practices, safety criteria and integrated construction methodology.

The entire length of pipeline shall be monitored at Mangala and Viramgam terminals for various parameters like temperature, pressure, and other pipeline condition monitoring parameters. Voltage, current and other important parameters associated with the Skin Effect Heat Tracing System will also be monitored. Motor operated valves / shut down valves / remote operated valves will be provided at the entire length of pipeline at suitable locations

2.7.1 Safety Provisions and Facilities

External / Internal Corrosion Coating

Suitable anti-corrosive coating would be provided for external corrosion protection. Compatible joint material shall be provided at the joints following welding.

As the crude oil and gas to be transported through the proposed pipeline is sweet, no internal coating is envisaged. However this aspect will be taken into consideration during the detail design phase.

Insulating Joints

Insulating joints would be provided between underground and aboveground portions of the pipeline for electrical isolation. Insulating joints would be of monoblock type and suitable for aboveground / underground installations.

Cathodic Protection

The proposed Gas pipeline only would be cathodically protected by an impressed current system. Cathodic Protection (CP) stations would be located at approximately 18 km intervals. The power source would be either power generating unit or grid power. These provisions will be finalised during detailed engineering design stage.

Leak Tests before Operation

The pipeline will be hydraulically tested to a pressure as per the design code requirements of the pipeline system. Also, the hoop stress will not be allowed to exceed 90% of the Specified Minimum Yield Stress (SMYS). The maximum operating pressure of the pipeline is 90 bar g. The hydraulic test will be for a minimum of 24 hours and will be conducted as required by the internationally accepted standard for high pressure pipeline design, construction and testing. Any test issues which are not addressed in the above standard and those specific to pipelines on land, will be referred to ASME 31.8.

Leak Tests during Operation

The construction standard will require all welds to be totally radiographed by x-ray and then followed by the hydraulic test. This will ensure that there are no leaks from the pipe manufacturing source or the construction work. In order to ensure that the pipeline can be controlled, should there be any leaks due to third party interference, then section line valves (block valves) will be installed in accordance with the design at intervals. The entire pipeline system will be monitored continuously from a control station. This monitoring will be electronically supervised by a Supervisory Control and Data Acquisition System (SCADA). The monitoring station will be manned continuously. An electronic leak detection system capable of closing down transmission of gas / hydrocarbon automatically will be provided by the SCADA system.

Leak Detection System

An integrated approach to meet the objective of accurate pipeline leak detection and location in a speedy manner, while minimising false alarms and keeping in view, simplicity of design and ease of interfacing with SCADA system has been proposed for the pipeline.

Brief description of various sub-techniques i.e. volume, balance, transient modelling proposed for pipeline are mentioned below.

Volume Balance

The basis of the volume balance method of leak detection is a balance of fluid volume over each section of a pipe. The volume balance relates directly to the conservation of mass within the pipelines. A leak is reported to be present in the pipeline section, if the difference between the instantaneous inlet and outlet flows is different from the steady state inventory of fluid in the section.

Transient Modeling

In this method, a mathematical model of the pipeline is used to calculate / predict flow rates and pressure which can be compared with measured values. When the deviation between calculated and measured values becomes greater than a certain threshold values, leak is reported.

Fire Fighting System

Before the pipeline is commissioned, various documents will be prepared. These documents will include a Safety Case (SC), a Major Accident Prevention Document (MAPD) and an Emergency Response (ER) document. This ER document will address the problem of an emergency such as a leak or fire and a procedure will be considered in detail within the document. This procedure will identify the involvement of all emergency services and will list the contact names and telephone numbers of Police, Fire and Ambulance officials. Hospital contacts will also be listed. Details of how people in remote areas can be transferred quickly to hospitals, in an unlikely event, will be addressed. This emergency procedure will be agreed with all emergency services and will be practised from time to time. In this way, improvements will be identified and the procedure will be revised accordingly.

SCADA System

The pipeline is proposed to be provided with latest state of the art computer based Supervisory Control and Data Acquisition System (SCADA) for safe and efficient operation of the pipeline. The Master Control Center (MCC) of the

pipeline SCADA system will be located at Mangala. MCC shall perform data gathering, monitoring and control of the complete pipeline through SCADA and Pipeline Application Software running under multi-programming, multi-tasking, real time operating system environment which will be modular in structure for efficient maintenance and taking care of future expansion needs. The remote Terminal Units (RTUs) installed at each station location shall provide interface between station instrumentation and the SCADA system. Dedicated telecommunication system will be provided for data transfer.

The main features of SCADA system besides remote plant monitoring and control functions are pipeline applications such as leak detection, batch scheduling, batch-tracking, pig-tracking, Interface detection, instantaneous reporting of alarm / events, pipeline operation optimisation, simulation of operations for training the operators, keeping inventory of the pipeline, MIS functions, Mimic display, Monitoring of data from the connected CP locations and self diagnosis. In addition to these features, it is also proposed to incorporate the operating status and mimic display of the tanks from which the products will be drawn as well as the status of the tanks at respective destinations in which the gas is proposed to be delivered.

The system shall be provided with Uninterrupted Power Supply (UPS) system for continuous working.

Main features of SCADA system are:

- Leak detection and location
- Tracking system for pigs and batch
- Interface detection system for the above
- Instantaneous reporting of alarm / events
- Pipeline operation optimization
- Monitoring of data from the connected cathodic protection locations, station fire fighting system, emergency generators, compressors, etc.

2.7.2 Environmental Mitigation Measures Incorporated into Project

Environmental and social aspects for the pipeline project have been considered right from the conceptual stage such as selection of pipeline routing in such a manner to avoid and minimize the adverse impacts and incorporation of design specification in various facilities to prevent the pollution. The same philosophy

will continue during construction, operation and decommissioning stages. Environment and social issues management during all these stages will be governed by Cairn's HSE and CSR policies. The environment and social issues management plan takes into account regulatory requirements, applicable international protocols and international best practices. The key steps of the whole exercise has been summarised in the following table:

Stages	Environmental and Social Stages
Initial Planning Phase	
Conceptual development	Screening of Environmental and social impacts
Front-End Engineering Design and detailed Engineering phase	Scoping of environmental and social issues through consultation with project group, HAZID studies to consider the company policies and objectives and regulatory requirements Identify needs for re-routing, location of pumping / pigging / heating and storage terminals, width of corridors etc. Design considerations such diameters of pipeline, thickness, No. of pumping / heating stations, No. of valves etc. Preparation of Detailed ESIA reports
Mitigation Management and Monitoring Phase	
Construction and commissioning	Implementation of Environmental and social mitigation and management measures and monitoring
Operation of Pipeline and storage facilities	
Pipeline decommissioning and abandonment	Preparation of Abandonment plan, if any and implementation

Advanced controls and instrumentation for operations and control of the pipeline and leak detection techniques shall be implemented for this project. No liquid effluent is envisaged as part of the operations. Any oil spillages as part of routine maintenance / operations shall be dealt with suitable spillage handling procedures with disposal to safe locations.

Spoil generated during trenching will be back filled into the pits. Top soil will be separately stored and restored in original position upon completion of pipeline construction. No hazardous wastes are envisaged from pipeline construction activities. The oily wastes (waxy) generated during pigging operations will be re-melted and injected back to the line itself along with the flowing crude oil. Solid wastes generated from the temporary camp sites, canteen and other wastes like

plastics, paper, cardboard, etc. will be properly collected, segregated and reused appropriately (recycle, reuse, and composting).

No wastewater on continuous basis from pipeline operations is envisaged. The wastewater generated during hydrostatics testing of equipment and pipeline will be reused for multiple tests. The residual hydro testing wastewater at the end of the testing will be collected in holding ponds and tested for its toxicity and biodegradability. Depending upon the quantity of wastewater upon treatment, the wastewater will be either solar evaporated or disposed into near by CETPs in Gujarat.

There will be insignificant emissions as the natural gas is preferably used as fuel for power generation and these source emissions will confirm to the MoEF / CPCB norms. No flaring or open venting is envisaged as part of normal / emergency operations is envisaged. All other wastes generated during the construction, pre-commissioning and commissioning activities will be disposed off appropriately in compliance to the rules and regulations.

2.7.3 Compliance to Legislation and HSE Requirements

The following major national and international codes and practices will be followed while laying the pipeline.

Technical Standards

- API Std 1104, Welding Pipelines and Related Facilities
- API 5L Specification for Line pipe
- ASME Section VIII Div. 1
- ASME B31.3, Process Piping
- ASME B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids.
- ASME B31.8, Gas Transmission and Distribution Piping Systems
- ASME Section V Non-Destructive Examination
- ASME Section IX Welding
- OISD-STD-141, Design and Construction Requirements for Cross Country Hydrocarbon Pipelines

- OISD-STD-117, Fire Protection Facilities for Petroleum Depots and Terminals Amended Edition
- OISD-STD-118, Layouts for Oil and Gas Installations
- OISD-STD-108, Recommended Practices on Oil Storage and Handling

Following list outlines the applicable Indian regulations related to Safety and Environment that will apply throughout the project.

Environment Regulations

- The Water (Prevention and Control of Pollution) Act 1974 and Rules
- The Air (Prevention and Control of Pollution) Act, 1981 and Rules
- Environment (Protection) Act, 1986 and Rules
- The Hazardous Wastes (Management and Handling) Rules, 1989 and Amendments
- Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 and Amendments

Safety Regulations

- The Petroleum Act 1934 and Rules 1976
- Gas Cylinders Rules, 1981
- Static and Mobile Pressure Vessels (Unfired) Rules, 1981
- Motor Vehicles Act 1988 and Rules
- Explosives Act and Rules
- Indian Electricity Act and Rules
- Indian Boiler Act and Regulations
- The Public Liability Insurance Act, 1991 and Rules
- OISD standards

For pressure relief and excess pressure and surge protection, necessary equipments and systems will be provided. The pipeline design takes into consideration the line stress analysis, thermal expansions and surge analysis.

2.8 Assessment of New Technology

Cross country oil and gas pipelines have been constructed and operated world wide including in India. The construction and operation of pipelines including storage and other facilities are common and their technological and environmental performance is well tested and proven. Though the establishment of heated pipelines are common in oil and gas industry, the laying and operation of such long heated pipeline with SEHT heating system is a first of its kind in India.

The proposed pipeline will transport crude with high wax content. The heating system will maintain the oil temperature above 65℃ and in worst case conditions will be required to restart flow after a prolonged shut down (cool down). The design approach adopted by the project is to provide a heating system capable of warming the cooled pipeline and its contents to 65℃, at which temperature the crude will freely flow.

The preferred method recommended by the project is based on a Skin Effect Heat Tracing ((SEHT) System installed along the pipeline in combination with insulation of the buried pipeline. Skin Effect Heat Tracing System (SEHT) to be used in this pipeline and associated facilities project is a versatile engineered heat management system configured to deliver heat for medium to long pipelines. This system can be used for material transfer lines, snow and ice melting, tank foundation heating, subsea transfer lines and prefabricated lines.

This heating system would be fed via multiple electrical feeds along the pipeline route. SEHT system may also be used during normal operation to improve flow and moderate wax deposition. Details of Skin Effect Heat Tracing System is shown in **Fig. 2.7**.

This Skin Effect Heat Tracing System (SEHT) has considerable applications over other heating systems like pipe in pipe co-current water heating system. Insulation cost is higher in pipe heating system because of the increased size of the outer pipe. Cost for implementation of pipe in pipe heating system is more as compare to SEHT System. Skin Effect Heat Tracing Systems are custom engineered in accordance with ANSI / IEEE 844, NEC 426 / 427 and plant standards.

Maintenance of SEHT systems is easy due to simple access to pull / splice boxes without disturbing insulation. This system is feasible to heat up to 20 kilometers (12 miles) from a single source using supply voltages approaching 5,000 volts.

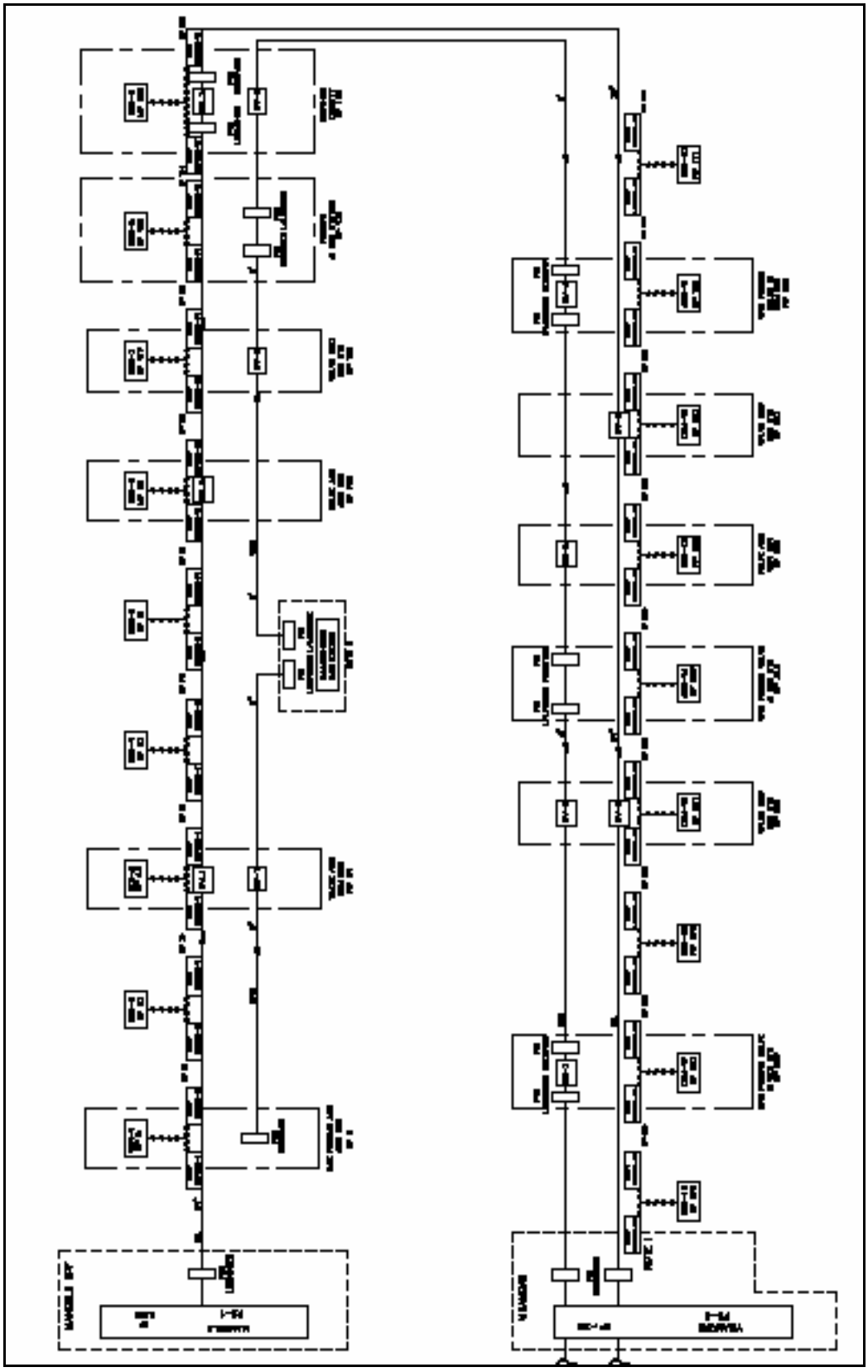


Fig. 2.1: Schematic Showing of Pipeline and Related Facilities from Mangala to Viramgam Terminals

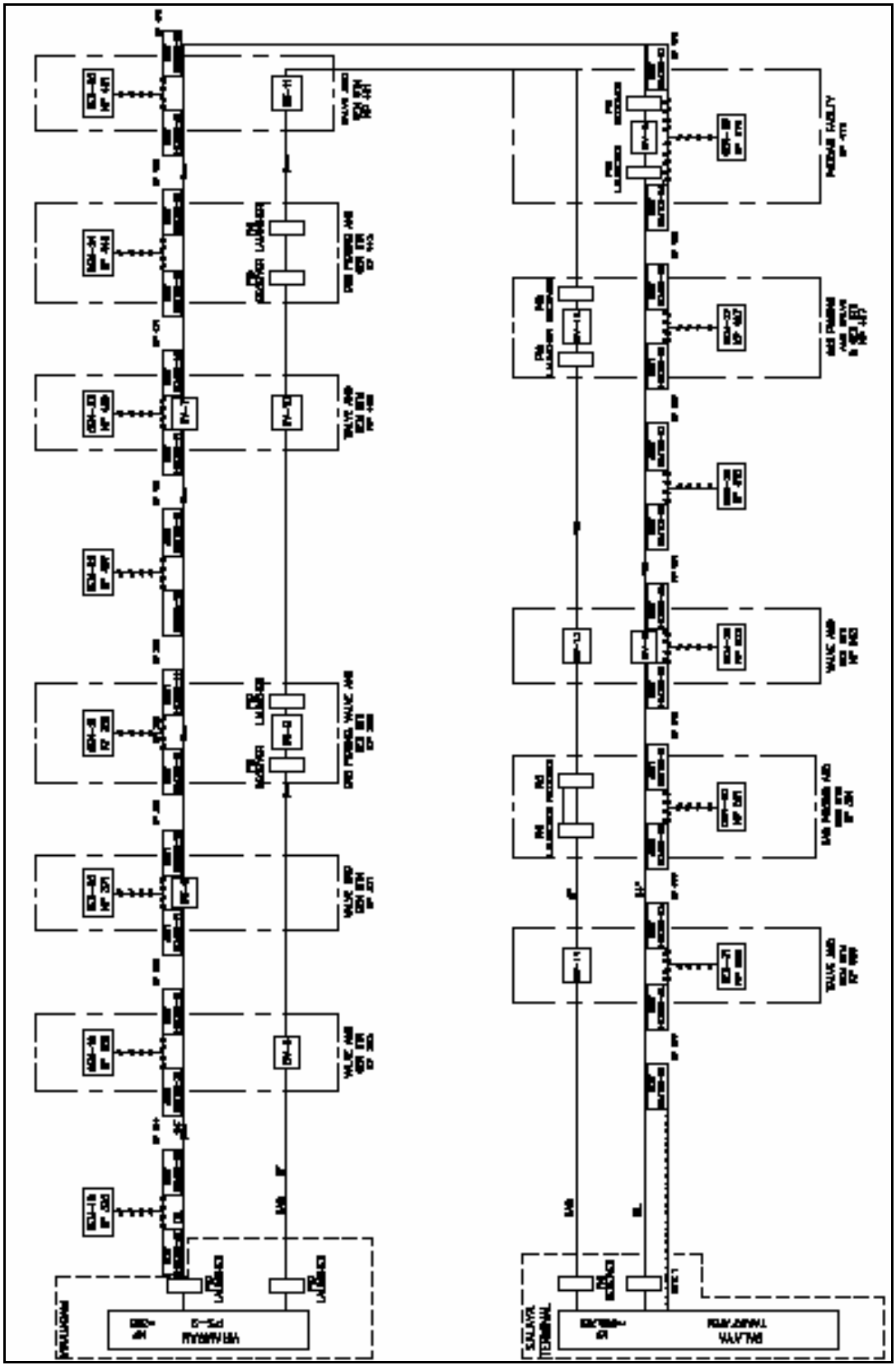


Fig. 2.2: Schematic Showing of Pipeline and Related Facilities From Viramgam to Salaya Terminals

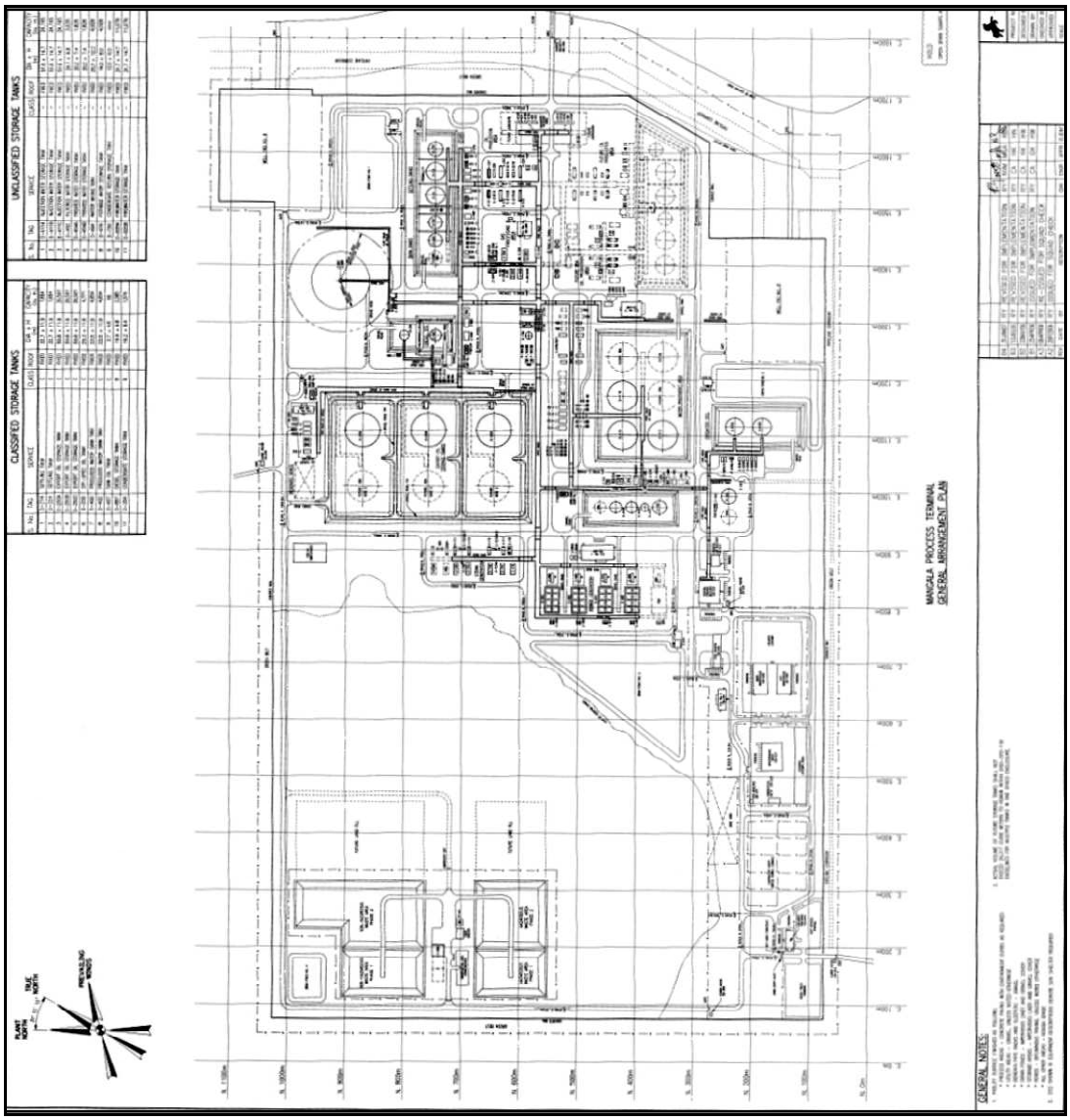


Fig. 2.3: Plot Plan of Mangla Terminal

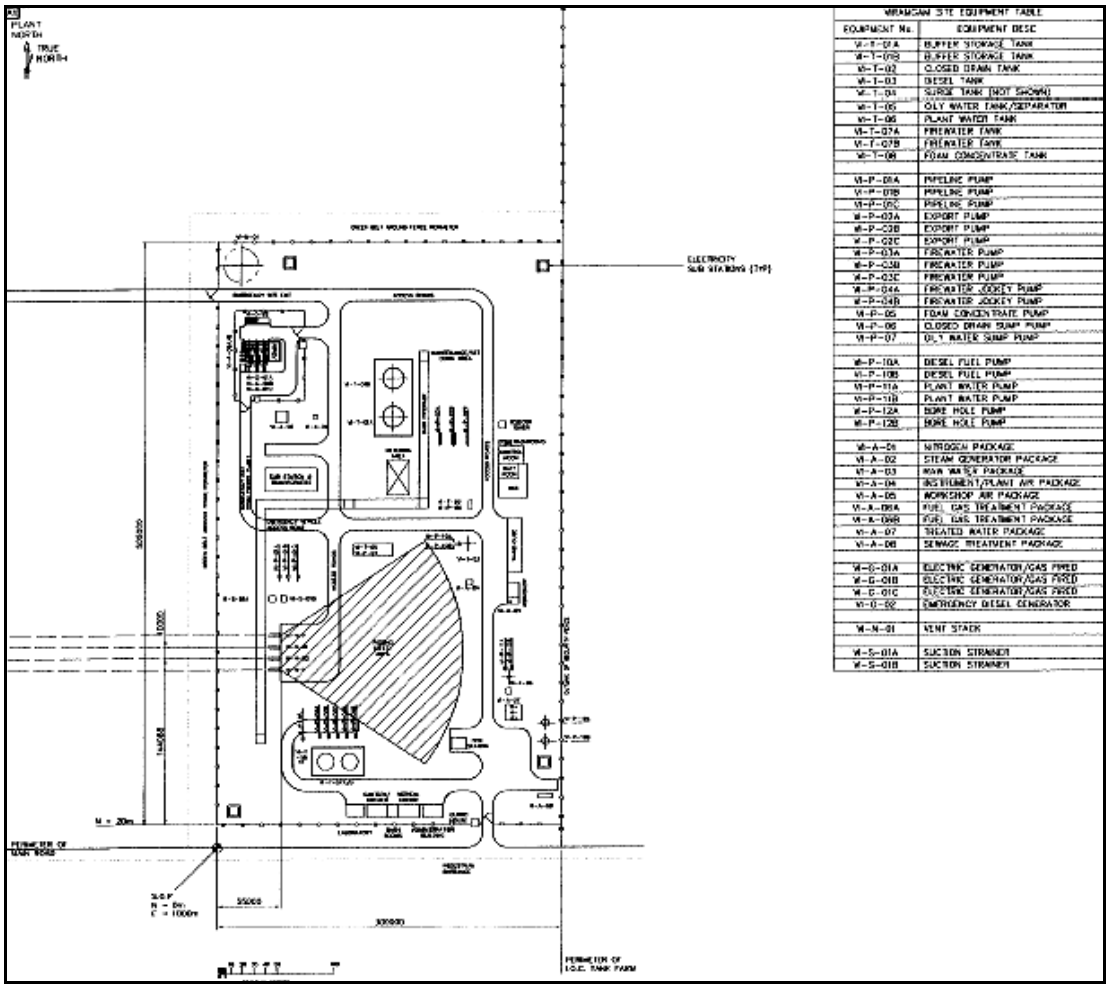


Fig. 2.4: Plot Plan of Viramgam Terminal

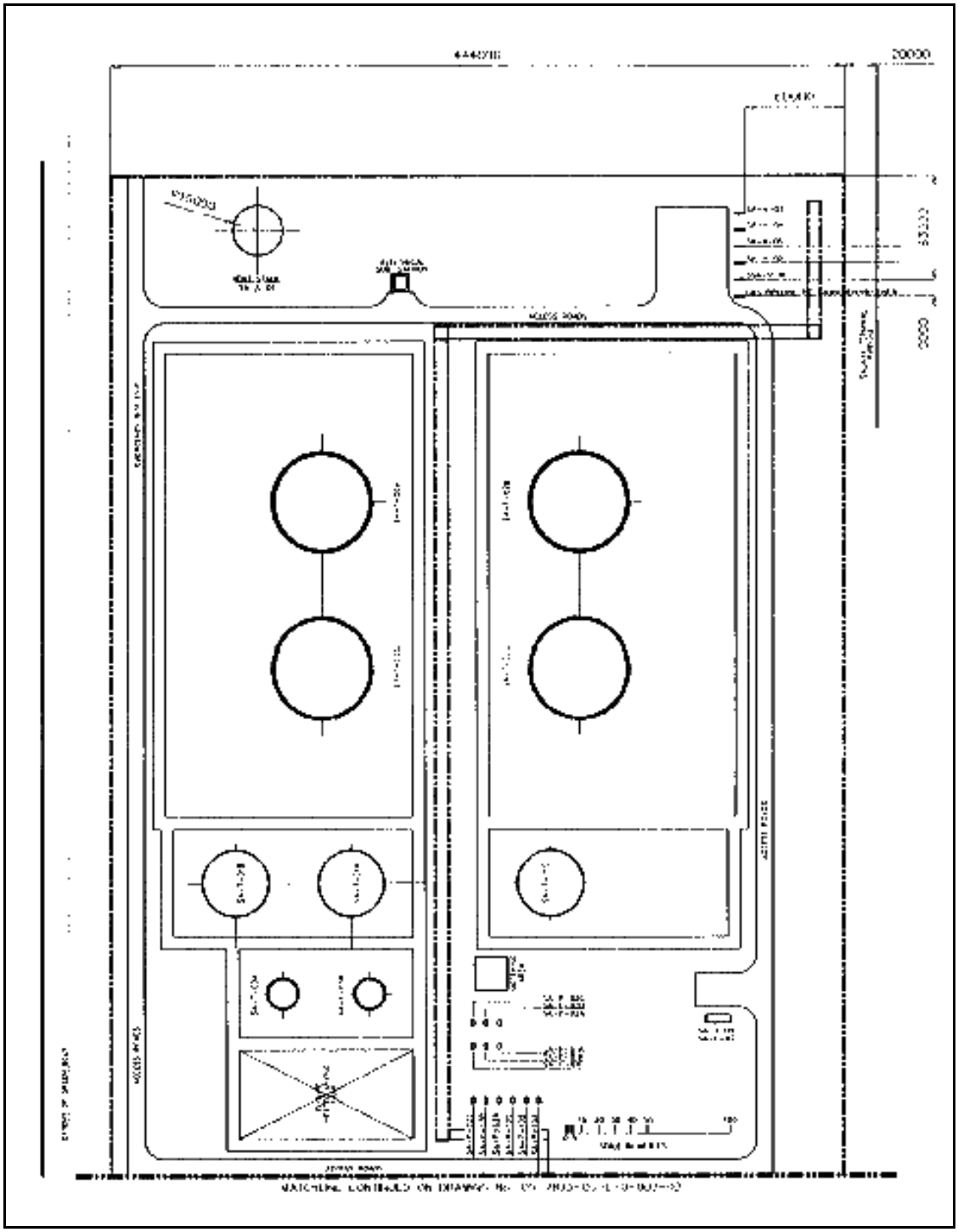
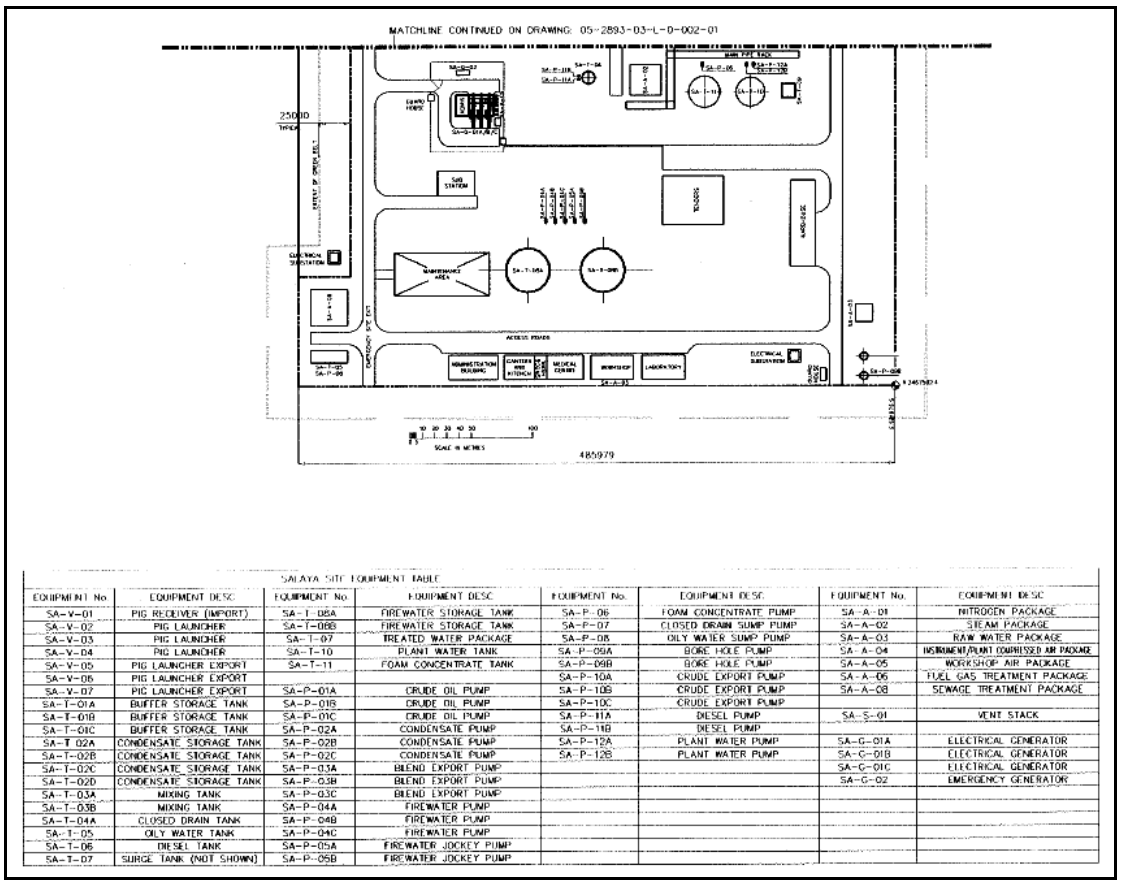


Fig. 2.5: Plot Plan of Salaya Terminal (Part A)

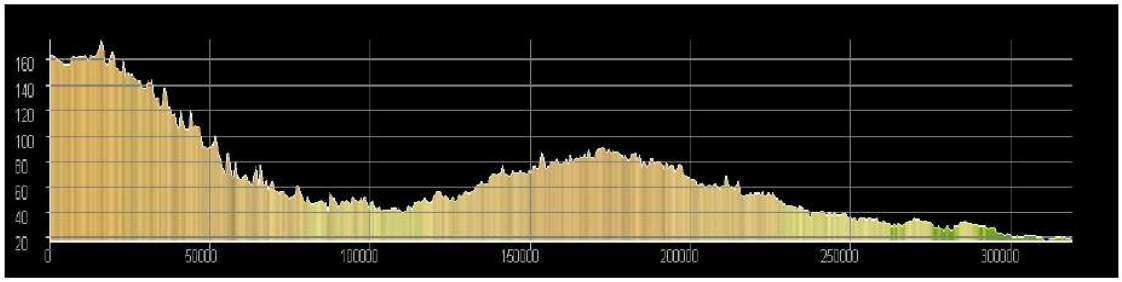


SALAYA SITE EQUIPMENT TABLE

EQUIPMENT No.	EQUIPMENT DESC.	EQUIPMENT No.	EQUIPMENT DESC.	EQUIPMENT No.	EQUIPMENT DESC.	EQUIPMENT No.	EQUIPMENT DESC.
SA-V-01	PIG RECEIVER (IMPORT)	SA-T-08A	FIREWATER STORAGE TANK	SA-P-06	FOAM CONCENTRATE PUMP	SA-A-01	NITROGEN PACKAGE
SA-V-02	PIG LAUNCHER	SA-T-08B	FIREWATER STORAGE TANK	SA-P-07	CLOSED DRAIN SUMP PUMP	SA-A-02	STEAM PACKAGE
SA-V-03	PIG LAUNCHER	SA-T-07	TREATED WATER PACKAGE	SA-P-08	OILY WATER SUMP PUMP	SA-A-03	RAW WATER PACKAGE
SA-V-04	PIG LAUNCHER	SA-T-10	PLANT WATER TANK	SA-P-09A	BORE HOLE PUMP	SA-A-04	INSTRUMENT/PLANT COMPRESSED AIR PACKAGE
SA-V-05	PIG LAUNCHER EXPORT	SA-T-11	FOAM CONCENTRATE TANK	SA-P-09B	BORE HOLE PUMP	SA-A-05	WORKSHOP AIR PACKAGE
SA-V-06	PIG LAUNCHER EXPORT			SA-P-10A	CRUDE EXPORT PUMP	SA-A-06	FUEL GAS TREATMENT PACKAGE
SA-V-07	PIG LAUNCHER EXPORT	SA-P-01A	CRUDE OIL PUMP	SA-P-10B	CRUDE EXPORT PUMP	SA-A-08	SEWAGE TREATMENT PACKAGE
SA-T-01A	BUFFER STORAGE TANK	SA-P-01B	CRUDE OIL PUMP	SA-P-10C	CRUDE EXPORT PUMP		
SA-T-01B	BUFFER STORAGE TANK	SA-P-01C	CRUDE OIL PUMP	SA-P-11A	DIESEL PUMP	SA-S-01	VENT STACK
SA-T-01C	BUFFER STORAGE TANK	SA-P-02A	CONDENSATE PUMP	SA-P-11B	DIESEL PUMP		
SA-T-02A	CONDENSATE STORAGE TANK	SA-P-02B	CONDENSATE PUMP	SA-P-12A	PLANT WATER PUMP	SA-G-01A	ELECTRICAL GENERATOR
SA-T-02B	CONDENSATE STORAGE TANK	SA-P-02C	CONDENSATE PUMP	SA-P-12B	PLANT WATER PUMP	SA-G-01B	ELECTRICAL GENERATOR
SA-T-02C	CONDENSATE STORAGE TANK	SA-P-03A	BLEND EXPORT PUMP			SA-G-01C	ELECTRICAL GENERATOR
SA-T-02D	CONDENSATE STORAGE TANK	SA-P-03B	BLEND EXPORT PUMP			SA-G-02	EMERGENCY GENERATOR
SA-T-03A	MIXING TANK	SA-P-03C	BLEND EXPORT PUMP				
SA-T-03B	MIXING TANK	SA-P-04A	FIREWATER PUMP				
SA-T-04A	CLOSED DRAIN TANK	SA-P-04B	FIREWATER PUMP				
SA-T-05	OILY WATER TANK	SA-P-04C	FIREWATER PUMP				
SA-T-06	DIESEL TANK	SA-P-05A	FIREWATER JOCKEY PUMP				
SA-T-07	SURGE TANK (NOT SHOWN)	SA-P-05B	FIREWATER JOCKEY PUMP				

Fig. 2.5: Plot Plan of Salaya Terminal (Part B)

Mangala to Viramgam Route Elevation Profile



Viramgam to Salaya Route Elevation Profile

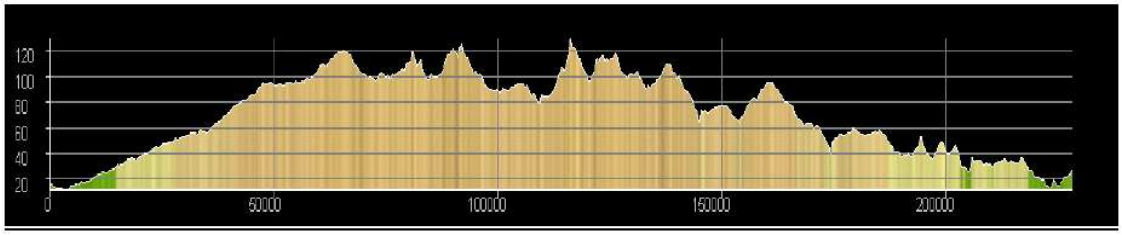


Fig. 2.6 : Topography in Terms of Elevation Versus Chainage

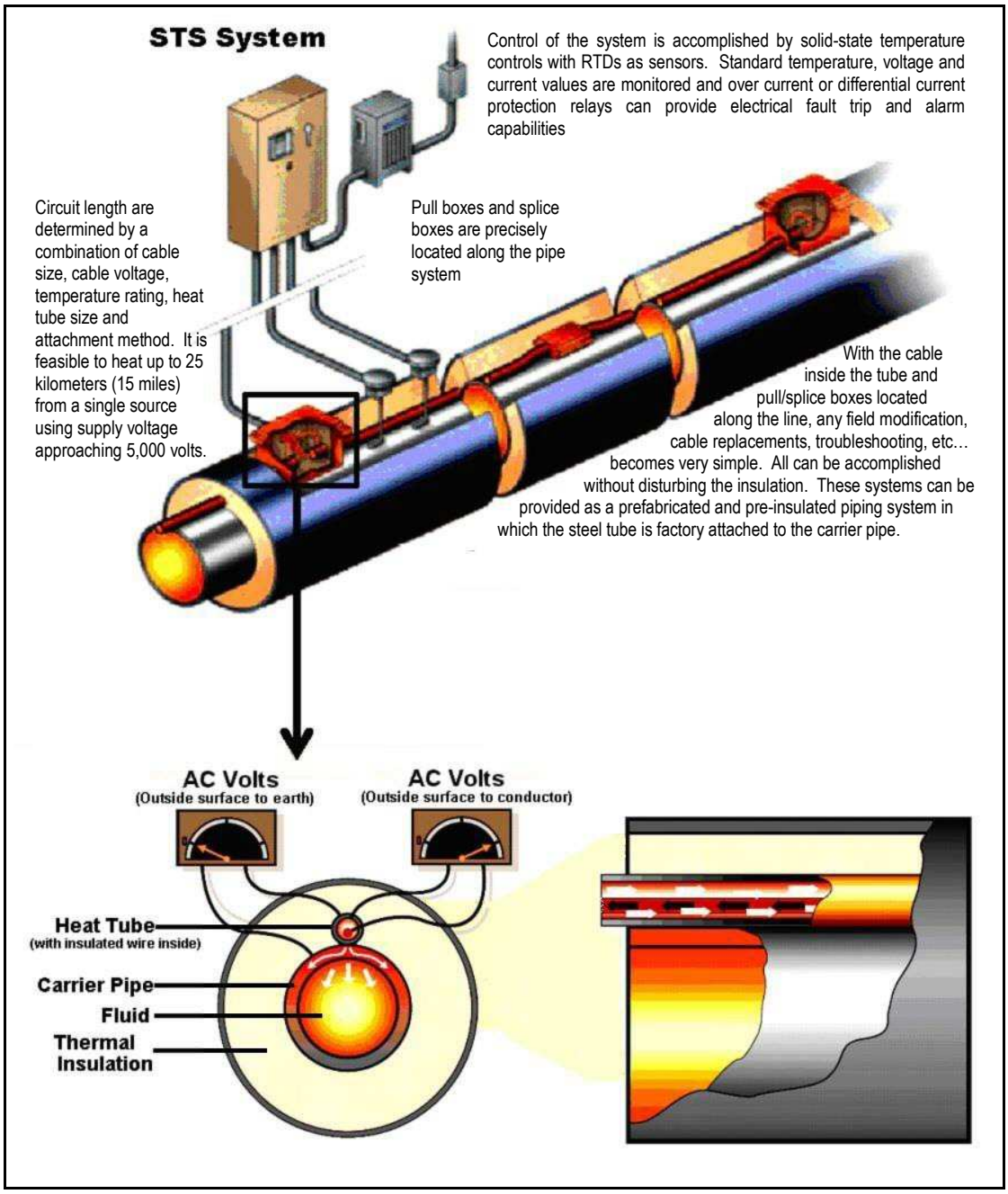


Fig. 2.7: Details of Skin Effect Heat Tracing System

Table 2.1

Pipeline Route Length through Various Districts

Sr. No.	State	District	Length (km)
1	Rajasthan	Barmer	103.42
2	Rajasthan	Jallore	49.04
3	Gujarat	Banaskantha	87.21
4	Gujarat	Patan	40.80
5	Gujarat	Ahmedabad	16.95
6	Gujarat	Surendranagar	133.36
7	Gujarat	Rajkot	76.75
8	Gujarat	Jamnagar	81.25

Table 2.2

Pipeline through Various Tahsils and Villages

Sr. No.	Districts	Tahsils	Villages
1	Barmer	2	37
2	Jallore	1	27
3	Banaskantha	4	42
4	Patan	2	18
5	Ahmedabad	2	13
6	Surendra Nagar	6	35
7	Rajkot	3	36
8	Jamnagar	3	35
	Total	**23**	**243**

Table 2.3

Crossings along the Pipeline

Sr. No.	Type of Crossing	No. of crossings		Total
		Phase		
		I	II	
1.	National Highway	2	1	3
2.	State Highway	13	15	28
3.	Railway Line	4	7	11
4.	Asphalted/Metalled Road	58	49	107
5.	Major Canals	8	14	22
6.	River	8	18	26
7.	Drain Channel & Nala	2	24	26
	Total	**95**	**128**	**223**