TATA CONSULTING ENGINEERS LIMITED

Pre-Feasibility Report

For 1,50,000 TPA PVC Plant, Gas Storage
17 MW Gas Based Captive Power Plant
& 3,60,000 TPA PMB Plant

M/s. Veritas Polychem Private Limited

Veritas House, 70, Mint Road, Fort, Mumbai 400 001, Maharashtra

March 2017

CONTENTS

III.	PFD Demineralised Water
IV.	PFD Reactor
V.	PFD VC Recovery & Storage
VI.	PFD Blowdown
VII.	PFD stripping & Slurry Storage
VIII.	PFD Dryer
IX.	PFD Screens & Product Handling
X.	PFD Waste water stripping
XI.	PFD for Ship Unloading & Transfer
XII.	PFD for Gas storage
XIII.	PFD for Tanker Loading
XIV.	PFD for Nitrogen Generation system
3.	MAN POWER REQUIREMENT CHART
4.	PAST PERFORMANCE DATA OF EXISTING PVC PLANT

REVISION STATUS

REV. NO.	DATE	DESCRIPTION
P0	07-03-2017	For Review & comments
R0	23-03-2017	For Reference & Records

CHAPTER – 1
EXECUTIVE SUMMARY

1. PREAMBLE

Veritas India Limited (VIL), founded in 1985 by Nitinkumar Didwania, and a listed Indian company, engaged in the business of international trade and distribution of chemicals-petrochemicals, polymers, paper and paper boards, rubber, heavy distillates and metals. VIL, through its subsidiary company, has about 450,000 T of supply contract. An opportunity was made available to VIL to buy out the PVC polymerization plant from Petronas, Malaysia. Considering the opportunity of backward integration, the promoter decided to set up the facility in India, at Dighi Port, as India is currently importing around 1.4 MMTPA of PVC. Accordingly, VIL proposes to set up a 150,000 MTPA Polyvinyl Chloride (PVC) manufacturing plant, a 360,000 Polymer Modified Bitumen (PMB) plant with storage tanks and a 17MW captive gas based power plant (collectively referred to as 'Project') through its wholly owned subsidiary Veritas Polychem Private Limited (VPPL) at Dighi Port.

TATA Consulting Engineers Limited has been entrusted the work relating to preparation of the Pre-Feasibility Report (PFR) for the integrated project (PVC Resin Manufacturing Plant, Captive Power Plant, Polymer Modified Bitumen Plant and a Gas storage terminal.

2. PROMOTERS

Veritas (India) Limited (VIL), a listed entity on BSE. VIL is Groupe Veritas Enterprise (GV) focuses on international Trade & Distribution of Chemicals / Polymers / Paper & Paper Boards / Metals & Minerals / Rubber / Petroleum / Fertilizers. Apart from International Trade & Distribution, advancement into logistics and infrastructure is the new focus area.

Other prominent group company is Hazel Mercantile Limited which is a flagship trading company in the group. The company – Veritas (India) Ltd and its subsidiary is collectively known as 'Groupe Veritas'. Financials of Veritas (India) Limited is given below:

(Rs. Cr.)

For the FY ended March 31	2014	2015	2016	H1-2017
Total Sales	1205.49	1502.75	1455.83	814.26
EBIDTA	39.29	57.10	68.21	36.6
Profit Before Tax	8.70	10.89	8.77	31.65
Profit After Tax (PAT)	31.04	48.03	60.23	30.73
Gross Cash Accruals	31.60	48.63	60.93	31.09

Tangible Net worth (TNW)	191.37	1023.49	1115.76	-
Total Outside Liabilities (TOL)	235.54	402.67	678.28	-
TOL/TNW	1.23	0.39	0.61	-
Current Ratio	1.75	1.48	2.14	-

External credit rating for the company was assigned by CRISIL on March 2016 for the Long

Term Facilities. The same is mentioned in the table below:

Facilities/Instruments	Amount (Rs. Cr.)	Ratings
Term loan	1.99	Crisil BBB+ (Stable)

3. Basis of the Study

Based on the inputs provided by VPPL in terms of the product capacity, and required capacities of utilities system etc, TCE carried out the technical feasibility to prepare the draft report, based on following methodology.

1. Study of various plants – Processes and Equipment
2. Cost estimation of each plant and overall cost of the plant from vendor quotation / in-house data.

4. Project Brief

The Project comprises of a 150,000 MTPA Polyvinyl Chloride (PVC) manufacturing plant and a 360,000 Polymer Modified Bitumen (PMB) plant, 16 mounded bullets for storage of gases with a 17MW captive gas based power plant at Dighi Port, Maharashtra. The brief description of Project is given below:

a. PVC Plant

VPPL proposes to buy a PVC plant form Petroliam Nasional Berhad (Petronas) in Malaysia. This plant is capable of producing suspension grade PVC (grades K57, K67 and K70).

The manufacture of suspension grade PVC is envisaged through vinyl chloride monomer (VCM) route, where VCM is polymerized to produce the PVC slurry using agitators and additives. The license for the plant shall be provided by Ineos Technologies, UK., the world's largest PVC technology provider having long standing experience in the related field.

The key requirements / constituents envisaged for the PVC Plant includes the following:

Major Equipments:

- 4 polymerization reactors,
- Strippers,
- Scrubber columns with associated centrifuges.

Process Control:

- Advance Systems' by Yokogawa and Rosemount,
- Instrumentation and control panels with adequate PA system.

Inside Battery Limit Facilities:

- Demineralized Water facility,
- VCM Recovery & Storage facilities,
- Drying facilities
- Final Product Handling facility.

Outside Battery Limit Facilities:

- Cooling Tower and Pumps,
- Seawater Desalination and RO Plant,
- Demineralized Water Unit,
- Boiler House/ Steam Supply,
- Instrument and Plant Air
- Nitrogen Supply and
- Effluent Treatment facility & Zero Liquid Discharge Plant.

Raw Material:

The basic raw material required for the PVC plant is Vinyl Chloride Monomer (VCM) and water. VPPL proposes to import VCM from Qatar and shall have adequate storage capacity for the same.

b. <u>Polymer Modified Bitumen (PMB) Plant and Ancillary Facilities</u>

Bitumen, one of the commercial products of petrochemical refinery, is primarily used in road construction, the tar roads to be specific. PMB is a specific type of bitumen which has higher tensile strength than normal bitumen. Locally, PSU's such as IOCL, BPCL, and HPCL produce VG30 grade of bitumen. The manufacturing process of PMB entails heating normal bitumen (VG30 grade bitumen) with styrene butadiene styrene (SBS) or ethyl vinyl acetate (EVA) at about 180 Deg C in large Blenders. SBS or EVA is thermoplastic additive which binds with the bitumen when heated at high temperatures to produce PMB. The key requirements / constituents envisaged for the PMB Plant include the following:

Major Equipments:

- Bitumen heating tanks
- Pumps, filters, flow meter
- Solid dosing
- Bitumen reactor
- Heated pipelines
- PMB storage tanks with stirrer and electric controls
- Semi Automatic drumming facility

Raw Material:

The basic raw material required for the PMB plant is Bitumen, styrene butadiene styrene (SBS) / ethyl vinyl acetate. VPPL proposes to import bitumen.

c. Gas Storage Terminal

VPPL proposes to construct 16 mounded bullets which would be used for storage of chemicals at high pressure. Each of these bullets would have a capacity of 2500 m3 aggregating to storage capacity to 40,000 cum. Out of these 16 tanks, 6 are proposed to be utilized for storage of VCM, the raw material for PVC production. The remaining 10 tanks would be utilized for trading other chemicals viz:- LPG & propylene.

d. Gas Based Captive Power Plant

VPPL proposes to setup a 17MW gas based power plant for captive consumption. The gas required for the production of power is proposed to be sourced from GAIL through gas pipelines including the Metering Station, which shall be within the boundary limit of the plant. There is already a pipeline connecting Dabhol and Panvel passing through Mangaon. GAIL will lay the pipiline up to the plot area including metering station located within the boundary limit of plant. Alternatively, LNG can also be procured using the local transport / can be imported at the port and can be re-gassified from the third party contractor.

Major Equipments:

- Genrators
- Turbine
- Waste Heat Recovery Boiler
- Transmission line
- Switchyard

5. Land

VPPL owns 65 acres of land at Dighi Port with its own waterfront for implementation of the Project.. The sub-concession agreement (SCA) for using the land has already been executed for development of the Project. Dighi Port is an all-weather port located in Raigad district of Maharashtra on the western coast of India about 150 Km south of Mumbai. The port is capable of handling bulk, break bulk, liquid, RoRo & container cargo. VPPL's plan for future involves building its own jetty for its own cargo inputs. The port has been identified as the one of the 7 National Investment and Manufacturing Zones (NIMZ) under the new manufacturing policy.

6. Project Cost

Sr	Particulars	INR in Crs
1	Plant & Machinery	358.54
2	Civil construction and Errection Cost	98.06
3	Others	29.00
4	Utilities	149.65
5	Contingencies	86.94
	Sub Total	722.19
1	Gas Storage Terminal	336.00
2	PMB Plant	49.00
3	Captive Power Plant	66.50
	Sub Total	451.50
	Total Project Cost	1,173.69

7. Key strengths of the project

a. Market for PVC:

PVC market is a huge market in India (2.8 Million Tonnes in FY16) and is expected to cross 5.0 MT in 2020. At present, the domestic PVC capacity is 1.5 MT and operational capacity is 90%. India's per capita consumption of PVC is 2kg as compared to the global

average of 8kg. About 50% of India's PVC demand is met through imports from South Korea, Taiwan, USA, Japan and China. The Group has an offtake contract to supply 450,000 tonnes of PVC. NHAI has plans to construct 30,000 km of roads in the next three years therefore demand for PMB would also increase in future.

b. Promoter experience and group financials:

The promoter has an experience of more than two decades in the trading and distribution business and has a strong acumen for commodity trading. The trading business has been scaled up from turnover of Rs. 16 billion in 2009-10 to Rs. 110.0 billion in 2014-15. The Group has also good relationship with banks viz; Axis Bank, Punjab National Bank, State Bank of India, Union Bank of India and IDBI Bank. The group's credit standing is well rated by CRISIL.

c. Strong relation with several customers and suppliers:

Veritas has been in the chemicals and rubber trading business for more than two decades and has established itself among the major players in the domestic as well as international markets. The group has not only free trade zones in UAE but also has strong relationships with large chemical suppliers and customers which includes large corporates such as Reliance Industries Ltd, Indian Oil Corporation Ltd, Asian Paints Ltd, Kansai Nerolac Paints Ltd, Sun Pharmaceuticals Ltd, Lupin Ltd and Deepak Fertilizers and Petrochemicals Ltd. Among the suppliers the group has strong relationships with Exxon Mobil Chemical Company, Eastman Chemical Company, Shell International and Dow Ltd.

d. Established Global presence with wide distribution network:

Over the years the group has established its presence globally, as indicated by its strong relationships with chemical suppliers and customers. The group imports most of its requirements and derives 40% of its revenues from international markets.

Internationally the group is present in 15 countries supporting a signicant increase in its scale of operations. Even in the domestic market the group has large storage capacities at almost all key ports and has offices in 16 cities each of which is a dry dock stock point.

e. Contractual structures:

The implementation of the project has already begun. We understand the agreement for purchase of the plant from Petronas and license from Ineos has already been executed. The process of dismantling the plant from Petronas has begun. The Company has

entered into a Sub Concession Agreement (SCA) with Dighi Port for implementation and operations of the Project.

CHAPTER – 2
COMPANY PROFILE

Veritas (India) Limited (VIL), a listed entity on BSE. VIL is Groupe Veritas Enterprise (GV) focuses on international Trade & Distribution of Chemicals / Polymers / Paper & Paper Boards / Metals & Minerals / Rubber / Petroleum / Fertilizers. Apart from International Trade & Distribution, advancement into logistics and infrastructure is the new focus area.

Business Verticals; VIL operates into the following key business Verticals;

- General Trading in line with Group Activities
- Logistics Park and services
- Power Generation through non-conventional methods
- Agro Venture with vast land under cultivation

Other prominent group company is Hazel Mercantile Limited which is a flagship trading company in the group. The company – Veritas (India) Ltd and its subsidiary is collectively known as 'Groupe Veritas'. Financials of Veritas (India) Limited is given below:

- (Rs. Cr.)

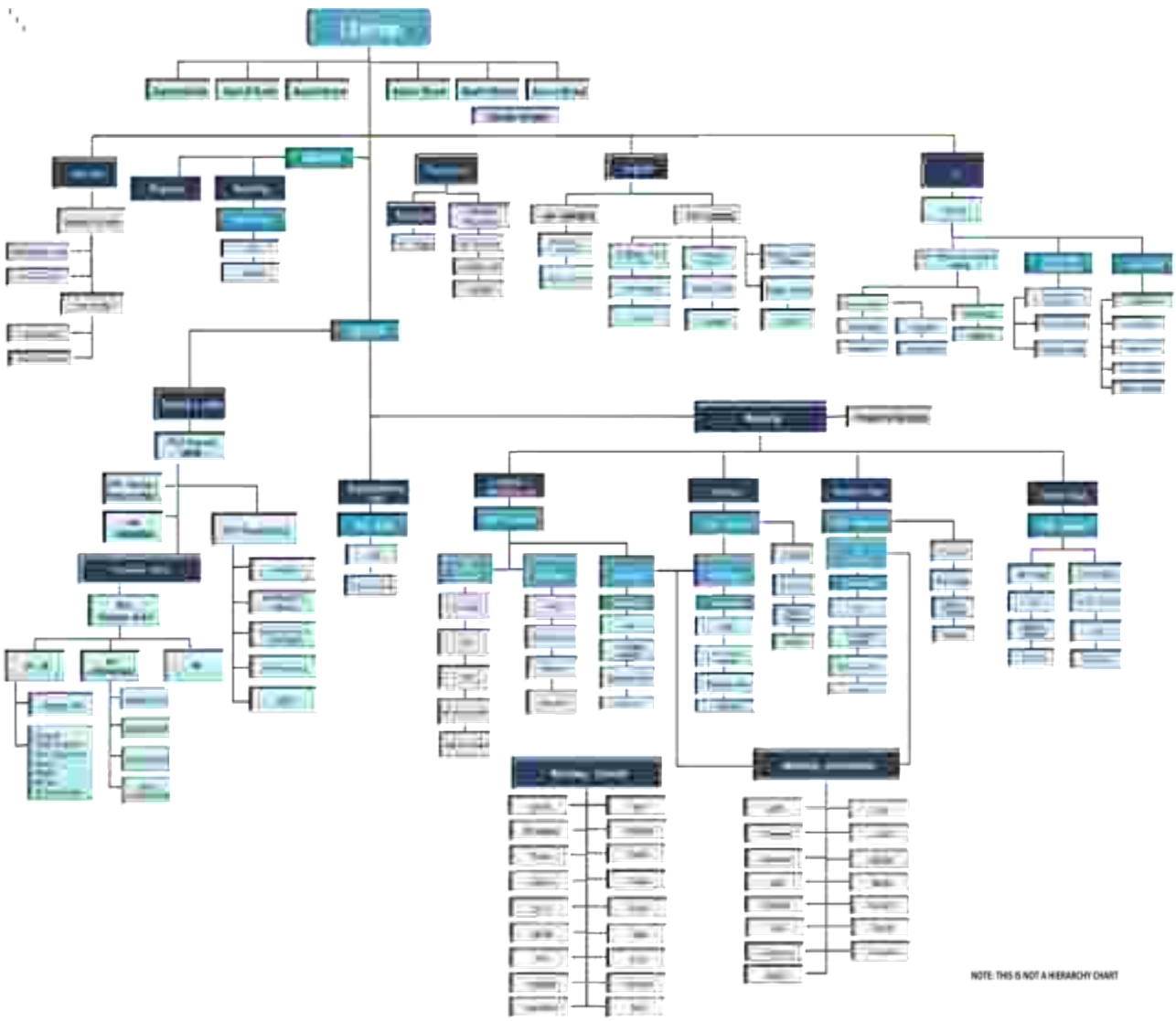
For the FY ended March 31	2014	2015	2016	H1-2017
Total Sales	1205.49	1502.75	1455.83	814.26
EBIDTA	39.29	57.10	68.21	36.6
Profit Before Tax	8.70	10.89	8.77	31.65
Profit After Tax (PAT)	31.04	48.03	60.23	30.73
Gross Cash Accruals	31.60	48.63	60.93	31.09
Tangible Net worth (TNW)	191.37	1023.49	1115.76	-
Total Outside Liabilities (TOL)	235.54	402.67	678.28	-
TOL/TNW	1.23	0.39	0.61	-
Current Ratio	1.75	1.48	2.14	-

External credit rating for the company was assigned by CRISIL on March 2016 for the Long

Term Facilities. The same is mentioned in the table below:

Facilities/Instruments	Amount (Rs. Cr.)	Ratings
Term loan	1.99	Crisil BBB+ (Stable)

Organization Structure



CHAPTER – 3
PROJECT DESCRIPTION

The project comprises of a 1,50,000 MTPA Polyvinyl Chloride (PVC) manufacturing plant and a 3,60,000 Polymer Modified Bitumen (PMB) Plant, 16 bullets for VCM, LPG & Propylene storage with a 17 MW captive gas based power plant at Dighi Port, Maharastra. The brief description of project is as follows:

1. PVC Plant

VPPL proposes to import the second hand plant from Petroliam Nasional Berhad (Petronas) and situated in Malaysia. This plant is capable of producing suspension grade PVC (grades K57, K67 and K70). The plant is being setup with world largest PVC technology providers, namely Ineos Technologies, UK.

The plant will be a polymerization plant which will convert Vinyl Chloride Monomer to Poly Vinyl Chloride. Ineos will provide all the technology upgrades and developments and tailored support on environment.

It would be a state of the art plant with the latest technology in the plant provided by Ineos technologies. The Plant design meets and exceeds European Union Standards and safety and environment, which are among the highest in the world. The location of the plant close to the Port has distinct advantages. Dighi port is known for all weather jetty with a draft more than 14.5 Mts. Direct pipelines from the jetty till plant location make it most advantageous. The Proposed production capacity for PVC will be 150,000 expandable to 200,000 Tons / Annum. The basic raw material required for the production would be VCM and would be imported from Qatar, apart from this the product would also be imported from Japan, China or Europe. It will be primarily stored under pressure in Mounded Bullets with the ASME specifications.

The other component would be water. Especially for India, Ineos technologies condenser process allows fast reactions without the use of chilled water for cooling the reactors. This is specially as advantage in India, where cooling water temperatures are high because it saves the high energy consumption. The total requirement of Fresh water would be 1970 Kilo Liters per Day (KLD) and that of recycled water would around 1000 KLD. The water requirement for process and domestic purposes would be met from Kudki Dam and Sea water desalination systems.

2. Gas Storage Tanks

It is envisaged to construct 16 bullets of 2500m3 capacity each. It will boost the total storage capacity to 40000m3. Out of these 16 bullets, 6 bullets are proposed to be

utilized for storage of VCM, the raw material for PVC production. The remaining 10 bullets would be utilized for storage and trading other chemicals viz. LPG & Propylene.

Following are the brief description of the Gas storage terminal:

VCM, LPG & Propylene will be supplied through jetty (approx. 1600 Meters away from plot location). Existing pipe route is considered for proposed pipe routing upto Tank farm. New pipe from jetty to tankfarm (of others) is presumed to be taken along the existing road from tank farm to the proposed location.

Product to be stored	**Capacity/ Bullet**	**Number of Bullets**	**Pressure**
Vinyl Chloride Monomer (VCM)	2,500 M^3	6 (4 in existing contract, 2 is additional scope)	10.0 Kg/ cm^2
LPG	2,500 M^3	2	14.5 Kg/cm^2
Propylene	2,500 M^3	8	23.0 Kg/ cm^2

Tanker loading facility for LPG & Propylene.

3. <u>Polymer Modified Bitumen Plant</u>

Bitumen, one of the commercial products of petrochemical refinery, is primarily used in road construction, the tar roads to be specific. Its demand in India is ever increasing due to persistent infrastructure development in the country.

Bitumen is offered in many varieties defined in its penetration power, however, the 60/70 penetration grade (also referred to as VG30 Grade) remains the working horse of the road construction and pavement industry. Locally, the PSU's, IOC, BPCL, and HPCL produce these grades.

A typical VG30 quality bitumen can be suitably modified by formulating it with either a plastomeric thermoplastic such as ethylene vinyl acetate copolymer (EVA) OR an elastomeric thermoplastic such as styrene-butadiene-styrene (SBS).

PMB's qualities:

- Greater Rigidity
- Better resistance to permanent deformation
- Higher Resistance to spreading cracks
- Greater water resistance
- Much higher durability

PMB is used for:

- Very Stressed Pavements
- High Traffic Volume
- High Loading
- High Temperatures Amplitude
- More Durable Pavements
- Draining Pavements

Following are the brief description of the PMB Plant:

- Bitumen will be supplied through jetty (approx. 500 meter away from plot location). Existing pipe route is considered for proposed pipe routing upto Tank farm. New pipe from jetty to tankfarm (of others) is presumed to be taken along the existing road from tank farm to the proposed location.
- Tanker unloading facility for bitumen
- Storage tanks for Bitumen - 2 tanks (combined capacity of tanks 5000 MT)
- Storage facility for combining agent / polymers including unloading facility.
- PMB mixer/blender plant.
- Finished product (PMB) storage tanks – 2 tanks (combined capacity of tanks 5000 MT)
- 450 - 500 drums/hr Mechanized and semi-automatic drumming facility for finished product.

4. 17 MW Gas Based Captive Power Plant

VPPL proposes to setup a 17 MW gas based power plant for captive consumption. The gas required for the production of power is proposed to be sourced from GAIL. GAIL will supply the gas up to the plant boundary.

CHAPTER – 4
MARKET STUDY REPORT

Poly Vinyl Chloride (PVC)

Globally, plastics industry is one of the leading contributors to economic growth. In spite of recession and long-term consolidation trend, the plastics industry has been one of largest and fastest-growing industry sectors of the economy. In the second half of the 20th century, plastics emerged as one of the most universally-used and multipurpose materials in the global economy.

The plastics industry is the third largest manufacturing industry in the US, contributing significantly to the nation's economy. In Europe, plastics industry is stabilised from the recession and now moving towards growth. Competition in the industry is constantly growing and plastics market is increasingly shifting towards Asia especially to China and India.

Global plastic demand in 2015-16 was observed to be approximate 170 million metric tonnes (MMT). Asia having 43% share, which is expected to grow to 47% by 2021, when global plastic consumption is estimated to reach 250 MMT

PVC is the third largest in the plastic consumption globally. PVC industry in India is 5 decades old with establishment of first PVC plant in 1961. With introduction of various PVC products in 1970s, PVC consumption in country started doubling almost every five years. During 1985 - 1995, adoption of Green Revolution by the country resulted in increased usage of PVC pipes in the agriculture sector due to their superior performance. The consumption of PVC raised to 2 MMT by 2012 due to massive infrastructure development in the country during 2004 to 2012 and because of contribution of PVC to end use applications including pipes, conduits, wires and cables, doors, partitions and windows.

Currently PVC consumption in India is about 2.3 MMT against domestic production capacity of 1.3 MMT. This is leading to demand-supply imbalance resulting in imports of 1 MMT PVC resin in the country. It was observed in last few years that in spite of slowdown in economic growth, PVC consumption is growing with double digit. PVC demand is estimated to reach 4.5 MMT by 2020 with modest growth rate of 10%.

India is one of the fastest growing infrastructure opportunity in the world. With an estimated investment of about US$ 311bn over the next 5 years. 42% of the infrastructure investments would be in the construction sector. The key thrust areas would be

- ¾ Building & Construction
- ¾ Roads, Ports, Aviation
- ¾ Power & Telecommunication

- Water & Sewerage
- Gas distribution & Industrial infrastructure

All the above has a huge potential for the polymer applications.

The Thrust areas of the Indian Polymer Industry are a) Special Economic Zone b) Agriculture c) Infrastructure and e) Retail Business.These are coupled by Rising Disposable Income – Low Per capital consumption – Buoyant Economic Growth – Favorable Demography and Growing Middle Class gives the Indian Polymer Industry an impetus to grow at a fast pace.

The Total Estimated Consumption of Polymers in India is as follows.

Products	Percentage in Polymers
LDPE	5.35%
LLDPE	8.69%
HDPE	19.51%
PP	35.55%
PVC	23.85%
Others	7.05%
Total	**100.00%**

PVC holds a significant share among polymers. PVC consumption in India is about 50 years old and is flourishing since last couple of decades. PVC consumption has doubled towards the end of 2010. The demand is growing at double digit rates as compared to global consumption. However, the production capacities have not increased.

The consumption drivers have been Pipes & Fittings towards Water Management / More Crop per Drop and energy Conservation.

The growth has been in the manufacture of Pipes & Fittings used in the agri sector. Profiles in the Construction sector. Calendering used in Pharma Sector / Floorings and Packaging / Profiles used in Constructions / Fabrication facilities and Energy conservation

PVC industry is one of the major contributors to the economy of the country. With huge investments in infrastructure development, India will be the growth centre of the global PVC industry. PVC products have huge potential to curb the challenges faced by the country. Introduction of innovative technologies and products based on PVC will certainly make difference in the sustainable management of country's infrastructure and economy.

Market Data

The Per Capita Consumption of PVC in India is one of the lowest standing at 1.16 Kg whereas the World average is at 5.1 Kg. Hence there is tremendous potential for growth. The Domestic scenario is a follows.

Capacity	**1.3 MMT**
Industry Growth	12% year on year
Consumption	2.22 MMT
Imports	1 MMT

Thehuge gap in the demand and supply of PVC in India is here to stay. The major manufactures in India are the Reliance Industries Group in Baroda,Gandhar&Hazira. Finolex Industries in Ratnagiri DCW in Tuticorin and Chemplast in Mettur. There are no new additions in the capacity. The gap is set to double with the lack of indigenous capacities.

Business Opportunity

Why India ?

It is observed that about 40% water is wasted during transportation due to leaks and breakages in ageing pipelines. Products like weldable PVC pipes, expandable PVC pipe have the capacity to reduce the wastage by rehabilitation of these aging pipelines. Advantage of these products is that they can be used with trenchless installations without disturbing the existing pipeline.

On the other hand, damaged leaking sewer pipelines are contaminating ground water resources leading to the severe health hazards. PVC products like spiral wound pipe renewal system, fold and form PVC pipes can be used for rehabilitation of these old damaged pipes to increase the life of the sewer system.

Similarly products such as PVC windows and wood PVC composites are taking care of ecology and environment through reducing the demand for wood and wood based products. Forest cover in the country has reduced to 19% of total geographical area from 30% at the beginning of 20th century. Wood PVC composites are considered as an option for wood and wood based products like plywood or particle boards for furniture applications as well as construction boards, tiles etc due to the superior water resistance. This industry is growing very fast in the country at the rate of 30%. There are many more applications yet to be emerged for wood PVC composites including

decorative profiles, decking, outdoor furniture, etc.

India is agriculture base country and is continuously improving the food grain production after Green Revolution. Food grain production increased to 253 MMT in 2013 from 241 MMT in 2011. Unfortunately available storage facilities of food grain cannot manage with this kind of production which is leading to food grain wastage to the tune of 20 MMT. PVC based food grain storage structures are beneficial in terms of handling and installation as well as they can be placed in open reducing the requirement of closed storage systems.

The structures are made gas tight through zip-lock type joint which gives perfect conditions for hermetic storage of food grains. Adoption of these structures can save precious resource – food grains with economical storage for long duration.

PVC industry is one of the major contributors to the economy of the country. With huge investments in infrastructure development, India will be the growth centre of the global PVC industry. PVC products have huge potential to curb the challenges faced by the country. Introduction of innovative technologies and products based on PVC will certainly make difference in the sustainable management of country's infrastructure and economy.

Why Dighi ?

Dighi port situated in Raigad District in the state of Maharashtra is a multipurpose, Multi cargo, all weather port which has direct berthing port with a state of the art cargo handling equipment's. It has ample land bank aprox 1,600 acrs. It is a natural harbor and an exclusive channel offering a depth of 14.5m, making if one of the deepest channels in Maharashtra.

The total waterfront of approx 5 kms are available for development of port related activities. The port is capable of handling bulk, break bulk, liquid, RORO & container cargo. The port is well connected with national highway no 17 by 4 state highways. And also is part of the Delhi Mumbai industrial corridor. The port has been identified as the one of the 7 National Investment and Manufacturing Zones (NIMZ) under the new manufacturing policy. The strategic location would facilitate fast turnarounds of vessels due to high levels of efficiencies.

Being on the Konkan i.e. western side of the country it has close proximity to the Middle Eastern region for souring of Raw materials which would be required for manufacture of PVC in the region.

The central government has already sanctioned and started the construction of the Railway line connecting the central railway at Roha to the Dighi port which is about 35

Kms from the port. This will enhance the connectivity with the central and Northern parts of the country where in there is a huge potential for revenue to be generated from the sale of the PVC so manufactured from the region. The nearest airport are Mumbai and Pune. Pune Jn railway is also about 169 km to the Dighi port.

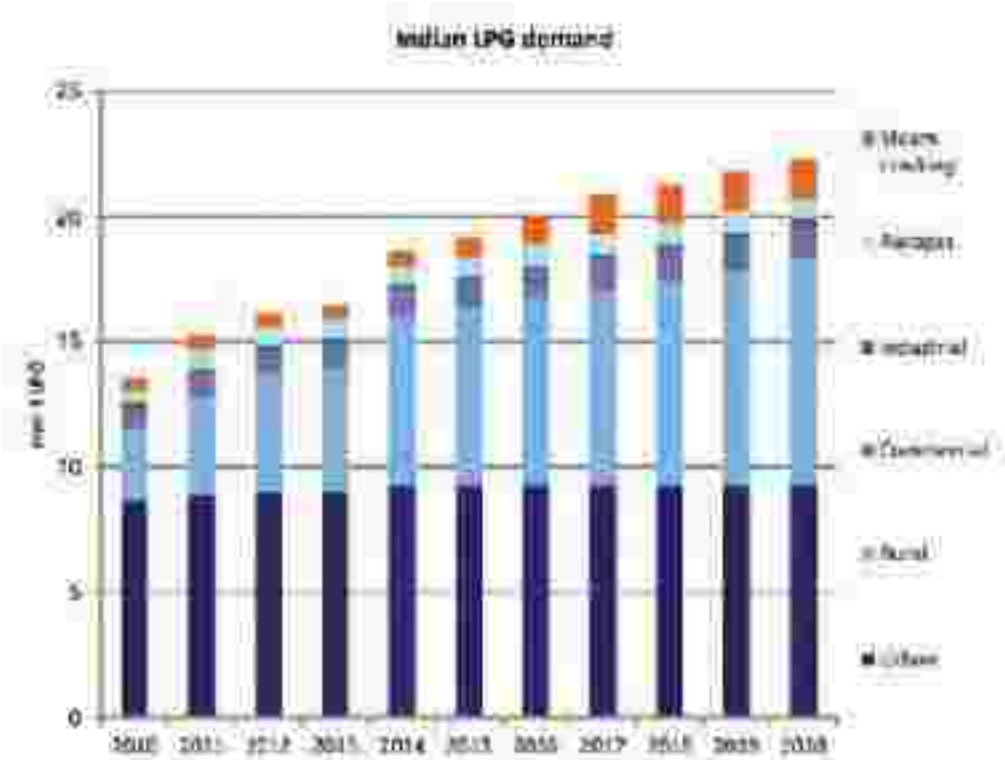
LPG

Description of the LPG Market:

Liquefied Petroleum Gas (LPG) is primarily a mixture of Propane and Butane.

The LPG Market is divided in two parts:

1. LPG for domestic (predominantly cooking gas)/ small consumers use
2. Commercial/ Industry Use (LPG can be used in many applications in the industrial sector namely: Any process-heating, powering industrial ovens, production of food, kilns, furnaces, metal finishing, textiles, production of packing material as well as in powering forklift trucks in warehouses. The graph below illustrates the Indian LPG – Sector wise demand:



During 1970's till 2015, the Indian government in an attempt to promote LPG consumption basically for environment issues, in lieu of Kerosene/ wood/ coal, subsidized it; which, exponentially increased LPG's local demand. Local refineries in India were not equipped to handle the sudden surge increasing the supply demand gap. Over time this gap has been reduced by refineries by increasing their production as well as increasing imports of LPG from the Middle East.

The current data from Petroleum Planning & Analysis Cell (Ministry of Petroleum & Natural Gas, Government of India) http://www.ppac.org.in/index.aspx & Oil Companies; Ministry of Petroleum & Natural Gas Report 2015 to 2016; shows heavy imports of LPG

into India.

	April 2014 to March 2015	April 2015 to March 2016	April 2016 to January 2017 (10 months)
LPG Production ('000 MT)	9840	10599.65	9234
LPG IMPORT ('000 MT)	8313.39	8959.20	8812.41
LPG IMPORT (Rupees Crore)	₹36,570.55	₹25,777.84	₹23,407.68
LPG IMPORT ('Million US$)	$5,954.76	$3,921.72	$3,465.77
LPG Consumption ('000 MT)	18000.10	19623.30	17861.60

LPG market is a lucrative, fast-growing, with current market size being as high as over 19.5 million tons in 2016 – 17 with annualized growth of 9%.
With growing market, the LPG imports have also been growing with a similar pace:-

Current IMPORT Market Analysis:

If we equate the imports of LPG in India, PSU's dominate the imports by far. However, with significant increase Government's vigilance & control over the use of 'subsidized' domestic LPG in the Industry and Auto segments, the imports of LPG for commercial use is increasing gradually.

The Duty Structure for LPG is as follows:

Product	**LPG**
Customs Import Duty	HS Code 27111900
Basic Duty	5%
Education Cess	2%
Secondary Higher Education Cess	1%
Countervailing Duty (CVD)	8%
Additional Countervailing Duty	0

Total Duty for LPG is 13.80%.
The cost calculation for Bulk LPG as on date is as follow:

CIF AG LPG	INR 41,993.00
Price with Import Duty PMT	INR 47,788.87

Storage 30 days	INR 1,500.00
Miscellaneous expenses	INR 100.00
Total Cost at Tanks	INR 49,388.87

Current Market price of LPG PMT	INR 63,947.37 (As quoted by BPCL one of the largest refineries in India for Commercial use LPG)
DIFFERENCE	INR 14,558.49
DIFFERENCE Percentage	25.69%

The current data from Petroleum Planning & Analysis Cell (Ministry of Petroleum & Natural Gas, Government of India) http://www.ppac.org.in/index.aspx & Oil Companies, shows that the current sale for LPG in the Western Part of India as follows.

State Wise Sale of LPG (WEST INDIA	**April 2016 to September 2016 (6 months)**
Chhattisgarh	104.20
Dadra & Nagar Haveli	8.20
Daman & Diu	4.90
Goa	29.70
Gujarat	450.60
Madhya Pradesh	394.10
Maharashtra	1251.70
TOTAL WEST INDIA	**2243.40**

The Total sale in 6 months between April 2016 and September 2016 of LPG within the West cost of India was estimated to be 2,243,000 MT. Maharashtra alone had a sale volume of 1,251,700 MT within the first 6 months for the financial year. There are 2 major PSU refineries in Maharashtra. BPCL's Mumbai refinery with a total production capacity of about 12 MMTPA out of which since 2004 till present it produces on average about 370,000 to 380,000 MT of LPG annually. HPCL's Mumbai refinery as well with a total production capacity of 6.5 MMTA since 2013 till present produces on average about 378,000 to 381,000 MT of LPG annually. Combine that's about 748,000 to 761,000 MT produced between HPCL & BPCL annually at their Mumbai refineries. Leaving a gap of about 877,700 MT to 871,200MT within the first 6 months of 2016 in Maharashtra alone.

The above table shows the demand for LPG to be strong in the region wherein Veritas plans to set up its Storage terminal. LPG would be supplied in bulk for industrial and

commercial use by 6 MT/ 12 MT and 18 MT trucks through its loading facility.

Sales Projections: -

Private companies like Veritas are not entitled for Government subsidy on LPG and they have to sell fuel at the market price, but with the Government restricting volume of subsidy as well as barring the consumers earning more than Rs.10 lakh per annum from the subsidized LPG, a ready-made market is now available for the private companies like Veritas under the parallel marketing scheme (PMS).

Veritas is planning to have a large capacity of storing 12,750 tons of LPG.

The proposed LPG storage capacities at Veritas gas terminal are as follows: -

Product	Capacity in M^3/ Bullet	Number of Bullets	Capacity in Tons (at 30˚C)
LPG	2,500 M^3	10	12,750

Total Capacity of LPG in M^3 will be 25,000M^3.

- Today, most fully pressurized oceangoing LPG carriers are fitted with two or three horizontal, cylindrical or spherical cargo tanks and have typical capacities between 3,500 M^3 and 7,500 M^3. The mid-size segment, of between 15,000 CBM and 40,000 CBM, is the next size above the capacity of the small size fleet. Primarily, vessels in this segment are used for shipping LPG's and ammonia.
- The sales projections for LPG proposed by Veritas are as follows:

Years of Operation		
First Year (CBM)	2nd year (CBM)	3rd Year (CBM)
390,000	585,000	780,000
1 Vsl(7500 CBM)/week	3 Vsls(7500 CBM)/fortnight	2 Vsls(7500 CBM)/week

Polymer Modified Bitumen

Polymer modified bitumen (PMB) is one of the specially designed and engineered bitumen grades that is used in making pavement, roads for heavy duty traffic and home roofing solutions to withstand extreme weather conditions. PMB bitumen with added polymer, which gives it extra strength, high cohesiveness and resistance to fatigue, stripping and deformations, making it a favorable material for infrastructure.

When a polymer is added to regular bitumen, it becomes more elastomeric, which provides it with additional elasticity. The polymer that is added is Styrene Butadiene Styrene (SBS), which acts as a binder modification agent. The primary objective of SBS polymer modified bitumen is to provide extra life to pavement, roads and construction designs. Some of the qualities exhibited by PMB are:

- Higher rigidity
- Increased resistance to deformations
- Increased resistance to cracks and stripping
- Better water resistance properties
- High durability
- PMB is used for:
- The development of very stressed pavement
- Roads for high and heavy traffic
- High loading
- High temperature amplitude
- More durable pavement
- Draining pavements

*Source: https://www.corrosionpedia.com/definition/3215/polymer-modified-bitumen-pmb

To meet the demands of technological and demographic changes, the use of polymer modified bitumen has become increasingly important. Increased stress on highways due to heavier loads, higher tire pressures, and ever rising traffic counts are causing premature failures. Severe climates, always a source of concern, and an increased emphasis on safety have prompted research towards the amelioration of highway paving materials. As the network of highways ages, the demand for quality maintenance and

recycling products is becoming more important than that for new construction. To address these problems, the highway engineer has turned to polymer modification for custom design of pavement materials. It is possible to construct roads which require overlay not before 8 to 12 years as well as save on huge quantities of fuel. PMB can enhance the service life of roads by 50% to 150%.

PMB can be used as binder for construction of "wearing course" or top layer of the road as well as "binder course" (bituminous layer under wearing course). Use of PMB increases the rut, creep and fatigue resistance of the pavement, enhancing its performance and service life.

Use of PMB in 'wearing course' enhances its overlay period where as its use in the binder course can enhance the design life of the road or reduce thickness of pavement resulting saving in initial cost of road.

Wearing course of a road costs around 10 percent of the cost of the road. Bitumen contributes around 50 percent to this cost. Use of PMB costs around 25 to 50 percent more than convention bitumen, depending on the type of PMB. Thus use of SBS PMB in wearing course, increases the cost of wearing course by 12.5 percent to 25 percent and that of the road by 1.25 to 2.5 percent. But the life of wearing course increases by 50 to 150 percent.

Period of overlay of a road, ordinarily being overlaid at five years, will increase to eight (or even 12) years if PMB is used as binder in place of conventional bitumen. Thus saving costs in the long run.

There are guidelines and specifications on modified bitumen issued by BIS (IS 15462:2002), by IRC (SP 53 2002, 2010) and the Ministry Of Surface Transport And Highways (MORT&H) Specs 2001 Clause 521.

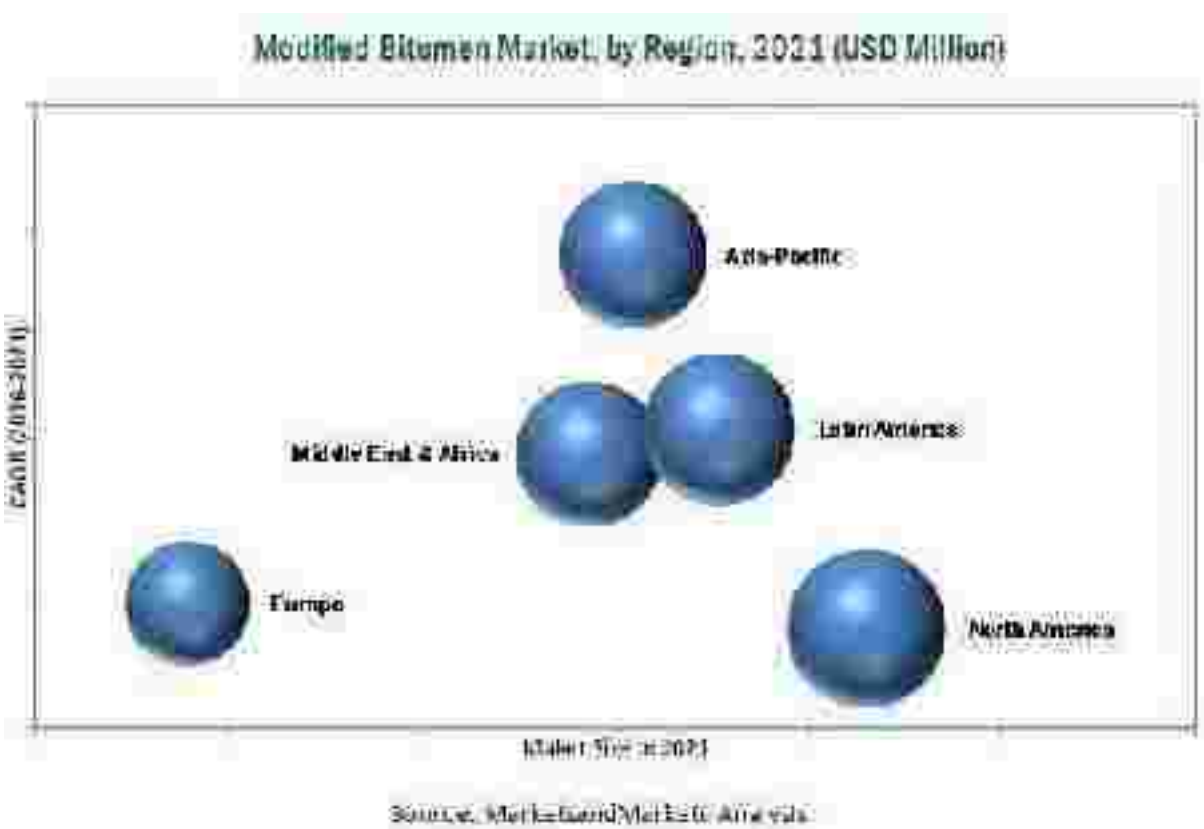
*Source: http://mobilegov.in/gov/news/public-reporter/how-govt-can-save-rs-40000-crore-year-road-repair

The global modified bitumen market is projected to reach USD 19.29 billion by 2021, at a CAGR of 6.5% from 2016 to 2021. The growth of the market is attributed to the growing

construction industry in emerging nations, cost-effectiveness of modified bitumen, and increasing demand for modified bitumen in regions such as Asia-Pacific and the Middle East & Africa. Modified bitumen is largely used in road construction. In addition, rising awareness about the benefits of modified bitumen is also fueling the demand. In 2015 – 2016 it is estimated that the demand for PMB in India was 430,000 MT. India is expected to lead the growth in the PMB market owing to its increasing consumption over the years for existing as well as new infrastructure projects. India has the second largest road network globally; in FY16 it was estimated to be over 5.23 Million Kilometers and, over 64.5% of all goods in the country are transported through roads, while, 85.9% of the total passenger traffic use the road network to commute. In FY16 the length of national highways was 100,475 kilometers and as part of infrastructure reforms, the government plans to double the length of national highways to 2,00,000 km. The Indian roads and bridge infrastructure industry will be worth USD19.2 billion by the end FY17.

*Source: https://www.giiresearch.com/report/mama428100-modified-bitumen-market-by-modifier-type-sbs-app.html

India Roads outlook . www.ibef.org



The Duty Structure for Bitumen and SBS are as follows:

Product	**Bitumen**	**Styrene Butadiene Styrene Block Copolymer (SBS)**
Customs Import Duty	HS Code 27132000	HS Code 40021990
Basic Duty	5%	10.00%
Education Cess	2%	2%
Secondary Higher Education Cess	1%	1%
Countervailing Duty (CVD)	14%	12.5%
Additional Countervailing Duty	0	4%

CHAPTER – 5
PLANT DESCRIPTION

PVC PLANT

Basic Structure of PVC

Poly Vinyl Chloride (PVC) is the most versatile thermoplastic forming on one extreme, highly rigid products such as pipes and profiles and on the other, highly flexible products such as soft leather cloth & flexible footwear. The basic structure of this polymer is (C2H3Cl)n. The degree of polymerization varies from 300 to 1500. The chlorine content in PVC is about 57% by weight which makes it less dependent on hydrocarbon content.

Review of Process Technology

There are mainly four polymerization routes for the manufacture of PVC. They are as follows :

Process Route	% of World Production
Suspension Polymerization	80
Emulsion Polymerization	10
Bulk or Mass Polymerization	8-10

It can be seen from above that suspension polymerization is the most prevalent technology in the world today. The leading licensors for this technology are Ineos Technologies (UK) and Oxy Vinyl Corporation (US) In this process Vinyl Chloride Monomer (VCM) droplets are dispersed in water medium aided with suspending agents and agitation in the Reactors/ polymerizers. Polymerization of VCM to PVC takes place in this medium initiated by peroxide catalyst. Multiple batch reactors discharge into a continuous polymer separation and finishing line. The polymer slurry from the reactors is first separated from unconverted VCM by degassing and steam stripping. Water is separated from the polymer by means of centrifuging followed by drying.

PVC produced through the Emulsion polymerization process is mainly used as latex or paste in speciality applications. In Europe manufacture of PVC started with the emulsion process. The process is similar to the suspension process except that large amounts of emulsifying agents are used which result in very fine PVC particles. Consequently separation of these fine PVC particles from water cannot be done by centrifuging action. Hence this technology employs spray dryers to separate water from the fine PVC particles.

Product Applications of PVC

PVC products are generally classified in the industry in terms of K-value. Higher the K-value, higher is the molecular weight. A low molecular weight PVC with a K-value of 57

finds main application in rigid films and sheets; blow molded bottles and other injection molded articles. PVC if used in food applications should have a residual VCM content of less than 1 ppm. Higher molecular weight PVC with a K-value of 66-67 finds major application in extrusion of pipes and profiles. This constitutes one of the major PVC consumption. PVC with a still higher K-value of 70-72 along with higher poresity finds typical applications in wires & cables and other flexible applications such as shoe lasts, flexible films etc. Emulsion PVC is used in form of plastisols or latex typically for PVC coatings, multilayer films, battery separators and such specialty applications.

Indian Industry Status

PVC industry in India is more than 55 years old. The first production plant of 60,000TPA capacity was commissioned in 1961 by M/s. Calico Industries In India, PVC production is having a strong background of chloroalkali plants, which are essentially promoted by producers of textiles, paper and soda ash for want of sodium hydroxide in their process. Earlier PVC was produced from calcium carbide through the acetylene route. However this route proved to be highly utility intensive, with heavy usage of mercury in the process and hence uneconomical. Much later companies like NOCIL and IPCL put up PVC plants using the alternate ethylene route available from naphtha cracker.

Till date there are five PVC manufacturers having an installed capacity of 1.4 Million Tons with a capacity utilization of around 100%. Reliance being the leaders having plant capacity of 735,000 TPA, Finolex with capacity of 270,000 TPA, Chemplast Sanmar with capacity of 250,000 TPA, DCW with capacity of 90,000 TPA and Shriram Chemicals with capacity of 70,000 TPA follow the leader. With total consumption of PVC being around more than 2.8 Million Tons per annum, 1.4 Million tons of PVC is being currently imported.

The committee for Perspective Planning of Petrochemicals Industry estimates PVC demand to be around 3.2 Million tons by 2020 and over 3.6 Million tons by 2025 AD.

1.0 **Product**

Plant capable of manufacturing K-57, K-66,K-70 grades of suspension PVC. Low K value and High K Value grades also can be produced. The plant is capable to produce the full range of PVC grades for fulfilling most market requirements.

2.0 **Installed Production capacity**

150,000 MTPA expandable to 200,000 MTPA within the same infrastructure without

any further expansions. The plant at present is assumed to be working for 300 days in a year of suspension grade PVC.

3.0 Process Description

This section shall comprise the following production units:

- VCM unloading, storage and Feeding system
- Preparation and charging of de-mineralized water
- Preparation and feeding of addition agents
- Polymerization reaction
- VCM recovery System
- PVC slurry stripping
- PVC drying
- PVC packaging and Product ware house.

1. VCM Unloading, storage & Feeding system:

3.1.1 VCM (Vinyl Chloride Monomer)

VCM is a colourless liquid with a characteristic sweet odour. It is highly reactive, though not with water, and may polymerise in the presence of oxygen, heat and light. Its vapours are both toxic and flammable. Aluminium alloys, copper, silver, mercury and magnesium are unsuitable for vinyl chloride service. Steels are, however, chemically compatible.

Component	%	CAS Number
Vinyl Chloride	99.5 – 100	75-01-4

3.1.2 OTHER PROPERTIES:

Molecular Weight:	62.5
Molecular Formula:	C2ClH3
Boiling Point/Range:	7 °F (-14 °C)
Vapor Pressure:	2660 mmHg @ 25 °C
Vapor Density (air=1):	2.15
Specific Gravity (water=1):	0.91 @ 25/25 °C
Water Solubility:	2.7 g/L
pH:	Not applicable
VOC Content(%):	100%
Volatility:	100%

Evaporation Rate (ether=1): >15

Flash point: -108 °F (-78 °C)

Sr. No.	Parameter	VCM
1.0	**Unloading condition**	
1.1	Unloading at	Dighi Port
1.2	Unloaded by	Marine Unloading arm
1.3	Pressure at ship pump flange, kg/cm2g	30.0 (min)
1.4	Unloading Carrier	7500 CBM

Each consignment of 7500 cbm pressurised liquid VCM shall be unloaded from ship with the help of ship unloading pumps through one numbers of 8" marine unloading arm & shall be transferred to proposed VCM storage bullets at VPPL gas storage Terminal.

3.1.3 **Pipeline transfer facilities:**

8" lines shall be employed for transfer operation of VCM from Ship. Two mass flow meters, one at jetty end & one at tank end shall be provided for mass measurement & input to leak detection system. The motorised operated valve shall be provided at jetty for emergency shutdown operation in case of leak.

3.1.4 **Receipt & Storage facility at Gas Storage Terminal**

The VCM from ship will be transferred & stored in 6 nos of pressurised VCM bullets at 10.5 kg/cm^2.

The Mounded Vessels shall be fabricated & installed as per OISD-150.

The mechanical design of storage vessel shall be based on following considerations:

i. Design Code - ASME SEC. VIII or PD - 5500 or equivalent duly approved by CCOE. A single code shall be adopted for design, fabrication, and inspection and testing. The specific consideration shall be given to
   a) Internal vapour and hydraulic pressure
   b) External loadings on the vessel
   c) Internal vacuum
ii. Material - The material of construction for bullets is SA 537 CL.II, the selected material conforms to design code.
iii. Design Temperature is (-) 27 ^{o}C to + 55 ^{o}C.

iv. Design Pressure is 25 kg/cm2 g.

v. Other Considerations

a) Internal Corrosion Allowance: 1.5 mm (minimum)

b) Radiography: Full

c) Stress Relieving: 100% irrespective of thickness.

d) Earthquake pressure as per IS: 1893

e) Hydrotest pressure: As per Design Code

The Cathodic protection shall be provided to protect the external surface of the bullet from corrosion.

Fire safe Remote Operated Valve(s) (ROVs) shall be provided on first flange on liquid line(s) at a minimum distance of 3 m from the vessel.

Each vessel has two safety relief valves (SRV). Each storage vessel shall have minimum two different types of level indicators and one independent high level switch.

Each vessel is provided with one pressure and temperature measuring instrument. The pressure gauge shall be provided with isolation valves.

2. Preparation and charging of de-mineralized water

Part of de-mineralized water from de-mineralized water tank is used in polymerization charging, bearing seal priming, sealing, agitator/ pump seal flushing, reactor rinsing etc..

Part of cold de-mineralized water cooled by cooling water is stored in cold de-mineralized water tank and used for buffer preparation, catalyst preparation and additive preparation.

3. Preparation and feeding of addition agents

All the chemical agents of polymerization, such as initiators, dispersants, buffering agents, de-foaming agents ,Shortstops (terminators), etc. are prepared and stored in their own reservoirs. When the polymerization reaction occurs, chemical agents are sent to polymerizer by pumps according to specified quantity in the recipe and specified procedure.

4. Polymerization

De-mineralized water, dispersants, buffers and initiators are automatically added into the polymerization reactor in a closed state according to PVC production process recipe for the type and amount of raw materials and the feeding program of DCS settings. Polymerization starts when the initiators are automatically added. By automatically

adjusting the level of cooling water, the reaction temperature is maintained. Polymerization reaction takes place in accordance with the required temperature curves; the polymerization reaction heat is measured by a microcomputer to calculate the monomer conversion rate. When the conversion rate is met, the terminators are automatically added into polymerization reactor to terminate polymerization, PVC slurries automatically discharged to the Vessel. After PVC is blowdown, the reactor wall shall be rinsed with water of appropriate pressure.

5. Shortstop (Terminator) System

This process adopts two shortstop systems for two different purposes, and adopts different shortstops. One is for normal production stop of each batch operations; the other is for emergency, during mechanical or power failure.

6. Vacuum System

Vacuum system shall be adopted to draw out air from all equipment of the unit contacting VCM to ensure safety of the unit after maintenance.

7. VCM recovery System

Un-reacted VCM from polymerization reactor and stripping outlet trough shall pass through the VCM Recovery unit in order to be used for utilization in the polymerizer.

8. PVC slurry stripping

PVC slurry stripping process shall be provided to efficiently remove and recover residual vinyl chloride monomer from PVC resin. The PVC from the blowdown vessel enters the stripping tower. In the stripping tower PVC slurry shall make heat exchange with cooling water in a countercurrent flow. After stripping, the PVC slurry shall be stored in bin and sent to PVC drying section. The VCM after stripping tower passes through the top stripping tower condenser then to gas-liquid separator and finally sent to VCM recovery section.

9. PVC Centrifuge and drying

This section is composed of dewatering, finished product drying, screening and gas conveyance.

PVC slurry after stripping enters centrifuge. After de-watering in the centrifuge, wet PVC resin is fed in dryer. Warm air shall be used to dry wet PVC resin. Then after, the PVC

enters the vortex type cyclone dryer for drying of critical moisture content. The dried PVC powder shall be separated with the air flow by the cyclone separator set. Finished PVC product after screening shall be delivered to PVC intermediate silo and it goes into packaging process by mixing pump.

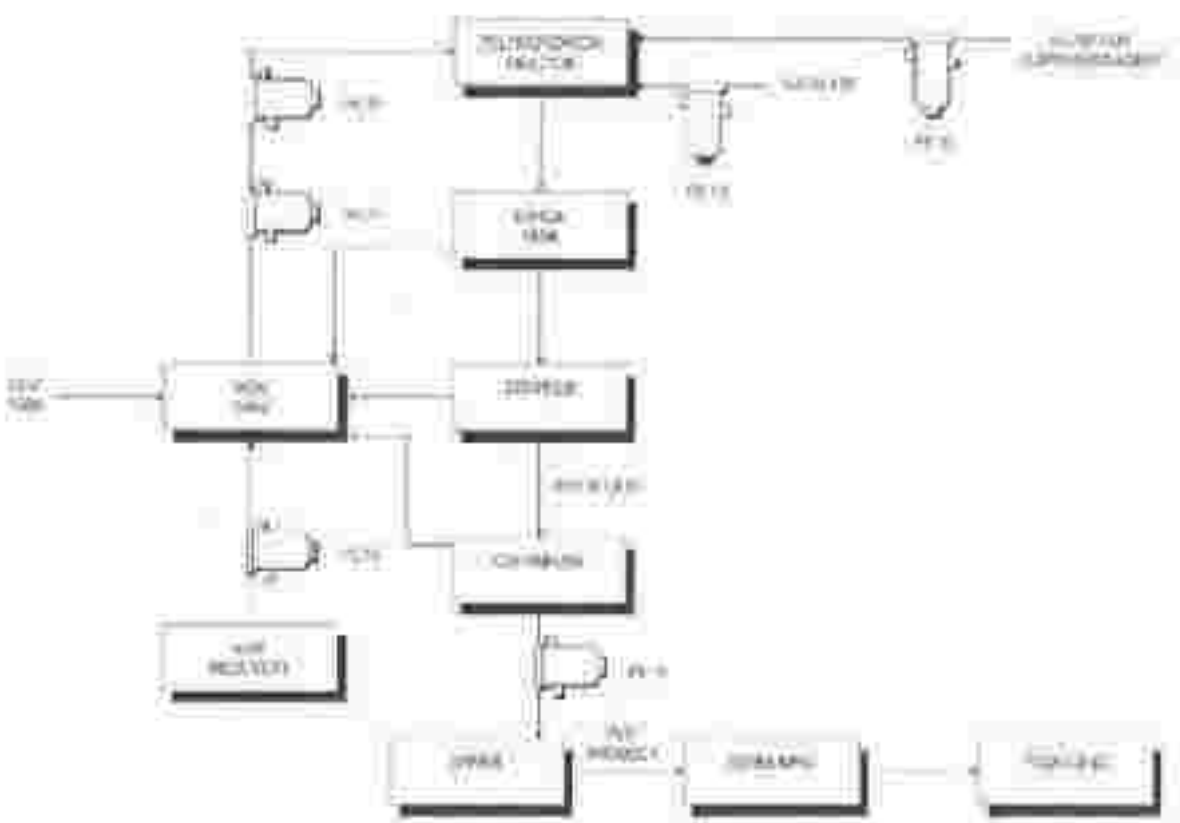
Part of the mother liquor from the PVC centrifuge goes to stripping tower for flushing the tower, and part of it goes to PVC mother liquor treatment and recycle system.

10. PVC Packaging and Product ware house

PVC material from finished product silo is measured and bagged into 25kg/bag by quantitative semi-automatic packaging machine. After packaging, the packed PVC will be transported to PVC ware house by forklift.

4.0 Process Flow Diagram

Brief process flow diagram is indicated below. Detailed process flow diagram is attached as Annexure.



5.0 Major Equipment List

No	Tag	Description	Width (D) (mm)	Length (mm)	Est Weight (kg)
1	C-501	SLURRY STRIPPING COLUMN	1900	19440	19860
2	C-502	SLURRY STRIPPING SCRUBBER	2385	11000	575
3	C-801	WASTE WATER STRIPPING COLUMN	12” pipe	9525	1700
4	D-501A1	HEAT EXCHANGER 1	1640	3905	3700
5	D-501A2	HEAT EXCHANGER 1	1640	3905	3700
6	D-501A3	HEAT EXCHANGER 1	1640	3905	3700
7	D-501A4	HEAT EXCHANGER 1	1640	3905	3700
8	D-501A5	HEAT EXCHANGER 1	1640	3905	3700
9	D-501B1	HEAT EXCHANGER 2	1250	3905	3000
10	D-501B2	HEAT EXCHANGER 2	1250	3905	3000
11	E-201	DEMIN WATER COOLER	10” pipe	5060	800
12	E-301A	REACTOR CONDENSER	1587	7174	18000
13	E-301B	REACTOR CONDENSER	1587	7174	18000
14	E-301C	REACTOR CONDENSER	1587	7174	18000
15	E-301D	REACTOR CONDENSER	1587	7174	18000
16	E-303	VACUUM PUMP SEAL	1400	2557	120
17	E-403	FIRST STAGE LIQUEFIER	1120	7004	9600
18	E-404	SECOND STAGE LIQUEFIER	660	6048	2000
19	E-405	HP VC COMPRESSOR SEAL WATER COOLER	205	2171	200
20	E-408	LP VC COMPRESSOR SEAL WATER COOLER	205	2171	200
21	E-501-1	SLURRY INTERCHANGER	1180	1700	13000
22	E-503	STRIPPER CONDENSER	950	2900	2000

23	E-504	FIRST STAGE AIR HEAT FOR DRYER D501	1760	3223	2365
24	E-505	SECOND STAGE AIR HEATER FOR DRYER D501	1224	3223	1232
25	E-507	AIR COOLER FOR CONVEYING SYSTEM A504	1224	3223	1232
26	E-601	AIR COOLER FOR CONVEYING SYSTEM	406.4	2485	580
27	E-802	WASTE WATER CONDENSER	300	2775	450
28	E-5401	CHILLED WATER DRUM	620	3430	2990
29	E-5402	CONDENSER	457	4445	2280
30	E-6101	PLATE HEAT EXCHANGER	760	2018	1830
31	R-301A	REACTOR	4260	7000	53000
32	R-301B	REACTOR	4260	7000	53000
33	R-301C	REACTOR	4260	7000	53000
34	R-301D	REACTOR	4260	7000	53000
35	S-201A	DEMIN WATER COOLER	396	1375	285
36	S-201B	DEMIN WATER COOLER	396	1375	285
37	S-405A	VCM FILTER	699	1545	635
38	S-405B	VCM FILTER	699	1545	635
39	S-501	RUNDOWN FILTER	600	1100	690
40	S-502A	STRIPPING FEED FILTER	12" pipe	1255	305
41	S-502B	STRIPPING FEED FILTER	12" pipe	1256	305
42	S-801	WASTE WATER FILTER	6" pipe	605	60

43	S-503A	CENTRIFUGE			7380
44	S-503B	CENTRIFUGE			7380
45	S-601A	TEST HOPPER AIR FILTER	1400	3300	300
46	S-601B	TEST HOPPER AIR FILTER	1400	3300	300
47	S-602	FINAL PRODUCT SILO AIR FILTER	1400	3300	300
48	S-603	REJECT HOPPER AIR FILTER	1400	3300	300
49	S-604	BAGGING HOPPER AIR FILTER	1400	3300	300
50	S-605	CONVEYING SYSTEM AIR FILTER	1400	3300	300
51	T-102	CATALYST B FEED TANK	1200	2000	1665
52	T-103	GRAN SOLUTION TANK (JACKETTED)	3100	4500	17880
53	T-104	GRAN A FEED TANK (JACKETTED)	3100	4500	17880
54	T-106	GRAN B TANK	1700	2800	1721
55	T-107	STABILISER TANK	1000	1800	864
56	T-109	ANTIFOAM TANK	1600	2800	2242
57	T-110	EVICAS TANK	600	1000	377
58	T-111	GRAN A HOPPER	700	2200	310
59	T-112	CAT. C NEUTRALIZATION TANK	1200	1000	1182
60	T-117	CATALYST E FEED TANK	1500	2800	1995
61	T-118	CAUSTIC STORAGE TANK	3500	3500	5000
62	T-120	BUFFER SOLUTION TANK	1500	3425	2015
63	T-121	BUFFER FEED TANK	1500	2800	1421

64	T-201	DEMINERALIZED WATER TANK	1500	2800	15160
65	T-202	CHILLED DEMIN. WATER TANK	2800	5000	4851
66	T-404	INHIBITOR ADDITION TANK	600	1300	129
67	T-503A	PVC SLURRY TANK	7000	7500	33116
68	T-503B	PVC SLURRY TANK	7000	7500	33116
69	T-505	CONVEYING SYSTEM FEED HOOPER	1200	982	475
70	T-601A	TEST HOPPER	4412	15890	6000
71	T-601B	TEST HOPPER	4412	15890	6000
72	T-602	FINAL PRODUCT SILO	7650	26835	23600
73	T-603	REJECT HOPPER	4400	15970	6700
74	T-604	BAGGING HOPPER	4400	15970	6700
75	T-6101	EFFLUENT SETTING SUMP	15000	9600	N/A
76	T-6102	ADDITIVE AREA CATCH PIT	1500	1500	N/A
77	V-115	CATALYST C VESSEL	1200	1800	1700
78	V-116-1	CATALYST D VESSEL	1000	1200	1500
79	V-125	CATALYST C WEIGHT VESSEL	300	600	216
80	V-126	CATALYST D WEIGHT VESSEL	250	510	320
81	V-127	EVICAS WEIGHT VESSEL	200	320	320
82	V-202	SEAL WATER ACCUMULATOR	1500	2800	4320
83	V-301A	SHORT STOP VESSEL	350	1400	450
84	V-301B	SHORT STOP VESSEL	350	1400	450

85	V-301C	SHORT STOP VESSEL	350	1400	450
86	V-301D	SHORT STOP VESSEL	350	1400	450
87	V-302	ESS INSTRUMENT AIR RECEIVER	1000	2500	1500
88	V-303	VACUUM PUMP SEPARATOR	700	670	225
89	V-401	HP VC COMPRESSOR CATCHPOT	1300	1800	1900
90	V-402	LP VC COMPRESSOR SEPARATOR	1300	1800	1900
91	V-405	RECOVERED VCM TANK	650	1704	9430
92	V-406	VCM SEPARATOR	800	2000	844
93	V-407	LP VC COMPRESSOR SEPARATOR	2400	7500	255
94	V-408	HP VC COMPRESSOR SEPARATOR	650	1704	255
95	V-410	VCM DAY TANK	3600	17500	40000
96	V-411	VENT SEPERATOR	1200	1450	1500
81	V-127	EVICAS WEIGHT VESSEL	200	320	320
82	V-202	SEAL WATER ACCUMULATOR	1500	2800	4320
83	V-301A	SHORT STOP VESSEL	350	1400	450
84	V-301B	SHORT STOP VESSEL	350	1400	450
85	V-301C	SHORT STOP VESSEL	350	1400	450
86	V-301D	SHORT STOP VESSEL	350	1400	450
87	V-302	ESS INSTRUMENT AIR RECEIVER	1000	2500	1500
88	V-303	VACUUM PUMP SEPARATOR	700	670	225
89	V-401	HP VC COMPRESSOR CATCHPOT	1300	1800	1900

90	V-402	LP VC COMPRESSOR SEPARATOR	1300	1800	1900
91	V-405	RECOVERED VCM TANK	650	1704	9430
92	V-406	VCM SEPARATOR	800	2000	844
93	V-407	LP VC COMPRESSOR SEPARATOR	2400	7500	255
94	V-408	HP VC COMPRESSOR SEPARATOR	650	1704	255
95	V-410	VCM DAY TANK	3600	17500	40000
96	V-411	VENT SEPERATOR	1200	1450	1500
97	V-501	BLOWDOWN VESSEL	5400	11000	46200
98	V-502	STRIPPER FEED VESSEL	3200	5100	10800
99	V-504A	HOT WATER EXPANSION TANK	1000	2748	2200
100	V-504B	INTER TANK	1000	2748	2200
101	V-803	VC CONTAMINATED WATER TANK	1300	2450	2200
102	V-5401	CHILLED WATER DRUM	1000	3050	1800
103	V-5402	OIL SEPARATOR	3200	3567	2120
104	V-5701	UTILITY AIR BUFFER RESERVOIR	2000	4100	6200
105	V-5801	INSTRUMENT AIR BUFFER RESERVOIR	2900	8506	13600
106	V-1901	FOAM CONCENTRATE STORAGE TANK	914	3124	1500
107	A-5101A	COOLING TOWER	10000	20600	N/A
108	A-5101B	COOLING TOWER	10000	20600	N/A
109	A-6103A	CHECK POND	3500	4700	N/A
110	A-6103B	CHECK POND	3500	4700	N/A

111	A-6103C	CHECK POND	3500	4700	N/A
112	A-508	GAS FIRE WATER BOILER	2250	4987	N/A
113	A-5801	AIR DRYER	762	2032	124
114	A-5801-1 B1	DRYER TANK	457.2	1470	124
115	A-5801-1 B2	DRYER TANK	457.2	1470	124
116	A-5801-1 B3	DESICCANT DRYER	457.2	1470	124
117	A-5801-1 B4	DESICCANT DRYER	457.2	1470	124

TECHNOLOGY LICENSOR: INEOS TECHNOLOGIES

1. INEOS is characterized by the following strengths:

- High-quality and low-cost production facilities
- Well-invested plants across the Globe
- Large plants that benefit from economies of scale
- Favorable locations
- Experienced Technical Management
- Leading market positions
- Operating diversity - products, customers, geographic regions, applications and end-use markets

2. INEOS Technologies key values are:

- Excellence in safety, health and environmental performance
- Focus on customer satisfaction, total quality and reliability
- Continuous improvement to reduce costs
- Encouragement of innovation and reward for achievement

3. Ineos Technologies (VINYL)

Leveraging INEOS' position as the largest PVC producer in Europe; INEOS Technologies Vinyls delivers a wide range of technologies, products, know-how and expertise that helps customers all over the world to maximize operational performance.

INEOS Technologies (Vinyl) services are tailored to meet ultimate Customer's requirements, from assistance during engineering design and construction through to plant commissioning and from research and development support to reliable supply of PVC additives and catalysts.

4. Vinyls Licensing

INEOS Technologies (Vinyl) is the leading licensor of Poly Vinyl Chloride (PVC), Ethylene Di-Chloride (EDC) and Vinyl Chloride Monomer (VCM) technologies for the PVC and Vinyl industry worldwide.

With long experience of over 60 years through its founder companies, INEOS Technologies Vinyls' technical expertise is recognized as being the industry leader. Their S-PVC licensing technology brings together features from all of INEOS Chlor-Vinyls'

plants, and which has been continuously developed to keep INEOS Chlor-Vinyls' plants competitive in the challenging European & Asian markets in terms of cost, quality and environmental performance.

In addition, the Licensing Group, working closely with contractors, has developed the Licensed process to minimize the total Installation Costs, and developed other aspects to suit operation in warmer climates.

5. Vinyls Catalyst & Additives

Based on over 70 years of chlor-vinyls experience, INEOS Technologies Vinyls' range of PVC additives brings real value to PVC plants. Process economics are improved by using INEOS Technologies Vinyls' high quality and well-proven additives to reduce wastage, increase output, reduce down-time and improve quality.

INEOS Technologies Vinyls supports the entire range of vinyls additives with technical support from across the INEOS group, drawing on dedicated people with many years of experience in chemistry, engineering, vinyls technology and vinyls production.

6. SAFETY, HEALTH & ENVIRONMENTAL BENEFITS

INEOS Technologies' plant designs meet and exceed European Union standards of safety and environmental performance, which are among the highest in the world. Our process complies fully with all the European Council of Vinyls Manufacturer (ECVM) environmental standards.

The closed process design minimizes reactor opening loss, with associated operator hygiene and environmental benefits. The expected opening frequency is once in 500 batches, although frequencies of once per 2000 batches have been achieved on several licensee plants.

The continuous Stripping Column reduces the residual VCM in finished product to less than 1 ppm. The stripper also reduces the loss of VCM to atmosphere from the Slurry Tanks and Dryer.

The reactor protection systems against major hazard releases are of very high integrity and include a reaction short stop system of extremely high reliability and effectiveness. INEOS has > 400 reactor years of operating experience on large reactor plants without ever experiencing a release of VCM to atmosphere.

The INEOS Technologies' process for initiator synthesis external to the reactor is intrinsically safe in that it is very difficult to overcharge initiator. Overcharging one of the initiator components does not increase the yield of initiator but rather reduces the yield.

Initiator is not stored for any significant length of time but is made up as required and used immediately. The inventory of initiator on the plant is very low and is in dilute solution. It therefore does not constitute a significant hazard.

Unlike Competitors, Initiator does not require sub-zero refrigerated storage.

The VCM Recovery system does not use a gasholder, this gives obvious environmental benefits.

All VCM contaminated Water is stripped before final discharge to levels < 1 ppm VCM.

7. PROCESS ECONOMICS

INEOS Technologies' Low Cost Initiator reduces initiator costs to those of the precursors, all of which are easily available chemicals. This gives a significant saving in additive costs per ton of PVC.

INEOS Technologies' condenser process allows fast reactions without the need to use Chilled Water for cooling the reactors. This is especially an advantage where Cooling Water temperatures are high because it saves the capital expense of a large refrigeration system and high electricity costs.

6.0 DESIGN BASIS

The detailed feasibility study is based on the following process parameters

LPG – Composition – mole %

Designation	Straight Run LPG	Cracked LPG
Sp. Gr. @ 15 Deg C	0.51 – 0.58	0.51 – 0.58
Viscosity @ ST, CST	0.18 – 0.40	0.18 – 0.40
Water content in LPG	200 ppm (As Caustic Solution)	200 ppm (As Caustic Solution)
RSH – H (wppm)	10 (Max)	5 (Max)
Re Entry – S + RSH – S, wppm (Max)	40	40
Caustic (NaOH)	Traces	Traces
Total Sulphur Presence, ppm	150 (Max)	150 (Max)

Liquid Propylene: - Composition wt%

Designation	PROPYLENE	
Composition, Wt. %	Case - 1	Case – 2
Ethylene	0.02	0.093
Ethane	1.089	0.233
Propylene	95.196	95.198
Propane	3.69	4.470

Properties of Propylene

Water Content in Propylene	200 ppm (As Caustic Solution)
As H_2S, RSH & COS, wppm (max)	5, 10 , 10 Respectively
Sp. Gr. @ 15 Deg C	0.515 – 0.522
Viscosity @ ST, CST	0.15 – 0.38
Total Sulfur Presence, ppm	25 (Max)
Caustic (NaOH)	Traces

Sr. No.	Parameter	LPG	Propylene
A	**Unloading condition**		
1	Unloading at	Dighi Port	Dighi Port
2	Unloaded by	Marine Unloading arm	Marine Unloading arm
3	Pressure at ship pump flange, kg/cm2g	30.0 (min)	30.0 (min)

4	Unloading Carrier	7500 cbm	7500 cbm

7.0 PROCESS DESCRIPTION

1. Unloading & Handling facilities at Dighi jetty:

Pressurized liquid LPG and propylene shall be unloaded from ship with the help of ship unloading pumps through two numbers of 8" marine unloading arm & shall be transferred to proposed LPG and propylene Bullets at VPPL gas storage Terminal.

2. Pipeline transfer facilities:

Both the 8" lines shall be employed for transfer operation of LPG and propylene from Ship. Two mass flow meters, one at jetty end & one at tank end shall be provided for mass measurement & input to leak detection system. The motorised operated valve shall be provided at jetty for emergency shutdown operation in case of leak.

3. Receipt & Storage facility at Gas Storage Terminal

The LPG from ship will be transferred & stored in 2 nos of pressurised LPG bullets at 14.5 kg/cm^2 and Propylene from ship will be transferred & stored in 8 nos of pressurised propylene bullets at 23.0 kg/cm^2 .

The Mounded Vessels shall be fabricated & installed as per OISD-150.

The mechanical design of storage vessel shall be based on following considerations:

vi. Design Code - ASME SEC. VIII or PD - 5500 or equivalent duly approved by CCOE. A single code shall be adopted for design, fabrication, and inspection and testing. The specific consideration shall be given to
   d) Internal vapour and hydraulic pressure
   e) External loadings on the vessel
   f) Internal vacuum

vii. Material - The material of construction for bullets is SA 537 CL.II, the selected material conforms to design code.

viii. Design Temperature is (-) 27 ^{o}C to + 55 ^{o}C.

ix. Design Pressure is 25 kg/cm2 g.

x. Other Considerations
   f) Internal Corrosion Allowance: 1.5 mm (minimum)

g) Radiography: Full
h) Stress Relieving: 100% irrespective of thickness.
i) Earthquake pressure as per IS: 1893
j) Hydrotest pressure: As per Design Code

The Cathodic protection shall be provided to protect the external surface of the bullet from corrosion.

Fire safe Remote Operated Valve(s) (ROVs) shall be provided on first flange on liquid line(s) at a minimum distance of 3 m from the vessel.

Each vessel has two safety relief valves (SRV). Each storage vessel shall have minimum two different types of level indicators and one independent high level switch.

Each vessel is provided with one pressure and temperature measuring instrument. The pressure gauge shall be provided with isolation valves.

4. Despatch Facilities at Gas storage Terminal

7.4.1 LPG & Propylene truck Loading:

LPG and propylene will be sent to truck loading facility.

5. PROCESS PARAMETERS

7.5.1 Unloading & handling facilities at Dighi jetty:

Ship unloading frequency	Max. 2 Vessels in a week
Unloading by	2 Nos of 8” Marine Unloading Arm

7.5.2 Pipeline transfer facilities

Unloading through	2 Nos of 8” transfer line/

7.5.3 Receipt & Storage facility at LPG Marketing Terminal

Storage Capacity of Bullet : cu.m	8 Propylene bullets with storage capacity of 2500 M^3 in each bullet 2 LPG bullets with storage capacity of 2500 M^3 in each bullet
No. of Mounded Bullet	2 LPG + 8 Propylene

Size	one mound consisting of eight (8) Propylene bullets (each 70m long & 7.4m dia. Propylene storage capacity of 2500 M^3) shall be constructed and One mound consisting of two (2) bullets (Each 63m long & 7.4m dia. LPG storage capacity 2500

7.5.4 **VCM / Propane / Butane Transfer Pump:**

Liq. VCM from bottom outlet of all the VCM bullets is pumped to the PVC plant by two (2) VCM transfer pumps out of the two pumps, one is standby.

Liq. LPG from the bottom outlet is pumped to marketing area by two (2) LPG transfer pumps out of two pumps, one LPG pump shall be used for Recirculation and another pump is common standby.

Two Propylene pumps (1+1) of similar draw suction of liq. Propylene from bottom of the Propylene Bullets and send the product to marketing area.

VCM Transfer Pump

Type	Vertical Canned Type with double mechanical seal
Flow, MT/hr	25 (1W + 1S) Each for LPG & Propylene
MOC	LTCS

LPG Transfer Pump

Type	Vertical Canned Type with double mechanical seal
Flow, m3/hr	100 (1W + 1S)
MOC	LTCS

Propylene Transfer Pump

Type	Vertical Canned Type with double mechanical seal
Flow, m3/hr	100 (1W + 1S)
MOC	LTCS

7.5.5 **Despatch Facilities at Gas erminal**

Loading to	Un-insulated road tankers.
Loading temperature, ºC	15
Loading by	LPG / Propylene transfer pumps
No. of loading Station	4 bay Tanker Loading Facility
Pumping Rate, MT/hr	100

Polymer Modified Bitumen Plant

8.0 **DESIGN BASIS**

The pre feasibility study is based on the following process parameters

Plant Capacity :- 1000 Tons / Day

Bitumen Class :- Class 60 – 70 and Class 80 – 100

Bitumen Property Table:-

Properties	**Class 80 - 100**		**Class 60 - 70**	
Penetration at 25°C, 0.1mm	80	100	60	70
Softening point, °C	45.0	52.0	45.0	52.0
Flash point, °C	276	-	276	-
Viscosity at 60°C (Poise)	140	-	260	-
Viscosity at 170°C (Poise)	0.45	-	0.65	-

9.0 **PROCESS DESCRIPTION**

1. Unloading & Handling facilities at Dighi jetty:

Bitumen shall be unloaded from ship at a with the help of ship unloading through one numbers of 12” marine unloading arm & shall be transferred to proposed storage tanks at VPPL.

2. Pipeline transfer facilities:

12“ lines shall be employed for transfer operation of Bitumen from Ship. Two mass flow meters, one at jetty end & one at tank end shall be provided for mass measurement & input to leak detection system. The motorised operated valve shall be provided at jetty for emergency shutdown operation in case of leak.

Unloading through	1 No of 12” transfer line

3. Receipt & Storage facility

The Bitumen from ship will be transferred & stored in 2 nos of storage tank with a storage capacity of 2500 Cu.M. each.

Bitumen is stored in Conical Roof & inverted cone at bottom storage tanks. Each inlet

line is provided with motorized valve which has provision to open / close by hand in case of power break-off. These tanks shall have one nozzle for inlet & one for pump recycle inlet, also one outlet nozzle for PMB blender pump suction header. Tanks are provided with LP steam supply & condensate return line to keep required temperature inside storage tank.

Inlet nozzle of recycle line is provided with jet mixer to mix the content in the tank & maintain uniform density. Tanks are equipped with temperature & pressure transmitter which are connected to level indicator. Level indicator will indicate level of tank after considering temperature & pressure in the tank. High level switch is also provided.

4. Combining Agent

Combining agents are sometimes added to PMBs to improve their performance properties and shelf life and will comply with the requirements of the AAPA Guide to the safe use of SBS.

5. Polymer

The common generic polymer types used for the manufacture of PMBs are Styrene Butadiene Styrene (SBS), Polyethylene's and Ethylene Vinyl Acetate (EVA).

6. Mixing

All polymer maintained at elevated temperatures for long periods will be subject to three competing reactions: increase in molecular weight leading to gelation, caused by cross linking of the unsaturated bonds; a similar, oxygen induced, polymerization; and breakdown reactions. Additionally bitumen are subject to hardening on prolonged high temperature exposure. All of these reactions can be minimized by maintaining close control of operating temperatures and residence times in the mixing equipment. Additional measures that will reduce any tendency to polymerize by nitrogen blanketing of the mixing vessel. Component materials have to be thoroughly mixed to ensure production of a homogeneous PMB. Critical elements that are common to all processes include procedures for proportioning of materials, temperature control, mixing time and conditions, and maintenance and cleanliness of equipment.

7. Storage Of The Finished Product

2 nos. of Tanks for the storage of finished product with a storage capacity of 2500 cu.m will be designed to minimize deterioration in storage, with strict control of temperature, minimal surface area to reduce oxidation, and provision for mixing or circulation to ensure that the product remains homogenous in storage.

Polymer Modified Bitumen is stored in Conical Roof & inverted cone at bottom storage tanks. Each inlet line is provided with motorized valve which has provision to open / close by hand in case of power break-off. These tanks shall have one nozzle for inlet & one for pump recycle inlet, also one outlet nozzle for drum filling pump suction header. Tanks are provided with LP steam supply & condensate return line to keep required temperature inside storage tank.

Inlet nozzle of recycle line is provided with jet mixer to mix the content in the tank & maintain uniform density. Tanks are equipped with temperature & pressure transmitter which are connected to level indicator. Level indicator will indicate level of tank after considering temperature & pressure in the tank. High level switch is also provided.

The heating system will be designed such that the PMB is not exposed to high contact temperatures around the heating elements or flues for prolonged periods. Prolonged exposure of PMBs to heating elements may result in deterioration and carbonization of the binder. Tanks will be provided with good circulation of the PMB around heating elements or flues, either through the use of mechanical stirrers and/or by circulating the tank contents with a pump.

The tank heating system commonly used for PMB storage uses heat transfer oil and automated temperature controls to limit overheating.

8. Loading Gantry

All supply lines throughout the plant, including loading equipment to be designed and procedures will be established as to avoid contamination during change of product or cleaning of supply lines. The use of oils such as kerosene, diesel, or gas oil for flushing lines will be avoided.

Where lines need to be flushed, it will be done with hot bitumen or finished product. Any oils used for flushing or cleaning of supply lines will be collected and disposed of separately and will not be added to products or components in storage or delivery vehicles.

9. Bitumen Barrel Filling And Packing Facility

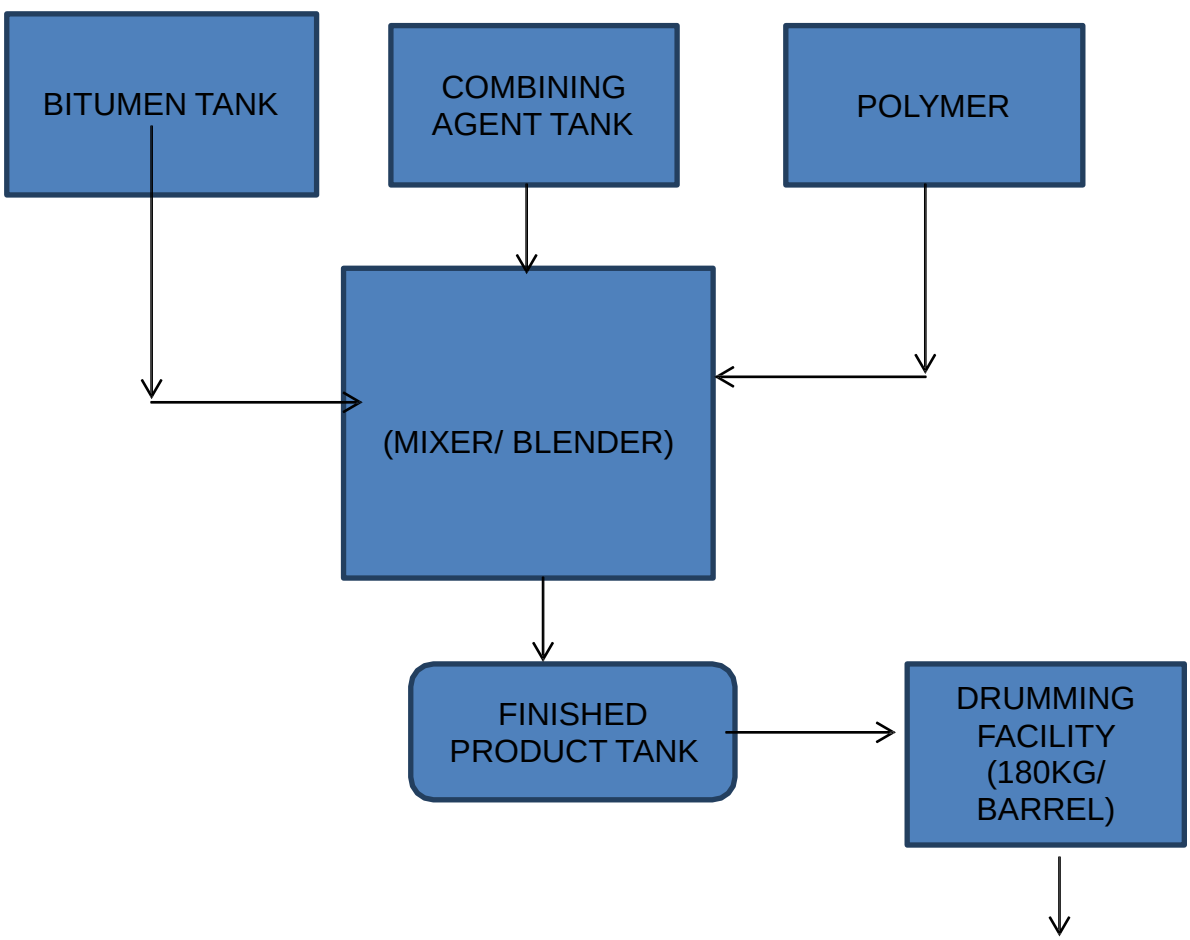
The Polymer Modified Bitumen will have a mechanized and semi auto with a capacity of

6000 Drums per day.

Facilities for receipt and storage of Bulk Bitumen and all infrastructures required for Bitumen handling including tank truck unloading arrangement.

10. Process Flow Diagram

Brief process flow diagram is indicated below.



10.0 UTILITIES

Following utilities are envisaged in this project. Further description of the utilities systems are in subsequent chapter.

- Electric Power
- Steam
- Raw Water / Fresh Water
- Cooling Water
- Demineralised water
- Nitrogen gas
- Instrument & Plant Air
- Effluent treatment

CHAPTER – 6

UTILITIES

17 MW GAS BASED POWER PLANT (GAS ENGINE GENERATORS)

For the operation of the Integrated Petrochemical complex, captive power has been envisaged.

The captive power producing a utilization power of 17 MW at 11000 V, 50Hz, shall be generated through Gas Fired Generators in multiple units, which is to be designed, taking into consideration, availability of 100% operating power during maintenance downtime of any one of the generating units.

The breakup of the power requirement is as detailed below.

ENVISAGED LOAD		
Sl.No.	**DESCRIPTION**	**ENVISAGED CONNECTED LOAD (KWH)**
1	PVC PLANT	7000
2	ADMINISTRATION BUILDING Lighting & Equipments	60
3	COMPRESSORS	2000
4	CHEMICAL STORAGE WAREHOUSE Lighting	50
5	FIRE STATION Lighting & Equipments	250
6	ENVIRO STATION	100
7	RIVER WATER INTAKE	225
8	SEA WATER INTAKE	150
9	DESALINATION PLANT (2 MLD)	2000
10	DM WATER PLANT	450
11	ZLD	1500
12	BOILER	1000
13	LABORATORY	300
14	WORKSHOP	1220
15	MAIN GATE AND MATERIAL GATE Lighting & Equipments	20
16	ENGINEERING STORES Lighting & Equipments	15
17	CANTEEN Lighting & Equipments	10
18	PARKING Lighting	0.5
19	STREET LIGHTING	150
20	TANK FARM AREA Lighting & Equipments	1510
	TOTAL CONNECTED LOAD	**18010.5**

Taking into consideration the economics and maximum utilization of the Natural Gas, reliability and ease of operation for generation of power, Gas Engine based Generators have been considered.

The fuel for the engine shall be Natural Gas which will be received from GAIL, tapped from the existing line in Mangaon.

The typical Range of Gas Composition shall be as follows (tentative)

GAIL GAS COMPOSITION - RANGE		
S. No	**Component**	**Range (Mole %)**
1	Methane C1	Not less than 77%
2	Ethane C2	9-0.69%
3	Propane C3	4.5-0.03%
4	Butane C4	2.5-0%
5	Pentane C5	0.35-0%
6	Hexane C6	0.15-0%
7	Carbon Dioxide CO2	5-0%
8	Nitrogen N2	5.1-0%
9	Total Non Hydrocarbon- not more than 8.0 mole %	
10	Total Sulphur including H2S – Not more than 10 PPM by weight (H2S content not more than 4PPM by volume)	

1.0 Genset design

Gensets comprise the following main components:

- Gas engine
- Generator
- Torsional flexible coupling
- Base frame
- Flexible bearing elements
- Control System
- Electrical Panels
- Transformers
- NGR
- Synchronizing Unit

Engine and generator are linked by a torsional flexible coupling and rigidly mounted to the base frame. The base frame is mounted to the foundation by flexible bearing elements. All flexible connections for the operating media are installed at the genset. Auxiliary units such as pre lubricators and lubricating oil level monitors are mounted to

the base frame. Preheating is to be provided for every engine. Dependent on the design of the system, this may be installed either at the genset or in the system.

2.0 Engine monitoring and cabling

The gas engine is equipped with sensors for monitoring and control purposes. The sensors are wired to a multifunction rail at cylinder rows. At the engine, all parts which are needed to be grounded are connected to the copper rail. This rail must therefore be connected to the earthing system of the switchgear or individually. All control and signal cables shall be neatly laid, dressed and terminated in the designated Junction Box / Control Panel.

3.0 Generator :-

The types used as standard shall be brushless synchronous generators, which, depending on the application, may be suitable for mains parallel and/or back-up power operation. These shall be 11000 V three-phase medium-voltage generators. The efficiency of the generators dependent upon size and power factor value (cos phi) is between 95.0 % and 98 %. If the generator is operated at a power factor of 1, efficiency is increased by approx 1-1.5 %. The generators shall be designed for an ambient temperature of 45° C and an installation altitude of 100 m. These generators can operate as standard in a power factor range of 0.8 - 1 inductive (lagging). Generators must be specially designed for use in the capacitive range. There are the criteria which have to be considered when designing the gas engine gensets. In back-up power operation, the max. permissible unbalanced load for the generator must be taken into account. The voltage regulator shall keep the generator voltage constant. The voltage regulator shall be either installed in the generator's terminal box or in the switchgear.

4.0 Basic function of the voltage regulator

The power supply of the voltage regulator is provided from the auxiliary exciter. The brushless three phase exciter receives its voltage supply from the actuating element of the voltage regulator. The voltage delivered from the three-phase rotor winding of the exciter is rectified and supplied as direct current to the rotor of the generator. In order to obtain a constant voltage level at the generator terminals with alternating load, it is necessary to adjust the current supply to the rotor accordingly. This function is carried out by the voltage regulator.

5.0 Set point adjustment of the voltage regulator

The inputs to the voltage regulator are the voltage set point from the set point adjuster and the actual generator voltage measured at the terminals U,V and W. The readjustment of the generator voltage is done via adjustment of the current supply to the

rotor. The adjustment of the voltage set point has to be done on site with regard to the voltage level at the local conditions. The range for the voltage adjustment is normally within 5% to 10% of the generator's nominal voltage.

6.0 Generator protection

To protect the generators, monitoring facilities must be included in the package.

The following generator monitoring facilities are absolutely essential and must be provided in the switchgear:

- ¾ Protection in case of short circuit
- ¾ Protection in case of overload

The following protection facilities are urgently recommended:

- ¾ Protection in case of time-delayed overcurrent
- ¾ Protection in case of voltage-related overcurrent
- ¾ Protection in case of directionally dependent overcurrent
- ¾ Reverse power protection
- ¾ Mains isolation facility
- ¾ Reactive current restriction
- ¾ Differential current protection Also, the following protection facilities are recommended:
- ¾ System earth fault protection
- ¾ Stator earth fault protection
- ¾ Unbalanced load protection

7.0 Earthing

The generator is connected to the base frame by an earthing wire. The earthing connection of the genset must be connected to the earth main grid of the system.

8.0 Requirements for the genset room

The genset room will be of adequate size. Aside from the added complication of operation and maintenance, a clear space of approx. 2 mtrs. in width should, under all circumstances, be allowed for all round the genset, increasing to 3 m for bigger engines. Care must be taken to ensure that the starter batteries are installed as close as possible to the electric starter. Preferably, this area should be arranged close to the engine in order to achieve access by the same EOT crane both for the pre-assembly area and the engine itself. Furthermore, the size of the room will be determined by the other components to be installed, such as e.g. heat utilization / recovery unit, switchgears, gas

control line, lube oil tank, batteries, exhaust pipe and silencer. The silencers for the inlet and exhaust air also require enough available room. It is essential to design large enough openings to bring in the genset, and to ventilate the system. No genset room should be without permanently installed lifting gear (crane), the load-bearing capacity of which corresponds to the heaviest single item in the room. It must, however, in all cases be guaranteed that, when carrying out maintenance work, dependent on the engine type, e.g. pistons, con-rods, cylinder heads or even a complete engine can be lifted. Both assembly and subsequent maintenance can then be carried out more quickly and more practically. The genset room should be of sufficient height to allow pistons and connecting rods to be withdrawn upwards, taking into account the lifting gear. The size of the room must permit work to be carried out unobstructed at all points around the genset and there must be space to park individual genset components and spares. Together with the planning of the engine room, the elastic mounting, the design of the foundation block, the pipe and cable work must be clarified. Also to be considered in the early stages of planning is the implementation of any special noise protection and anti-vibration insulation measures. For smaller installations, the genset and the switchgear can generally be set up in a separate room. For larger installations, it may be more practical to install the switchgear in a separate, sound-proofed operating room. When planning the genset room, consideration must also be given to the transport route, so that if necessary, an engine or generator can be dismantled and reinstalled (floor loading and space available). If access to the genset and its components is heavily restricted due to the engine room not being designed large enough, the OEM may claim additional costs when performing maintenance or repair work within the scope of the manufacturer's warranty. When operating and when performing maintenance work on the genset, lubricating oil and/or coolant can enter the genset room under certain circumstances. Restraining devices must be provided in the genset room drainage system which reliably prevents environmental damage from these materials.

9.0 Foundation and vibration damping

In the case of gensets with piston engines, gravity forces and moments of inertia cannot, in all cases, be completely balanced. The transmission to the foundation of the vibration and noise thus created can be significantly reduced by the use of elastic mountings. When installing gensets, the elastic mounting elements must therefore always be provided between the base frame and the foundation block.

10.0 Foundation block

For the base of the foundation, which must be implemented with special care, it is recommended that a soil investigation be carried out by an expert. There must be no groundwater veins either beneath or in the vicinity of the foundation block, as these can transmit vibrations over very long distances. This also applies to a high groundwater level which leads to stronger transmission of vibration than occurs in dry ground. Depending on local conditions, the foundation block may have to be set on a sole plate or pilework. Sinking and basing the foundation are in any case the responsibility of the EPCM. The EPCM must assess the load-bearing capacity of the soil and determine the solidity of the foundation block by specifying the requisite concrete mix and reinforcements to suit the local conditions. For calculation purposes, clients will be provided with data on the foundation load imposed by the genset and the natural frequencies of the elastic bearings. With the reasons mentioned above the foundation block as built should not have any contact with the foundation walls of the building or with the floor. The gap between the foundation block and the floor can be sealed with an elastic material. To accept the elastic bearing elements, the surface of the foundation must be horizontal and disked, without being smoothed with a trowel. The foundation surface must be flat to a tolerance of max. ± 2 mm.

11.0 Elastic support

In order to insulate the genset as far as possible from the foundation in terms of vibration and structure-borne noise, steel spring bearing elements are used. These bearing elements reduce the transmission of dynamic forces to the foundation. The insulation of low frequencies in buildings is of great importance. This is also achieved with a soft steel spring bearing support. Structure-borne noise insulation is guaranteed by means of reflection from the base plate of the bearing, thanks to the insulation effect of the steel / rubber plate arrangement. The elastic support must be recalculated for each application. The natural frequency of the system constituted by the genset / elastic support must be sufficiently far below the operating speed of the genset. Insulation levels of approx. 88 - 94 % are achieved with the bearing elements used. The spring elements which are used in gensets can be adjusted in height over a certain range. They have to be properly adjusted; meaning the load on each element has to be equal. A wrong setting of the spring elements leads to their destruction on a long term basis and the oscillations cannot be isolated anymore. Spring elements can compensate unevenness of the foundation only to some extent. Due to an uneven load, too great an unevenness of the

foundation and a wrong setting of the spring elements lead to the deformation of the genset's base frame. As a consequence, the alignment between the generator and the engine is no longer efficient. This can result in an incalculable destruction of the components.

12.0 Cable and pipe ducts

Cooling water and exhaust pipes can be laid in ducts beneath the floor. The requisite dimensions must be adapted to the size of the pipes and to local conditions. In general, care must be taken to ensure that ducts for pipes and ducts for cables are implemented separately from one another, whereby a further distinction must be drawn between power cables, control cables and signal cables. Ducts are laid with a fall leading away from the foundation block, with drains fitted with oil separators provided at the lowest points. The ducts can be covered with tread plate or grilles.

13.0 Noise issues

Since the acoustic requirements imposed by various laws and regulations on the installation of gensets with combustion engines are constantly increasing, a brief reference is appropriate here to the contexts and possible solutions to noise problems. Noise sources mainly include the combustion noise of the engine, mechanical engine noises and the air intake and exhaust noises from the engine. The fans, pumps and other auxiliary drives can also be the cause of nuisance noise. Likewise, excessive air speeds can cause noise. There is nothing that effective resources can do to reduce the source of noise themselves.

Thus most measures to mitigate noise are directed towards reducing the transmission of noise outside of the genset room.

13.1 **Possible means of mitigating noise**

Normal wall thicknesses of 24 cm or 36 cm damp the noise coming from within by 40 to 50 dB. Nevertheless, silencer sections 2 to 3 m in length must be provided for the air inlet and exhaust ducts, with approx. 40 dB noise reduction. Taking into account the volume of cooling air in the silencer section, the air speed should not exceed approx. 8 m/s on the delivery side and approx. 6 m/s on the extraction side. If acoustic materials such as sound insulating panels are installed in the genset room, the noise level can be reduced by approx. 3 dB, and indeed at considerable expense even by approx. 10 dB. Particular care should be taken to control the exhaust noise. With suitable silencers, reductions in noise levels of up to approx. 60 dB can be achieved here. Questions of sound insulation can only be solved on an individual basis, as they are highly dependent

on local circumstances. By way of assistance, the manufacturer provides octave analyses of exhaust gas and engine noises. Sound insulation measures should be designed as per requirement.

No fiber materials may be used to clad the interior of the room. Vibrations in the air cause particles to be released which then block the air filters and can even destroy the engine. When sound-proofing the building, it is necessary to consider not only the walls but also the windows, doors and so on. Technical sound-proofing considerations should also extend to additional sound sources such as auxiliary drives or horizontal-type radiators which are located outside of the engine room. Also gas control lines, pre-pressure control lines or zero-pressure control lines, which are installed outside the engine room or outside a sound capsule, can represent an additional noise source and must be considered in the design.

14.0 Engine room ventilation

An engine room is heated by convection and radiation from the engines, generators, heat recovery and piping systems installed therein. To avoid impermissibly high temperatures for the engines, components and switchgear, this heat must be dissipated with the aid of a ventilation system. Also, for systems operating in areas with extremely low ambient temperatures, it must be ensured that the minimum intake air temperatures specified in the genset data sheet are complied with. For this, it is recommended to utilize the radiation heat of the components to heat the engine room. In these cases, the engine room walls must be tight and good thermal insulation should be provided. In this respect, the design of the ventilation system is of particular importance; on the one hand, for the removal of the radiation heat in summer, and on the other hand, for the utilization of the radiation heat for engine room heating in winter.

14.1 Pressurized system

Air at ambient temperature is drawn in from the outside by a fan, forced through the engine room and returned to the environment via exhaust openings. An overpressure prevails inside the engine room. The use of this system is especially recommended in environments with a high dust content (desert regions, etc.). The overpressure inside the engine room prevents dust from penetrating into the room through leaks in the walls of the building or through open doors or windows. The ventilation systems must be fitted with appropriate filters to separate out the dust, e.g. inertia cyclone filters, dry type filters,