DETAILED PROJECT REPORT

FOR

GOBIND SUGAR MILLS LIMITED
ESTABLISHMENT OF NEW 60 KLPD DISTILLERY MOLASSES BASED ALONGWITH 2.2MW POWER GENERATION

AT

M/s. GOBIND SUGAR MILLS LIMITED
AIRA ESTATE, KAMARIA PANDIT, DIST. LAKHIMPUR KHERI,
UTTAR PRADESH

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AVANT-GARDE ENGINEERS AND CONSULTANTS (P) LTD.
68A, PORUR KUNDRATHUR HIGH ROAD, PORUR, CHENNAI-600116.

TEL: 91-44-24827843 / 24828532
Email: agec@vsnl.com
FAX: 91-44-24828531
Website: http://www.avantgarde-india.com
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EXECUTIVE SUMMARY

1.0 Gobind Sugar Mills Limited (GSML), established in the year 1952, was part of Dr.K.K.Birla group of sugar companies. The company which is now part of the Adventz Group is one of the oldest sugar mills in the country with almost 60 years of continuous operation. The sugar mill at Aira Estate in Lakhimpur Kheri District of Uttar Pradesh has a present cane crushing capacity of 7200 MT per day. Apart from selling the finished product plantation white sugar, the company also sells molasses, the basic raw material for ethanol production and the surplus bagasse from the season operations. The company is upgrading the crushing capacity of the mill to 10,000 TCD and is also adding a 500 TPD sugar refinery. The upgraded plant with the sugar refinery will be operational for the crushing season 2015-2016. As part of their program to utilize the by products of the sugar mill effectively, GSML is also adding a 30 MW bagasse based Cogeneration plant which is already ready for commissioning. After completing the sugar mill expansion and Cogeneration projects, GSML proposes to add a ethanol distillery, which will predominantly consume the molasses generated in-house.

2.0 The Alcohol is the generic term used for Ethyl Alcohol (C₂H₅OH) which is a hydrocarbon manufactured either from petroleum or by the fermentation of a monosaccharide like glucose or fructose. The Extra Neutral Alcohol (ENA) which is a purified form of alcohol, devoid of most of the commonly found impurities in the fermented alcohol, is fit for human consumption and its consumption worldwide is increasing annually. Apart from that, Alcohol in its anhydrous form is touted to be the future fuel as the world’s petroleum reserves are exhaustible. In fact automotive engines are now being designed to accept hydrous alcohol with about 4 to 5% of moisture which will eliminate the need for dehydrating the hydrous alcohol for blending with gasoline. Every sugar mill is a virtual production house for ethyl alcohol, as the molasses a by-product of sugar manufacturing contains substantial quantity of fermentable sugar, which can easily be fermented to alcohol by yeast.

3.0 Alcohol manufactured from sugar mills, by virtue of its renewable nature is an eco-friendly fuel which will be a worthy substitute for gasoline to prevent global warming. Many countries have taken up
aggressive usage of absolute alcohol, also commercially called as Ethanol, to reduce the dependence on petroleum. Presently, ethanol is blended with gasoline in varying proportions to get the motor spirit. Brazil has done pioneering work in this direction, followed by many countries. United States has launched an aggressive ethanol manufacturing program and European Union is also showing keen interest in ethanol. India also has a policy of blending 5% ethanol with gasoline and this percentage is being hiked to 10%. Alcohol, after limited purification, finds wide usage in industrial applications and also in blending alcoholic drinks.

4.0 The molasses from the sugar mill with around 40% fermentable sugar and at approximately 85 Brix is diluted with water and fermented with Yeast grown in the distillery's laboratory. As the fermentation is an exothermic process, the wash (fermented molasses) is required to be cooled by constant recycling through coolers. As the yeast cannot survive at high temperature approximately above 34 Deg.C, this continuous cooling of the wash is required. Once the fermentation is complete, the wash is taken in to the distillation section where the alcohol is stripped from the wash in distillation columns using low pressure process steam. Also electrical power is required for driving the various pumps and other rotating equipment in the distillery. The alcohol production in a distillery is an energy intensive process, which utilizes both thermal energy from low pressure steam as well as electrical energy. The raw alcohol thus obtained is called the "Rectified Spirit (RS)". RS contains about 94% to 95% ethyl alcohol by volume and it also contains impurities such as Acetic acid, Acetaldehyde, Ethyl acetate etc.

5.0 This RS is further purified by removing most of the impurities, through a few more fractionating columns, to get ENA (Extra neutral Spirit) which is used for blending potable liquor. ENA contains about 96% ethyl alcohol. The RS could also be used for the production of absolute alcohol, (Anhydrous Alcohol), by dehydrating RS to reduce the moisture content to less than 0.5%. While ENA can contain some percentage of water, the water content in ethanol should be almost nil, and that is the reason this ethanol is referred as anhydrous alcohol. This water removal is carried out using molecular sieve dehydration process. This
anhydrous form of ethanol contains a minimum of 99.5% ethyl alcohol.

6.0 The fermented wash after the stripping of the alcohol, in the distillation process, is called the spent wash. This Spent wash is highly acidic, brownish black in colour, due to caramalization of sugar in molasses and due to the bacterial action and is high on BOD and COD. This spentwash, with the BOD and COD levels of 50,000 ppm and 1,35,000 ppm, is highly polluting in nature and that is the reason a molasses based distillery is considered as a highly polluting industry and the environmentalists look at the distillery with a lot of suspicion. Environmental protection and the control of discharge of the liquid effluents are the key elements in the design of the distillery. Conventionally this spent wash had been disposed of by fert-irrigation or composting or bio-methanation. As none of these erstwhile disposal methods were very effective, the spent wash incineration technology had been proposed and had successfully been employed already in many molasses based distilleries. The spent wash generated from the distillery is generally with a solids concentration of around 14% w/w, which after concentration could be raised to 60% w/w level. This concentration of the spent wash will be done in a multiple effect evaporator system using steam as the heating medium. This concentrated spent wash with 60% solids content has a calorific value of around 1705 kCals/kg which could sustain combustion in an incinerator. To make the whole system energy efficient, the spent wash incineration is done in a specially designed steam generator which could effectively utilize the thermal energy released by the incineration of the spent wash for the generation of high pressure steam. As the spent wash contains a lot of alkanes, chlorides and sulphates, fouling of the heat transfer areas and both high and low temperatures corrosion are serious problems in using this spent wash as a fuel. The boiler design should take care of the above problems and ensure a longer uptime for the boiler. In India, quite a few number of distilleries have already successfully implemented this spent wash incineration technology. A major advantage of this technology is that the distilleries could be designed as “Zero Liquid Effluent Discharge” plants.
7.0 GSML proposes to install a 60 Kilo Litres Per Day (KLPD) capacity distillery very near to the sugar mill complex. This proposed plant will be a multi product distillery capable of producing Rectified Spirit, Extra Neutral Alcohol and Anhydrous Alcohol. The distillery complex will be located in an area already owned by GSML at a distance of about 300 meters from the sugar mill. From its cane crushing operations GSML will produce 60,750 MT of molasses annually with an average fermentable sugar content of 36.8%. The sugar mill already has a molasses storage capacity of 25,860 MT and additional storage facilitates will also be added in the distillery. Apart from the in house molasses GSML is confident of procuring a minimum of 15,000 MT of molasses from the nearby sugar mills and it is proposed to take this 15,000 MT also into account while calculating the total molasses availability for the distillery operations. As the procured molasses will be from the vicinity of the plant, it is assumed that the fermentable sugars in the bought out molasses will also be at the same level as the in house molasses.

8.0 The proposed 60 KLPD, multi product distillery will have installation of the plant and equipment for the following process areas / sections. As discussed elsewhere in this report, the distillery will be capable of producing RS, ENA and Absolute Alcohol. The proposed distillery could also be made to operate with grains as the raw material with the addition of a few front end equipment for the processing of the grains. However with minimum additions the distillery could operate with cane juice as the raw material and produce RS, ENA or AA as required.

**Bulk molasses storage**
- Fermentation section
- Wash to RS/ ENA/AA Distillation section
- Spent wash evaporation system
- Condensate and Spent Lees polishing section
- Alcohol daily receiver and bulk storage
- Laboratory instrument and glassware
- Water treatment plant
- Cooling towers and cooling water system
- Spent wash fired boiler
- 2.2 MW back pressure turbo generator and auxiliaries
- Plant electrical system
DCS based instrumentation for the process plant and the co-generation plant

9.0 This Detailed Project Report presents the details of the proposed scheme for the Distillery, Spent wash concentration system, Spent wash incineration boiler and co-generation power plant of the distillery, site facilities, availability of fuel and water, features of the main plant equipment including the co-generation power plant, cooling water system, electrical systems, environmental aspects, estimate of the capital cost and the schedule for the project implementation.

10.0 With 36.8% fermentable sugar in the molasses, one Metric Tonne of molasses could result in the production of 222.2 Litres of alcohol. For the production of 60,000 Litres of alcohol per day, the distillery needs 270 Metric Tonne of molasses. The annual in-house production of 60,750 MT of molasses, with 90% capacity utilization of the distillery plant, will meet the requirements of the distillery for the operation of 250 days. The expected bought out molasses quantity will enable the distillery to operate additionally for about 50 days, thus taking the total number of days of operation of the distillery per annum to 310. As the investment in the distillery with spent wash incineration system is high, it is important that the plant is operated for as many number of days as possible in a year. If GSML could find more molasses the plant operation could be even taken to 330 days per annum. However for the purpose of this DPR, it is assumed that the GSML's new distillery will be operated for a period of 310 days per annum.

11.0 The distillation process is the separation of ethyl alcohol from impurities like the acetaldehydes, acetones, esters and amyl alcohols etc.. With the capacity of 60,000 Litres of total spirits per day, the impurities will account for about 5% of the total production and these are removed in the distillation columns and all these impurities put together are called as technical alcohol. If the distillery is producing Rectified Spirit, the per day production will be 57,000 Litres. Producing ENA, where further purification of the ethyl alcohol is involved, the plant will produce 56,320 Litres of ENA. If the plant's entire production is Anhydrous alcohol, where the dehydration of the RS is involved, the daily production of AA will be 56,000 Litres. Operating for 310 days, with the plant
capacity utilization of 90%, the plant could produce 141.36 Lakh Litres of RS or 139.67 Lakh Litres of ENA or 138.88 Lakh Litres of AA. As RS has limited industrial use, for the purpose of this DPR, a product mix of 70% of ENA and 30% of AA is assumed. Apart from the above, the plant will also produce 8.37 Lakh Litres of Technical Alcohol and 0.17 Lakh Litres of Fusel Oil. The fermentation process will produces carbon-Di-Oxide as a by product and it proposed to leave the gas to the atmosphere downstream of the scrubber. At a later date if GSML wants to recover the CO₂ gas, it is possible to do so with the addition of a purification plant. It is estimated that about 35 TPD of purified CO₂ is recoverable from the distillery which could find usage in beverage industry, welding process, pharmaceutical and other chemical processing industries. Liquid CO₂ is a good refrigerant and it finds wide usage in food industry for warehouse storage and for storage during transportation. However, this report does not consider the carbon-di-oxide recovery and bottling plant as part of the 60 KLPD distillery plant.

12.0 The Distillery operations produce about 718 MT of raw spent wash per day with the solids concentration of about 14% w/w. This will be concentrated to 60% w/w solids in a standalone multiple effect evaporation plant using low pressure steam. The multiple effect evaporation plant will have a minimum of five effects with the combination of falling film and forced circulation bodies to optimize the performance. Thus the concentrated spent wash production in the plant will be 175 MT per day or 8.7 MT per hour. The estimated Gross Calorific Value of the concentrated spent wash is 1705 kCals/kg. This concentrated spent wash will be fired in the boiler along with bagasse to generate the required steam from the boiler. The 525 MT per day of condensate generated in the concentration plant will be treated and reused in the distillery plant.

13.0 The steam requirement for the production of RS from fermented wash is about 5.5 TPH at 2.5 bar (a) saturated. The steam requirement for production of ENA from fermented wash is 8 TPH at 2.5 bar (a) saturated. The steam requirement for production of AA from RS is 1.5 TPH at 4.5 bar (a) saturated. The steam requirement for Spent wash concentration from approximately 14% w/w solids to 60% w/w solids in the stand alone evaporation
The total power requirement (at 415V, 3 PH, 50 Hz level) for the distillery and cogeneration plant is given below:

<table>
<thead>
<tr>
<th>Process requirement</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distillery</td>
<td>775</td>
</tr>
<tr>
<td>Spentwash concentration plant</td>
<td>330</td>
</tr>
<tr>
<td>Condensate/lees polishing unit</td>
<td>100</td>
</tr>
<tr>
<td>Boiler and other utilities</td>
<td>620</td>
</tr>
<tr>
<td>Lighting and Misc.</td>
<td>25</td>
</tr>
<tr>
<td>Total (operating reqt.)</td>
<td>1850</td>
</tr>
</tbody>
</table>

With 2150 kW of generation under the MCR operation of the distillery, there will be a surplus power of 300 kW available for export. The spent wash fired cogeneration plant in the distillery will be operating in synchronization with the 30 MW cogeneration plant in the sugar mill, so that the surplus power could be exported to the sugar mill and then to the grid. The actual power requirements and the actual steam requirements will vary depending on the output product and the sections of the distillery that will be in operation and the total power and steam consumption discussed earlier are the maximum consumptions. The power generation is at 415 V level from the 2.2 MW turbo generator and will be stepped up to 11 kV in the transformer for synchronization with the 30 MW cogeneration Power Plant.

The water requirements of the distillery plant is proposed to be met by the water drawn from the bore wells. The water from the bore wells will be stored in a water reservoir for meeting the various uses of the distillery. The estimated raw water
requirement is 1500 cu.m per day for the operation of the distillery in wash to ENA mode. The water is required for the distillery process in the fermentation section, cooling tower make up for the distillery cooling towers. However with the usable water recovered from the condensate and spent lees polishing plant, the raw water required will come down to 700 cu.m/day. The DM water requirement for the distillery and for the boiler is approximately 300 cu.m per day. The DM water requirement will be met from a new Membrane based water treatment plant to be installed in the distillery.

16.0 The implementation of the new distillery project is expected to be completed within Sixteen (16) months, from the date of ordering of the main plant and equipment i.e the distillery process section and spent wash fired boiler. It is presumed that the ordering of these items could be done in early December 2015. If GSML gets the statutory clearances and the financial closure early or decides to start the basic design and the tendering process simultaneously, then the schedule could be advanced.

17.0 The size of the distillery project with the spent wash incineration based Cogeneration plant, calls for proper project management and control procedures to ensure implementation within the scheduled program. Adequate qualified and trained manpower shall be recruited to take care of the operation and maintenance of the new Distillery plant with spent wash fired boiler and cogeneration plant.

18.0 The total works cost, i.e., civil, mechanical and electrical for the complete distillery complex, including the miscellaneous fixed assets is estimated to be Rs.9,286.40 Lakhs. The total installed project cost, including the pre-operative expenses, interest during the construction, the margin money for the working capital and the contingency provision works out to be Rs.10,738.11 Lakhs. The total project cost of Rs.10,738.11 Lakhs will be funded with an equity of Rs.1,654.49 Lakhs, SDF loan of Rs.3,714.56 Lakhs and an institution term loan of Rs.5,369.05 Lakhs assuming a debt to equity ratio of 1:1. It is assumed that the financial institution loan for the project will be repaid in 6 years in 24 quarterly instalments with two (2) years moratorium period from the date of loan disbursement. It is also assumed that the interest rate on the
term loan will be 12.5%. The SDF loan repayment will be over five (5) years with the moratorium equal to the institution term loan repayment period. The cost of SDF loan will be 6.5%. As the processing of the SDF loan and the term loan may take some time GSML will arrange for some bridge loan to tide over the project funding requirements.

19.0 GSML proposes to use in-house generated molasses predominantly for the production of alcohol. However the company will also procure molasses from nearby sugar mills to run the distillery plant for a longer period. Based on the price levels existing presently, the average landed cost of bought out molasses is taken as Rs.5182.50 per MT inclusive of the basic cost, Excise Duty, cess, molasses development fund and an average transportation cost of Rs.300 per MT. As GSML is presently selling the molasses, the cost of the in-house molasses is also taken same as that of the bought out molasses less the transportation cost. As the sugar mill will be supplying the bagasse to be used as the supplementary fuel for the operation of the distillery boiler, the bagasse cost is also considered in the viability analysis. A value of Rs.1000 per MT is considered for the bagasse. The cost of production will include cost of utilities, water, chemicals, consumables, repairs and maintenance expenses, salaries and wages for the plant operating personnel & for contract labour, plant insurance cost, administration expenses and selling expenses for the various products of the distillery.

20.0 The saleable products from the distillery are the ENA, AA, technical alcohol and the Fusel oil. In addition the 300 kW of surplus power could be exported to the grid as the 30 MW Cogeneration plant will be exporting power to the grid during the season operation and part of the off-season period. In case the Cogeneration plant is not exporting power, the 300 kW could be used in the sugar plant for the regular off-season maintenance of the sugar mill and for meeting the requirements of the colony. Based on the existing price levels the selling price of ENA and AA are taken as Rs.43.00 and Rs.40.5 per Litre. The sale price of technical alcohol and Fusel oil is taken as Rs.20 per Litre. The exportable electrical energy is assumed to fetch Rs.5.50 per Unit of electricity sold.
21.0 No escalation is considered both in the input materials cost and in the price of saleable outputs.

22.0 The depreciation computed is on straight line basis at 6.33% for plant and machinery and 3.34% for buildings and civil works. However, for income tax computation purposes, depreciation rates of 10% for civil works, 15% for the plant and machinery are taken on the written down value of the assets.

23.0 Income tax at the rate of 30%, with a surcharge of 5% or 10% (depending on the net taxable income being less than Rs.1000 Lakhs or more) and a Cess of 3% is considered in the financial analysis of the project. Minimum Alternate Tax (MAT) as per Income-Tax Act is at the rate of 18.5% with surcharge of 5% or 10% (depending on the book profits being less than Rs.1000 Lakhs or more) and a Cess of 3% is also considered in the analysis.

24.0 A detailed financial analysis is made on the basis of the above given financial assumptions. The post tax Internal Rate of Return IRR for the proposed distillery project works out to 16.22%. The Net Present Value (NPV), with a Weighted average cost of capital of 11.3%, works out to Rs.3,039.74 Lakhs. The simple payback period is 5.2 years.

25.0 The return on Equity is calculated at 35.51%. The average debt equity ratio over the fifteen year period is 1.84.

26.0 Presently GSML is selling all their molasses. With the addition of the proposed ethanol distillery, one of the valuable byproduct of the sugar mill, will be put to better use. With the proposed distillery capable of producing both ENA and Anhydrous alcohol, the opportunities are enormous. With ethanol considered to be the future fuel for this planet, utilizing the molasses to produce ethanol will make good business sense. Even if there is a sluggish off-take of Anhydrous Alcohol for gasoline blending, the ENA will have an ever expanding market with the ENA consumption in India posting an average annual growth of 4 to 5%. With the advent of the spent wash concentration and incineration technology, the disposal of spent wash, one of the worst nightmares of the distillery industry, has been made easy. In fact the dreaded
effluent is now used as a fuel for powering the distillery, meeting almost 60% of the total energy requirements of the distillery. The project viability analysis indicate that the proposed distillery unit is immensely viable.
1.0 INTRODUCTION

1.1 Ethyl Alcohol commonly known as Ethanol, with the molecular formula of \( C_2H_5OH \), is an important organic compound which has wide use, in industrial applications, as fuel for internal combustion engines and as an intoxicating ingredient of alcoholic beverages. In the Industrial applications it is used as solvents and in the synthesis of varied organic chemicals like acetaldehyde, acetic acid, benzene, PVC etc. Even though the major consumption as of now is for alcoholic beverages, Ethyl alcohol has the potential to fuel the future relegating gasoline to a secondary place. Brazil has pioneered the blending of Ethyl alcohol with gasoline to be used as automotive fuel, followed by United States of America and many other countries. Many countries, including India, have implemented policies to ensure that the bio-fuels become important element of their transport fuel mix. Bio-ethanol, unlike petroleum, is a form of renewable energy that can be produced from agricultural feed stocks. Ethanol can be produced from several raw materials like sugarcane or sugar beet molasses, cassava, maize and other grains. Concerns about its production, from raw materials other than sugar cane molasses, relate to increased food prices, the large amount of arable land required for crops etc. However the latest developments with cellulosic ethanol production may allay some of these concerns relating to the food security.

1.2 India's total installed ethyl alcohol production capacity is 4 billion litres per annum in about a total of 350 Distilleries. The installed production capacity for anhydrous alcohol is 2 billion litres per annum. Most of the alcohol produced in India is from cane molasses and grains contributing to only a small fraction of the production for potable alcohol. With the cane supplies diminishing in the last two or three years the production of alcohol had also come down. The average annual consumption had remained at around 3 Million litres with Industrial, potable, gasohol and other segments contributing 35%, 55%, 5% and 5% respectively. The alcohol consumption for blending with gasoline has not taken off as expected due to various
reasons. Even though the notification to blend 5% alcohol with gasoline was made out in 2002; the 5% blending was made mandatory only in 2007. Later the Government of India mandated 10% blending of alcohol with gasoline from October 2009. The Government of India has planned to achieve 20% blending by 2017. However due to the vagaries in the price of oil, reduction in the production of alcohol due to less cane cultivation etc., the policy of blending could not be implemented in full. As against the consumption of about 1050 Million Litres per annum for 5% blending and about 2100 Million Litres for 10% blending the consumption had been only around 100 Million Litres in the last year. However this scenario will change for the better as the whole world is now moving towards bio fuels. With Brazil and USA showing the way, increasing concerns about the environmental degradation and with the oil prices set to increase ultimately, we will be left with no option other than to increase our ethanol production and go with higher percentage of blending. In addition the potable alcohol consumption has been steadily increasing at the rate of 5 to 7% per annum. Presently many of the organic chemicals that are synthesized from petroleum feed stock due to the price advantage will eventually shift to ethanol feed stock as the crude price increases.

1.3 With the demand for ethyl alcohol set to increase, in the industrial, alcoholic beverages and Gasohol segments the future looks very promising for the Alcohol industry. With the possible future pressure against the use of food grains for the production of alcohol and the demand for alcohol increasing, the alcohol produced with molasses or even cane juice as feed stocks will probably have a vast market.

1.4 Gobind Sugar Mills Limited (GSML), one of the oldest sugar mills in the country, with almost 60 years of continuous operation, is part of the Adventz Group. The company originally established in the year 1952, was part of Dr.K.K.Birla group of sugar companies. The company is listed in the Kolkata stock exchange. The sugar mill at Aira Estate in Lakhimpur Kheri District of Uttar Pradesh has a present cane crushing capacity of 7200 MT per day. Under the stewardship of
Chairman Mr. Suresh Krishnan and Managing Director Mr. R.S. Raghavan, the company is planning for performance and capacity enhancement, value addition to the product and utilization of the by products to create additional revenue streams. GSML, as part of their sugar mill modernization and capacity upgradation program is enhancing the crushing capacity of the sugar mill to 10,000 TCD, with 50% of the juice processing taking place in a modern and efficient boiling house. Along with this capacity upgradation, GSML is also setting up a sugar refinery of 500 TPD capacity and a high pressure bagasse based Cogeneration plant of 30 MW capacity. GSML will start this ensuing crushing season 2015-2016, with the upgraded capacity and with both the refinery and the high pressure Cogeneration plant in operation. Presently, apart from selling the finished product plantation white sugar, the company also sells molasses, the basic raw material for ethanol production, and the surplus bagasse from the season operations. The ongoing high pressure Cogeneration project will ensure that one of the two by products, namely the bagasse, is used effectively and efficiently to increase the revenue generation to the company. In order to derive the best value of the other by product, namely the molasses, GSML would like to implement an ethanol distillery project. It is estimated that the in-house generation of about 60,000 MT of molasses per annum will enable the company to implement a distillery of 60 Kilo Litres Per Day (KLPD) capacity operating for a period of 250 days per annum. Apart from that the company could also procure molasses from nearby sugar mills to the extent of about 15,000 MT, to take the number of operation days to 310. The proposed distillery will be multi product plant capable of producing Industrial grade rectified spirit, Potable Extra Neutral Alcohol and the Anhydrous ethanol used for blending with gasoline.

1.5 The distillery will be designed as a Zero Effluent discharge plant with the spent wash concentrated and incinerated in a specially designed boiler. The high pressure steam generated in the boiler will enable adequate power generation in a turbogenerator for meeting the requirements of the distillery operations and will also provide the process steam required for the distillery operations. The distillery
design will employ the multi pressure technology with the distillation columns operating under various pressures to economize on the energy consumption in the distillation process. This distillery project will also include a effluent treatment plant, based on anaerobic digestion, aeration, clarification and Reverse Osmosis, to treat the condensate generated in the spent wash concentration plant and the spent lees generated in the distillation process. The permeate from the RO system will be used as process water, thus reducing the dependence on external water and the concentrated RO reject will be mixed with the influent spent wash upstream of the concentration plant.

1.6 Having decided to implement the ethanol distillery project GSML has retained M/s. Avant-Garde Engineers And Consultants (P) Ltd., Chennai-600116, a consultancy company with good experience in the sugar and ethanol Industries, as their consultants for the preparation of the Detailed Project Report and for the implementation of this project.

1.7 The subsequent sections of this report furnishes the details of the proposed distillery process plant, the spent wash concentration system, the concentrated spent wash fired boiler system, the power plant, site facilities etc. The report also dwells on the environment aspects, estimate of the capital cost, financial analysis and the schedule for the implementation of the proposed multi product Distillery Project.
2.0 PLANT AND EQUIPMENT DESIGN CRITERIA

2.1 General

The proposed 60 KLPD distillery facility at Coromandel Sugars Limited will be operating almost for about 310 days in a year, with in house molasses and about 15,000 MT of bought out molasses. It is possible to increase the number of days of operation to 330 days per annum, if GSML is able to buy more molasses from the market at reasonable price. All the plant and systems shall be designed to achieve the best possible efficiency under the specified operating conditions. The boiler to be installed in the distillery shall be designed to fire concentrated spent wash along with bagasse for steam generation. The steam generated in the boiler will be supplied to a turbogenerator for power generation and the extracted/pass out steam will meet with all the process steam requirements and the steam required for spent wash concentration.

The complete plant instrumentation and control system for the distillery, spent wash concentration and incineration system and the 2.2 MW co-generation plant shall be based on Distributed Control System (DCS) philosophy, covering the total functioning requirements of measuring, monitoring, alarming and controlling, logging, sequence interlocks and equipment protection, etc.

The plant layout shall make optimum use of the land and facilities to minimize the cost of installation. The optimum arrangement of the equipment shall be determined by the considerations of functional requirements, economy of piping and electrical cables, economy of equipment supports, installation and maintenance access requirements, ventilation requirements and equipment generated noise and vibrations.

2.2 Plant & Machinery design criteria

This section of the report gives the basic criteria for the design of the plant. The design parameters like the size, layout, ratings, quantities, materials of construction, type of equipment etc., described in this report are tentative and approximate. Necessary
changes could occur as the detailed engineering of the plant progresses and such changes are permitted as long as the detailed engineering of the plant achieves the intent of this report.

2.3 Ambient Conditions

Plant Elevation above Mean Sea Level (MSL) : 160 meters

Temperatures:

- Maximum Temperature : 45 Deg.C
- Minimum Temperature : 3 Deg.C
- Plant Design Temperature (Dry Bulb) : 30 Deg.C
- Plant Design Wet Bulb Temperature : 28 Deg.C
- Plant Design Temperature for Electrical Equipment : 50 Deg.C

Relative Humidity:

- Maximum : 85.0 %
- Minimum : 47.0 %
- Plant Design Relative Humidity : 70.0 %

Precipitation:

- Total Annual Rainfall, average : 600 mm

Wind:

- Wind Direction : East - West
- Design Wind Velocity : As per IS:875

Seismic Coefficient:

- Design : As per IS:1893

Soil Bearing Capacity:

- At 2.0 m Depth : 12 MT/Sq.M
2.4 Plant input specification

2.4.1 Molasses

Molasses is the mother liquor left after crystallizing out a major portion of sucrose crystals from concentrated cane syrup. As one hundred percent exhaustion of the mother liquor is not possible, even the final molasses that leaves the sugar process house still contains appreciable quantum of sucrose. Apart from sucrose the molasses also contains other sugars, which are not crystallisable, but could be used for fermentation. The fermentable sugar (FS) content, which is the total of sucrose and other sugars that could be fermented, is the most important criteria to decide on the quantity of ethanol that could be produced from the molasses. The molasses also contains some form of sugars that are not fermentable and the total sugars in molasses, both fermentable and non-fermentable, are called total reducing sugars (TRS). The molasses proposed to be used is expected to have a fermentable sugar content of 36.8%. With this FS the ethanol yield in the distillery will be around 222 litres per MT of molasses. For the proposed 60 KLPD distillery at GSML, the molasses requirement with the FS of 36.8% will be 270 MT/day. In general the molasses characteristics are dark brown in colour, viscous syrup mass, miscible with water, pH 4.5 - 5.5 and Sp. Gravity-1.35 to 1.45.

Various components present in molasses are:- Water: 20% to 30% w/w, Total solids: 70% to 80% w/w, Organic solids like total sugars, non sugar substances, organic acids, vitamins, pigments. Factors affecting the composition of molasses are variety of cane, composition of soil, climatic conditions, harvesting practices, sugar factory practices and efficiencies etc.

Molasses should be free from any foreign material including any caramalisation products, known inhibitory elements of yeast metabolism (i.e.) lead, arsenic, poly electrolytes etc., or micro organisms producing side products. The molasses for this plant has been taken to have the following characteristics, based on the information furnished by the sugar factory:
### Fermentable Sugars

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermentable Sugars</td>
<td>36.8 % (w/w)</td>
</tr>
<tr>
<td>Brix (%)</td>
<td>89.4%</td>
</tr>
<tr>
<td>Total Organics (other than sugar)</td>
<td>Max. 6-8% w/w</td>
</tr>
<tr>
<td>Total inorganics</td>
<td>Max.13.79% w/w</td>
</tr>
<tr>
<td>Volatile Acids</td>
<td>Max. 500 ppm</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>NIL</td>
</tr>
<tr>
<td>Total viable count</td>
<td>Max.1000 cfu/gm</td>
</tr>
<tr>
<td>Free assimilable nitrogen content</td>
<td>Min. 1300 ppm</td>
</tr>
<tr>
<td>Sludge content</td>
<td>Max. 1.1% w/w</td>
</tr>
<tr>
<td>Caramel in terms of colour</td>
<td>Present</td>
</tr>
</tbody>
</table>

Proper care should be taken during storage of molasses, specifically during filling of the storage tanks. It is preferable to cool down the molasses before it goes to molasses storage tank. The molasses storage tank should have a suitable pump for recirculation of molasses.

There will be a total storage of 33,360 MT for molasses. This includes the already existing storage tank of 25,860 MT capacity in the sugar mill. The balance of the storage will be made up by adding one number of 7,500 MT capacity within the new distillery complex.
2.5 Other Distillery Chemicals

In addition to the molasses requirement, the distillery process also requires other chemicals, the composition of which are given below:

2.5.1 Concentrated commercial Sulphuric Acid

<table>
<thead>
<tr>
<th>Composition</th>
<th>Value in % w/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity</td>
<td>97 % Min.</td>
</tr>
<tr>
<td>Lead</td>
<td>0.001 Max.</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.0001 Max.</td>
</tr>
<tr>
<td>Iron</td>
<td>0.03 Max.</td>
</tr>
<tr>
<td>Moisture</td>
<td>2 Max.</td>
</tr>
<tr>
<td>Density</td>
<td>1840 kg/cu.m</td>
</tr>
<tr>
<td>Liquid form</td>
<td>Clear, colourless, odourless liquid</td>
</tr>
</tbody>
</table>

2.5.2 Antifoam agent: Turnkey Red Oil

<table>
<thead>
<tr>
<th>Composition</th>
<th>Value in % w/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of Sulphation</td>
<td>6 Min.</td>
</tr>
<tr>
<td>Total Alkali (KOH)</td>
<td>4 Max.</td>
</tr>
<tr>
<td>Total fatty matter (TFM)</td>
<td>60 Min.</td>
</tr>
<tr>
<td>Total Ash</td>
<td>8 Min</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 - 7.5</td>
</tr>
<tr>
<td>State of fluid</td>
<td>Liquid</td>
</tr>
</tbody>
</table>

2.5.3 Di-ammonium Phosphate

Di-ammonium phosphate (DAP), in the form of granules, confirming to following specifications. Values given below are in w/w %.
<table>
<thead>
<tr>
<th>Composition</th>
<th>Value in % w/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available Phosphorus as P2O5</td>
<td>50% Min.</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>20 Min</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.0001 Max</td>
</tr>
<tr>
<td>Iron</td>
<td>0.01 Max</td>
</tr>
<tr>
<td>Lead</td>
<td>0.001 Max</td>
</tr>
</tbody>
</table>

2.5.4 In addition to the above, the process requires chemicals like, Caustic (47% w/w) for neutralisation, Phosphoric acid (1% w/w) for membrane cleaning and Sodium Meta bisulphate (1% w/w) for membrane storage in the condensate and spent lees treatment unit. Caustic solution is required for CIP (Cleaning in Process) in the fermenters and Caustic solutions and Nitric acid are required for in process cleaning (CIP) of the distillation and evaporation sections.

2.5.5 The Fermentation process requires yeast for the conversion of glucose into ethanol and Carbon-di-Oxide. Yeast culture will be supplied by the distillery supplier in the form of slant during the plant start up. The distillery should further develop the culture for regular use during plant operation.

2.6 Water requirement for the Distillery

The raw water supply for the plant will be from the bore wells located within the plant. This raw water will be used as make up for the losses in the process steam, boiler blow down, cooling tower blow down, service water, make up water, etc. In addition water is required for fermentation section for dilution of molasses, for the ENA section for extractive distillation, make up water for the process cooling towers etc.

The design of the water treatment system will be based on the actual chemical analysis of the raw water at site. During contract stage, the water analysis will be carried out in a detailed manner before furnishing the same to the water treatment plant vendor.
The raw water quality considered for this project report is given below:

2.6.1 Physical Examination

- Appearance when Analysed: Clear on Settling
- Appearance after Filtration: Clear
- Turbidity, NTU: 2
- Total Suspended Solids, mg/l: 4
- Odour (Smell): Unobjectionable
- Colour, Hazen Unit: < 5
- pH @ 25°C: 8.0
- Electrical conductivity at 25°C (µS/cm): 835
- Colloidal (Molubdate Unreactive) Silica (as SiO₂), mg/l: 0.7

2.6.2 Chemical Examination

- Cations
  - Calcium (as Ca), mg/l: 31
  - Magnesium (as Mg), mg/l: 35
  - Sodium (as Na), mg/l: 100
  - Potassium (as K), mg/l: 3
  - Ammonium (as NH₄), mg/l: 0.33
  - Alumina (as Al), mg/l: < 0.02
  - Barium (as Ba), mg/l: 0.11
**Copper (as Cu), mg/l** 0.01

**Ferrous Iron (as Fe$^{2+}$), mg/l** < 0.1

**Ferric Iron (as Fe$^{3+}$), mg/l** 0.16

**Manganese (as Mn), mg/l** 0.04

**Zinc (as Zn), mg/l** 0.11

**Strontium (as Sr), mg/l** 0.28

**Anions**

**Chlorides (as Cl), mg/l** 19

**Fluoride (as F), mg/l** 0.5

**Nitrates (as NO$_3^{-}$), mg/l** 4

**Nitrate Nitrogen (as N), mg/l** 0.9

**Nitrite (as NO$_2^{-}$), mg/l** < 0.01

**Phosphate (as H$_2$PO$_4^{-}$), mg/l** < 0.05 (monovalent)

**Phosphate (as PO$_4^{2-}$), mg/l** < 0.05 (Divalent)

**Phosphate (as PO$_4^{3-}$), mg/l** < 0.05 (Trivalent)

**Sulphate (as SO$_4^{2-}$), mg/l** 55

**Sulphide (as S), mg/l** < 1

**Sulphite (as SO$_3^{2-}$), mg/l** < 1

**Lime (as CaO), mg/l (on the basis of Calcium)** 43
Molybdate Reactive Silica (as SiO₂) mg/l  21.1
Total Volatile Solids, mg/l  55
Total Fixed Solids, mg/l  465
Total Dissolved Solids  520
Total harness (as CaCO₃), mg/l  221
Methyl Orange Alkalinity (as CaCO₃), mg/l  359
Phenolphthalein Alkalinity (as CaCO₃), mg/l  Nil

2.6.3 Organic Constituents Examination

Biochemical Oxygen Demand (BOD) 8 (at 20°C for 5 days), mg/l
Chemical Oxygen Demand (COD), mg/l 36
Oxygen absorbed in 4 hours at 27°C (Tide’s Test), mg/l 0.7
Dissolved Oxygen (as O₂), mg/l 5.4
Total Organic Carbon, mg/l 0.9
Ammonical Nitrogen as N, mg/l 0.26
Albuminoid Nitrogen as N, mg/l 0.61

2.6.4 Toxic Substances

Lead (as Pb), mg/l <0.01
Cyanide (as CN), mg/l <0.01
Mercury (as Hg), mg/l <0.001
Total Chromium (as Cr), mg/l <0.01
Nickel (as N), mg/l <0.01
Cadmium (as Cd), mg/l <0.01
Arsenic (as As), mg/l <0.005
Sulphide (as H₂S), mg/l <1

2.6.5 Gases
Free Carbon di oxide (as CO₂), mg/l 1.8
Free Ammonias (as NH₃⁻), mg/l 0.01

2.6.6 Microbiological Examination
Total Bacterial Count 1.5 x 10⁴
Sulphate Reducing Bacteria/100 ml No Growth Observed

2.6.7 Additional Parameters
Bisulphate (as HSO₄), mg/l 56
(on the basis of SO₄)
Bisulphite (as HSO₃), mg/l <1
(on the basis of SO₃)
Bicarbonate (as HCO₃), mg/l 438
Carbonate (as CO₃, mg/l Nil

Note: BDL - Below Detectable Limit

2.7 Distillery Product Specification
The expected product output specifications shall be as given below.
The input molasses specification has a bearing on the exact product specification, but however the plant shall be designed to
give broadly the following product specification. The Detailed Project Report is based on a plant that could give the specification requirement as given below:
### 2.7.1 Rectified Spirit

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Colourless</td>
</tr>
<tr>
<td>Appearance</td>
<td>Clear and transparent</td>
</tr>
<tr>
<td>Ethanol content at 20°C</td>
<td>95% v/v minimum</td>
</tr>
<tr>
<td>Specific gravity at 15.6°C</td>
<td>0.8178 maximum</td>
</tr>
<tr>
<td>Aldehydes (as acetaldehyde)</td>
<td>0.0060% w/w Maximum (60 ppm)</td>
</tr>
<tr>
<td>Acidity (as acetic acid)</td>
<td>0.002% w/w maximum (20 ppm)</td>
</tr>
<tr>
<td>Esters (as ethyl acetate)</td>
<td>0.020% w/w maximum (200 ppm)</td>
</tr>
<tr>
<td>Furfural</td>
<td>Nil</td>
</tr>
<tr>
<td>Residue on evaporation</td>
<td>0.0050% w/w Max. (50 ppm)</td>
</tr>
</tbody>
</table>

### 2.7.2 Extra Neutral Alcohol

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol content, % v/v at 20°C, minimum</td>
<td>96</td>
</tr>
<tr>
<td>Relative density at 15.6°C</td>
<td>0.80692</td>
</tr>
<tr>
<td>Miscibility with water</td>
<td>Miscible</td>
</tr>
<tr>
<td>Acidity, as Acetic acid ppm max.</td>
<td>15</td>
</tr>
<tr>
<td>Residue on evaporation ppm max</td>
<td>15</td>
</tr>
<tr>
<td>Aldehydes, as Acetaldehyde ppm max.</td>
<td>5 - 10</td>
</tr>
<tr>
<td>Esters, as Ethyl acetate ppm Max.</td>
<td>13</td>
</tr>
<tr>
<td>Copper, as Cu ppm max.</td>
<td>0.02</td>
</tr>
<tr>
<td>Lead, as Pb ppm max</td>
<td>1</td>
</tr>
<tr>
<td>Methanol ppm Max.</td>
<td>5 to 7</td>
</tr>
<tr>
<td>Higher Alcohol as Iso-amyl alcohol ppm , max.</td>
<td>15</td>
</tr>
<tr>
<td>Furfural</td>
<td>Not Detectable</td>
</tr>
</tbody>
</table>
Permanganate Decolorization
Time, minutes, minimum | 45

2.7.3 Anhydrous Alcohol

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol content, % v/v at 15.6°C, min (excluding denaturant)</td>
<td>99.8%</td>
</tr>
<tr>
<td>Relative density at 15.6°C</td>
<td>0.7961</td>
</tr>
<tr>
<td>Miscibility with water</td>
<td>Miscible</td>
</tr>
<tr>
<td>Acidity, as Acetic acid, mg/l</td>
<td>Max.30</td>
</tr>
<tr>
<td>Residue on evaporation, % w/w</td>
<td>Max.0.005</td>
</tr>
<tr>
<td>Aldehydes, as Acetaldehyde, mg/l</td>
<td>Max.60</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>Nil</td>
</tr>
<tr>
<td>Methanol mg/l max</td>
<td>300</td>
</tr>
<tr>
<td>Appearance</td>
<td>Clear &amp; bright</td>
</tr>
</tbody>
</table>

2.8 Distillery Mode of Operation

The distillation system of the Distillery shall be designed in such a way that it will give the flexibility of running the plant in any of the modes such as wash to RS, wash to ENA, wash to ethanol and RS to ethanol. The distillation system shall be designed for accepting fluctuation in the molasses quality. The plant should be capable of producing RS of industrial quality, superior grade ENA and Fuel ethanol. Total spirit production shall be 60,000 litres per day out of which impure cut or technical alcohol shall not exceed 5%.

2.9 Distillery Equipment Design Criteria

2.9.1 Water usage should be as minimum as practical in the distillery.

The distillery should be designed for Zero effluent discharge. Process condensate and spent lees, should be treated in an effluent treatment system and reused for cooling tower and other process requirements.
2.9.2 All fermenters shall be provided with cleaning nozzles with ability to ensure proper cleaning, after the completion of each batch of fermentation.

2.9.3 The spent wash from distillery shall be concentrated to 60% w/w solids through an independent multiple effect evaporation system. The evaporator shall be designed to operate with 2.5 bar(a) steam.

2.9.4 TEMA Standards shall be followed for heat exchanger design. A minimum thickness of 3mm shall be provided over the calculated thickness towards corrosion allowance for all scantlings other than the heat exchanger tubes. The tube shall be connected to the tube sheets with expansion followed by welding. Vertical cut baffles shall be provided for horizontal condensers. Vapour entry shall be from the side for horizontal condensers. Heat exchanger tube shall be minimum 1.6mm thick. Tube sheet thickness shall be minimum 16mm. Vent connection shall be provided at highest point for venting non-condensable gases.

2.9.5 MOC for water headers, bonnets and steam heated reboilers shall be SS 304. Plate heat exchanges shall be single pass type on both sides. The plate shall be of wide gap type and plate thickness shall be 0.6mm.

2.9.6 All pressure vessels like distillation columns, molecular sieve drums, evaporation vessels, condensate pot etc shall be designed as per ASME Section VIII- Div.1. Columns and other equipment designed for steam or vapour applications and working above atmospheric pressure shall be designed for full vacuum as well as for the working pressure.

2.9.7 All the Columns shall be designed considering wind and seismic load as per applicable IS standards.

2.9.8 FRP type induced draft cross flow cooling towers shall be considered with appropriate ΔT in the design.

2.9.9 All process pumps shall be centrifugal type with mechanical seal. 100% standby shall be provided. MOC shall be SS 304 except for Sulphuric acid CIP pumps. Molasses pumps shall be of shuttle block
type with MOC of cast steel. The dosing pump shall be of plunger / diaphragm type.

2.9.10 Fermenters, product storage tanks, receivers, molasses bulk storage tanks shall be designed generally as per IS standards/API standard. All tanks shall be supported on civil foundations.

2.9.11 The Molecular sieve technology based Dehydration system for the production of Anhydrous Alcohol shall be designed to accept RS from the distillery or RS from the bulk storage.

2.10 Design & Guarantee Fuel for the Spent wash fired boiler

The design and guarantee fuel for the distillery boiler cogeneration plant will be concentrated spent wash (60% w/w solids) to be fired along with in house generated bagasse from the sugar mill. The following will be the analysis and the Gross Calorific Value (GCV) of the various fuels. The boiler shall be designed to burn about 8.7 TPH of concentrated Spent wash along with approximately 5 TPH of bagasse for generating 20 TPH of steam required for the plant. The fuel analysis of the various fuels is given below.

2.10.1 Bagasse Composition and GCV of bagasse

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>23.0%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>3.25%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>20.75%</td>
</tr>
<tr>
<td>Moisture</td>
<td>50%</td>
</tr>
<tr>
<td>Ash</td>
<td>3.0%</td>
</tr>
<tr>
<td>GCV with 50% moisture</td>
<td>2272 kCals/kg</td>
</tr>
</tbody>
</table>

2.10.2 Typical analysis of 60% w/w solids concentrated Spent wash

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>22.93%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>2.21%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>15.22%</td>
</tr>
<tr>
<td>Moisture</td>
<td>40%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.63%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.91%</td>
</tr>
<tr>
<td>Ash</td>
<td>17.11%</td>
</tr>
<tr>
<td>Gross calorific value</td>
<td>1705 kCals/kg</td>
</tr>
</tbody>
</table>
2.11 Steam Generator & Auxiliaries

The new steam generating system for the Cogeneration plant of the distillery will consist of One (1) bagasse and concentrated spent wash fired boiler with a Maximum Continuous Rating (MCR) of 20 TPH, with the outlet steam parameters at 45 bar(a) and 400 Deg.C. The tolerance on the super heater outlet temperature shall be ±5°C and -0°C. The 20 TPH of MCR capacity is arrived at considering the availability of 7 TPH.

The combustion system of the boiler shall be travelling grate with spreader stoker for bagasse firing and a spray burner system for burning of concentrated spent wash. The boiler efficiency shall be a minimum of 61% on the GCV basis while firing concentrated Spent wash with bagasse. The boiler shall be designed to meet with the requirements of the Indian Boiler Regulations.

The dust Concentration in the flue gases leaving the boiler shall be a maximum of 50 mg/N.Cum and the boiler shall be provided with a bag filter for flue gas cleaning.

The design of the boiler shall be of single drum, natural circulation; radiant furnace with water cooled membrane walls, two stage superheater with interstage Desuperheater and balanced draft. The boiler shall be top supported and shall be of semi-outdoor type. The boiler shall be capable of a peak generation of 110% of the MCR generation for a period of One (1) Hour in a shift. The operating excess air percentage at the outlet of the boiler shall be an average of 40%.

Boiler Feed Water

The boiler shall be capable of operating with the following feed water quality requirements.

- pH : 8.8 - 9.2
- Oxygen : 0.007 ppm
- Hardness : 0
- Total Iron : 0.01 ppm
- Total Copper : 0.01 ppm
- Total Silica : 0.02 ppm
- Hydrazine : 0.01-0.02 ppm
- Specific Electrical Conductivity at 25 °C measured after Cation exchanger in the H+ form and after CO2 removal (max) Steam Purity

The boiler shall be capable of supplying uninterrupted steam at the MCR rating with the following steam purity levels.

- Total Dissolved Solids : 0.1 ppm (max)
- Silica (max) : 0.02 ppm

Performance Guarantee Tests

* Maximum Continuous Rating (MCR) of the boiler while firing concentrated Spent wash and bagasse, with the feed water temperature of 150 °C and super heater outlet parameters of 45 ata and 400 °C 5 C and 0 C.

* Boiler Efficiency at MCR on GCV basis while firing bagasse and concentrated spent wash.

* Auxiliary Power Consumption under MCR operating conditions.

* Steam purity for all operating loads.

* Dust Concentration in the flue gases leaving the bag house, while firing Bagasse and concentrated spent wash.

2.12 Turbogenerator & Auxiliaries

The TG shall be a 2.2 MW nominal capacity backpressure machine with the exhaust at 3.5 bar(a). The following shall be the salient design parameters. The speed of the turbine shall be preferably less than 8000 rpm. The inlet steam parameter for the turbo generator shall be 42 bar(a) and 395°C. Under the normal
operating conditions, with the boiler generating 20 TPH of steam, the power generation in the turbogenerator shall be 2.15 MW, adequate for meeting the distillery requirements.

The generation voltage shall be 420 kV and the system shall operate in a standalone mode and when required in synchronization with the sugar mill Cogeneration plant as well as the start up DG sets in the distillery. A surplus power of about 300 kW will be exported to the sugar mill.

**Performance Guarantee Tests**

The performance test shall be conducted for the following parameters as per ASME PTC 6 and DIN 1943:

- Power Output at Generator Terminals with the Inlet steam parameters of as specified.
- Auxiliary Power Consumption under Guarantee conditions.
- Maximum temperature rise in the generator windings.

**2.13 Auxiliary Plant and Equipment**

**2.13.1 Fuel handling**

The fuel for the distillery cogeneration plant operation during the season is bagasse and concentrated spent wash from the distillery. The bagasse shall be conveyed to the new 20 TPH boiler by belt conveyors from the storage yard. The system shall have provision for returning the excess bagasse/biomass to the storage yard and also the provision for back feeding the bagasse from the storage yard to the boiler. The bulk density of bagasse shall be 150 Kg/Cum. Allowable inclination for the belt conveyor is 18 to 20°. The Belt speed shall be approximately 1.00 meters/sec. The maximum moisture percentage in bagasse shall be 56%.

**2.13.2 Ash handling**

The ash handling system envisaged for the cogeneration plant is of two types:
- Sub-merged scrapper conveyor system for grate ash
- Dense phase handling system for fly ash

The ash received in the grate discharge hoppers will be around 500 °C, with ash lumps of size 200 mm maximum. The ash from ash riddling hopper will be dry and powdery in nature and occasionally with hot solids. The temperature of the ash will be around 200 °C maximum.

The fly ash from bag house Hoppers will be dry and powdery in nature and occasionally with hot solids. The temperature of ash will be around 200 °C maximum.

All the ash will be collected in storage silo having a suitable capacity (24 hours) & will be disposed-off by trucks / trailers.

2.13.3 Cooling Towers

The cooling tower shall be Wooden/FRP type cross flow induced draft cooling tower of adequate capacity for the various applications of the distillery plant. The cooling tower shall be designed for a cooling range of 2 °C for the fermentation section, 6°C for MSDH section and 10°C for other section of the plant with an approach of 5 °C while operating under the atmospheric wet bulb temperature of about 28 °C. The cooling tower shall be carefully sited such that there is no re-entrainment of the vapours into the cooling tower. The location shall also be such that there will be no major contamination of the cooling tower basin water with the bagasse.

The cooling tower for the power plant shall be designed with an approach of 5 Deg.C and a cooling range of 8 Deg.C. The cooling tower for the power plant shall be separate from the process plant cooling towers. This tower will meet with all the cooling water requirements of the power plant.

2.13.4 Pumps

The head / flow characteristics of pumps will be such that the head continuously rises with decreasing capacity until a maximum
head is reached at zero flow. Maximum run-out flow should at least 130% of duty point flow.

The shut off head should be at least 1.1 times the duty point head and should not be more than 1.2 times the duty point head.

The power curve should be of non-overloading type with the maximum power occurring at or near duty point or towards maximum runout flow.

NPSHR curve should be a continuously rising one in the range of operation, from the minimum flow in the range to the maximum flow in the range. Required NPSH values shall not exceed available values over the entire range from minimum to rated flow.

2.13.5 Condensate System

The process condensate and spent lees mixture shall be treated in a treatment plant, based on anaerobic digestion, aeration, clarification, ultra filtration and reverse osmosis, with recovery of about 90%. This recovered water shall be recycled and used as make of water for cooling towers of the plant and also for molasses dilution in the distillery process.

Process Steam from turbine extraction shall be supplied to the reboilers of pre rectifier cum exhaust column, rectifier cum exhaust column and extractive distillation column in the distillery process plant and to the evaporators in the spent wash concentration plant. The condensate from these reboilers outlet will not be contaminated and hence can be reused in the boiler. The pure condensate from the process area shall be stored in a condensate recovery tank from where it will be fed to the deaerator of the spent wash fired boiler.

2.13.6 DM Plant

The Demineralized water quality at the outlet of the DM plant shall be as follows:

* Hardness (ppm) : 0
* pH @ 25°C : 8.8 - 9.2
* Conductivity @ 25 C : 0.5 (microsiemens / Cm)
* Oxygen (maximum) (ppm) : 0.007
* Total Iron (maximum) (ppm) : 0.01
* Total Copper (maximum) (ppm) : 0.01
* Total Silica (maximum)(ppm) : 0.02
* Residual Hydrazine (ppm) : 0.01-0.02

The DM water required for the distillery and the spent wash incineration boiler will be supplied from a new dedicated water treatment plant. Necessary piping, valves, fittings, flow meters shall be installed for the clarified water to the process and DM water to the boiler and distillery.

2.13.7 Vessels & Heat Exchangers

The design shall be as per ASME Sec.VIII, HEI and TEMA. All heat exchangers and vessels for steam application shall be designed for full vacuum conditions. The heat exchangers shall be provided with start up vent connections. The design shall have provision for complete drainage on both shell and tube sides. The heat exchangers shall be provided with emergency drains, shell side safety valves, and individual bypass with manual valves. A minimum corrosion allowance of 3 mm shall be provided. The tube bundle shall be of removable type. The tube material shall be stainless steel, unless otherwise specified in the specifications.

2.13.8 Tanks

The distillery plant tanks should have storage capacities as required by design of the systems, requirement from the statutory authorities and necessity to have storage facilities built in the plant to match with marketing of the products. Tanks will be of the closed top type. The Tanks will be fabricated in accordance with the guidelines established by Indian Standards, API-650, BS-2654. The tanks shall be provided with proper feeding arrangement of the product into the tank. Drain valves, discharge valves, manhole, safety railing, vent, vent condensers as applicable, ladders shall be provided for the tanks. Water spraying facility shall be provided for the molasses tank. The AA, ENA & RS storage tank shall strictly adhere to the safety regulations.
The receiver tanks for RS, ENA and AA will be of 60 KL capacity each. There will be three (3) receiver tanks for each of RS, ENA and AA. The technical alcohol receivers will be 25 KL capacity and there will be three such tanks. There will be two (2) bulk storage tanks for each of RS, ENA and AA. The capacity of each such bulk storage tanks will be 450 KL. There will be one tank each for the bulk storage of TA and Fusel oil with the capacity of 90 KL and 2 KL respectively. Apart from these tanks, denaturant will be stored in 3 nos. 2 KL capacity tanks, and there will be two (2) denatured spirit blending tanks each with the capacity of 60 KL for RS and AA.

2.13.9 Piping

All piping system shall be designed as per ASME B 31.1. In addition, statutory requirements of the Indian Boiler regulations shall be complied with, wherever applicable.

Stress Analysis shall be carried out for all possible operating modes and shall be as per IBR and ASME B 31.1 requirements. Supports, guides, Directional Anchors shall be selected to satisfy all the operating conditions.

All piping shall be sized considering the allowable velocity and allowable pressure drop in the system. The suggested flow velocities of various mediums are,

* Superheated Steam : 45 to 55 M/Sec
* Saturated Steam : 15 to 30 M/Sec
* Boiler Feed Water
  * Pump Suction : < 1M/Sec
  * Pump Discharge : 2.5 to 4 M/Sec
* Water
  * Pump Suction : < 1M/Sec
  * Pump Discharge : 2.5 M/Sec
* Condensate
  * Pump Suction : 0.6 to 0.7 M/Sec
  * Pump Discharge : 2.5 M/Sec
* Compressed Air : 12 to 18 M/Sec
2.13.10 Piping Materials

The piping material selection shall be based on the following recommendations.

For temperature 400°C to 510°C, SA 335 Gr. P11/P12/P22 shall be used.

For temperature 399°C & below SA 106 Gr.B/C or ASTM A-53 seamless shall be used.

For HP/LP chemical dosing SA 312 TP 304, Stainless Steel shall be used.

All pipe fittings other than those mentioned shall confirm to ASTM A 234 standard and dimension as per ANSI B 13.9 / B 13.28 / B 13.11.

For Cooling water, Raw water, Service Water, Safety/ Relief valve exhaust carbon steel ERW pipes shall be used.

For the alcohol system stainless steel AISI - 304 shall be used.

For Service air applications the piping shall be carbon steel Black Medium Class.

For instrument air applications: Galvanized pipe shall be used.

2.13.11 Insulation

All exposed portions of the plant which operate at temperatures of 60°C and above during normal operation shall be thermally insulated so that the temperature on the outer surface of the cladding shall not exceed by more than 20°C above ambient, based on an ambient temperature indicated in site data. The specified insulation thickness shall not include the thickness of wire netting.
finishing cement or any other finishing or weatherproofing application. Insulation shall not fill the contours of the expansion bellows. Piping and equipment that are not insulated but having a surface temperature exceeding 50 Deg.C shall be insulated for personnel protection.

2.14 Civil & Structural

The reinforced concrete structures shall be designed in accordance with the latest version of Indian Standards. The structural steel design shall be as per Indian Standards. The design wind speed and seismicity shall be in accordance with the applicable Indian Standards. The structures shall be designed to withstand the calculated Dead loads, Live loads, along with the wind and seismic loads in appropriate combinations recommended by the Codes. The minimum dead and live loads for the design of the platforms and walkways shall be 500 kg/sq.m.

Structural steel shapes, plates and other structural materials shall conform to IS, with minimum yield strength of 25 kg/sq.mm. Welding electrodes shall be as per AWS. HYS reinforcement steel bars shall conform to IS standards. All structural steel and MS members will be painted with two coats of red oxide zinc chromate paint and two coats of synthetic enamel paint.

Most of the foundations shall be of the spread footing or mat type, with the ones for heavily loaded equipment designed with piles. Soil Bearing Capacity shall be 12 MT/Sqm at two meter depth and Settlement shall be 25 mm at a depth of 2.0 m below ground level. The above soil bearing capacity shall be verified by soil investigation before final design. The site is assumed to be relatively flat, requiring minimal grading & levelling (levelling & grading upto ± 0.5m). Minimum grading / levelling works are envisaged, as the land area is presently under cane cultivation. All excavation work shall be done by conventional manual methods or by mechanical equipment method (wherever required). For substructures & superstructures Ordinary Portland Cement (grade 43) will be used. Grade of Concrete for steam turbogenerator & heavy rotating equipment foundations & chimney shall be with a compressive strength of 25N/sq.mm for a 150mm test cube at 28 days and all other foundations / pedestals / buildings etc. shall be
with a compressive strength of 20N/sq.mm for a 150mm test cube at 28 days.

2.15 Electrical system

All equipment for the distillery plant cogeneration unit shall be designed for satisfactory operation for a life time of minimum 30 years under specified site conditions. All equipment shall be suitable for rated voltage of ±10% and frequency of 50 Hz with ±5% variation and 10% (absolute sum) combined voltage and frequency variation.

The generator shall be of synchronous type with brushless excitation system, and shall be designed for rated voltage & frequency of 420 V & 50 Hz, with corresponding variations of ±10% and ±5%. The generator shall have closed circuit air-cooled system with external water circuit (CACW cooling) and the windings shall have class 'F' insulation, with temperature rise limited to class 'B' insulation limits, under specified cooling water & ambient air temperatures.

One (1) no. of 2.5/3.15 MVA distribution transformer shall be installed as a stand-by supply, which in turn receives supply from co-generation plant at 11 kV voltage level.

The nominal voltage of main DC system for protection & control systems and turbine emergency oil pumps shall be 110 V.

UPS system with rated voltage of 230 V AC shall be envisaged, for meeting UPS power requirements of the plant DCS and other instrumentation / control loads.

All equipment shall comply with the applicable provisions of relevant IS / IEC / IEEE standards, as listed elsewhere in this document.

Breakers for LV system shall be Air break type circuit breaker.

All interconnections at 11 kV shall be carried out through 11 kV, UE grade, armoured, XLPE insulated cables. Connection between secondary of the distribution transformers and the respective PCC
/ Panels shall be through non-segregated phase busduct, with electrolytic grade aluminium busbars and aluminium alloy enclosure. All other LT connections (power as well as control) shall be with PVC insulated, armoured, aluminium / copper cables.

**Sizing of cables shall be as follows:**

The cables shall be derated for the site ambient and ground temperatures, grouping and soil resistivity. Cables shall be selected to limit the maximum voltage drop at equipment terminals, during normal operation and starting conditions, to be well within permissible values.

Cables in circuits controlled by circuit breakers shall be capable of withstanding the maximum system fault currents till the breaker opens by main protection. For 11 kV grade cables, screen shall be suitable for carrying earth fault current of 1 kA for a duration of 1 sec.

Current ratings of the cables shall be assigned considering continuous conductor temperature of not more than 70 Deg.C for PVC and 90 Deg.C for XLPE. Cables should also be sized to carry system fault current for the duration specified above without exceeding the temperature limit of 160 Deg.C for PVC and 250 Deg.C for XLPE.

For 415V system, ACBs shall be provided for rating 630A and above, and MCCB shall be provided for lesser ratings. Motor feeders shall have fuse MCCB / MPCB, over load relays and air-break contactors. Motors of rating above 30 kW shall be provided with star-delta starters, depending on application.

All motors shall be of squirrel cage type and shall have class ‘F’ insulation, with temperature rise limited to class ‘B’ limits under specified ambient and voltage / frequency conditions.

**Fault Level**

All equipment shall be designed to withstand the maximum fault, under voltage variation of ±10%, 40 kA for 3 seconds at 11 kV system and 50 kA for 1 sec in 415 V system.
Auxiliary transformers and all accessories shall be capable of withstanding for two seconds without damage during any external short circuit at the terminal.

All Switchgears, MCC & Distribution Boards shall be capable of withstanding the maximum fault currents that may arise, duly considering the maximum fault levels on high voltage system, negative tolerance on transformer impedance and maximum possible motor contribution for maximum possible fault clearing time on ultimate backup protection but not lower than one second in any case.

Degree of Protection

* Synchronous Generator : IP54
* LT Switchgears : IP52
* Switchgears located outdoor : IP55.
* LT busduct Enclosure : IP52 (in the indoor portion)
  : IP55 (in the outdoor portion)
* Control Panels : IP42 (in air-conditioned area)
  : IP52 (in other areas)
* Push Button Stations : IP54 (indoor)
  : IP55 (outdoor)
* Induction Motors : IP54 (indoor)
  : IP55 (outdoor)

Neutral Grounding

415V transformer neutrals shall be solidly earthed through bolted links.

DCS Interface

The system shall be compatible for accepting / sending signals from / to DCS. Winding, bearing and cooling circuit (where applicable) RTDs shall be hooked up to DCS for signal processing
and necessary tripping shall be arranged from DCS, for tripping of the corresponding motor.

Signals from all transformers for winding temperatures, oil temperatures, oil level gauges, Buchholz relay outputs for alarm and tripping shall be brought to DCS.

Status (ON/OFF/TRIP) of all breakers, LT breakers in PCCs and all motor feeders shall be brought to DCS, for plant monitoring. Control of motor feeders, as per system requirement, shall also be arranged for control from the DCS system.

2.16 Instrumentation & Control system

The distillery and cogeneration plant’s Instrumentation and Control system, based on Distributed Control System philosophy, will be designed to provide monitoring and control capabilities to ensure safe and reliable operation, minimize operator manual actions and alert operators on any conditions or situations requiring manual intervention in a timely manner. The control functions shall be backed up by interlocks and safety systems which cause pre-planned actions like tripping or sequential shut down of equipments during situations where unsafe conditions develop faster than the controls or the operator’s reaction time. All I&C equipment will be of proven design and will be selected to achieve highest level of plant availability and facilitate equipment maintenance.

Signals of various process parameters shall be electrical signals generated by field mounted micro processor based smart type transmitters. The above signals will be processed in the DCS to produce electrical signal outputs which will control the final actuators through converters. All computation, signal conditioning and control function generation will be done in the DCS. More details on the Instrumentation and Control systems are furnished in Section - 7.0 of this Detailed Project Report.

2.17 Codes & Standards

Systems and equipment will be designed in accordance with the applicable sections of the following codes, standards and regulations in effect at the date of this Contract. Applicable
sections of codes, standards and regulations will be defined in specifications.

**Bureau of Indian Standards (BIS)**

**IS:325: 1996**  Three-phase induction motors

**IS:456: 2000**  RCC Structures

**IS 800: 2007**  Code of practice for construction in Steel

**IS:807: 1976**  Code of Practice for Design, Manufacture, Erection and Testing (Structural Portion of Cranes & Hoists)


**IS:1554:1988**  PVC insulated (heavy duty) electric cables

**IS:1893:2002**  Criteria for Earthquake Resistant - Design of Structures

**IS:2042:2002**  Insulating bricks

**IS:2309:1989**  Practice for the protection of the buildings and allied structures against lightning - code of practice

**IS:2429:1987**  Round Steel Short link chain electric butt welded Gr.30

**IS:2544:1973**  Porcelain post-insulators for systems with Nominal voltage greater than 1000 V.

**IS:2705: 1992**  Current Transformers

**IS:2825:1969**  Code for unfired pressure vessels

**IS:3043:1987**  Code of practice for earthing

**IS:3144:1992**  Methods of test for Mineral Wool Thermal Insulation Material
IS:3156:1992  Voltage Transformers
IS:3177:1999  Code of Practice for design of Electric Overhead Traveling Crane and Gantry Cranes
IS:3832:1986  Hand Operated Chain pulley blocks
IS:4503:1967  Shell and Tube Heat Exchangers
IS:4776:1977  Troughed Belt Conveyors
IS:5422:1996  Turbine type generators
IS:5521:1980  Steel Tanks for Storage of Molasses
IS:7098:1973  Cross linked polyethylene insulated PVC Sheathed cables
IS:7155:1990  Code of recommended practice for Conveyor Safety
IS 8466  Bagasse Carrier Chains
IS:8531  Pulleys for Belt Conveyors
IS:8623:1993  Low voltage switchgear and control gear assemblies
IS:9921:1985  Alternating current disconnectors (isolators) & earthing switches for voltage above 1000V
IS:11592:2000  Code of Practice for Selection and Design of Belt Conveyors
IS:13118:1991  High voltage alternating current circuit breakers

IS:13947:2004  LV switchgears and controlgear

IS:13779:1999  Static watthour meters, class 1 and 2

IS:14164:1994  Industrial application and finishing of Thermal insulating materials at temperatures above 80°C and upto 700 Deg.C

IS:1162:1958  Specification for cane molasses

IS:323:1959  Rectified spirit specification

IS:324:1969  Specification for ordinary denatured spirit

IS:6613:2002  Neutral spirits for alcohol drinks specification

IS:321:1964  Specification for absolute alcohol

IS:15464:2004  Test methods for absolute alcohol

**American Society of Mechanical Engineers (ASME)**

ASME Section I  Rules for construction of power Boilers

ASME Section IX  Welding & Brazing Qualifications

ASME section VIII  Unfired Pressure Vessels Code

ASME Section IX  Welding Qualification

**ASME Performance Test Code**

ASME PTC 4.1  Steam Generating Units
ASME PTC 4.3  Air Heaters
ASME PTC 3.0  Guide for evaluation of Measurement Uncertainty in Performance test of Steam Turbine
ASME PTC 19.11  Water and Steam in the Power Cycle (Purity and Quality, Leak detection and Measurement)
ASME PTC 25.3  Safety and Relief Valves

American National Standards Institute
ASME B13.5  Pipe flanges and flanged fittings
ASME B 13.9  Butt welding fittings
ASME B 13.1  Socket Welding and Threaded Fittings
ASME B 31.1  Code for Power piping

IEEE Standards
IEEE:141  Recommended Practice for Electric Power Distribution for Industrial Plants
IEEE:142  Recommended Practice for Grounding Of Industrial and Commercial Power Systems
IEEE:241  Recommended Practice for Electric Power Systems in Commercial Buildings
IEEE:242  Recommended Practice for Protection And Coordination of Industrial and Commercial Power Systems
IEEE:446  Recommended Practice for Emergency and Standby Power for Industrial and Commercial Applications.
<table>
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<td>Recommended Practice for the Design of Reliable Industrial and Commercial Power systems.</td>
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### IEC Standards

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IEC:270  Partial discharge requirements
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IEC:298  AC metal enclosed switchgear and controlgear for rated voltages above 1 kV and upto and including 52 kV
IEC:376  Specification and acceptance of new sulphur hexafluoride
IEC:439  LV switch gears and controlgear assembly
IEC:502  Extruded solid dielectric insulated power for rated voltages from 1 kV upto 30 kV
IEC:529  Classification of degree of Protection
IEC:542  Application guide for on load tap changers
IEC:694  Degrees of protection provided by enclosure (IP code)
IEC:885  Electric test methods for electric cables
IEC:909  Short-circuit current calculation in three phase AC systems
IEC:947  LV switch gears and control gear
IEC:1036  Static meters

Industry Standards

American Gear Manufacturers Association (AGMA)

American Petroleum Institute (API)

American Society for Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) Handbook
American Society for Testing and Materials (ASTM)

American Water Works Association (AWWA)

American Welding Society (AWS) Structural Welding Code (AWS D1.1)

Conveyor Equipment Manufacturers Association (CEMA)

Cooling Tower Institute (CTI)

Heat Exchange Institute (HEI)

Hydraulic Institute (HI)

Institute of Electrical and Electronics Engineers (IEEE)

Instrument Society of America (ISA)

Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry

National Electrical Manufacturers Association (NEMA)

National Fire Protection Association (NFPA)

Pipe Fabrication Institute (PFI)

Tubular Exchanger Manufacturers Association (TEMA)

Turbine:

IEC Recommendation Publication No: 45

CSN 080030

DIN 1943
British Standards

BS 4592  Industrial type metal floors, walkways and Stair treads

BS 5395  Stairs, ladders and walkways

BS:2573  Permissible Stresses in Cranes

BS:466   EOT Cranes for general use in factories, workshops and Ware houses.

BS:5316  Performance Testing of Pumps Part-I Class C
3.0 PROCESS DESCRIPTION, UTILITY REQUIREMENTS AND DESCRIPTION OF PLANT MECHANICAL EQUIPMENT FOR THE DISTILLERY PROCESS PLANT

3.1 Process & Technology

The various sections involved in the process of Manufacture of Alcohol in a multi product zero effluent discharge distillery are:

- Molasses receiving, Storage and Handling Section
- Feed stock weighing, distribution and Fermentation Section.
- Distillation for production of Extra Neutral Alcohol.
- Absolute alcohol production section
- AA, ENA, RS and Technical Alcohol Daily Receiver & Bulk Storage Section
- Spent wash concentration plant
- Utilities comprising of Boiler, TG, DM water plant, Cooling towers, compressed air system and Electrical Section
- Laboratory, stores
- Fire fighting and alarm systems for the plant
- Civil and structural work for the complete plant

3.2 Manufacturing Process

The production of alcohol from molasses is based on the property of some specific micro organisms in metabolizing the sugar content of molasses into alcohol. The activity is generally termed as Fermentation. This practice of molasses fermentation into alcohol is widely prevalent all over the world in both the cane sugar and beet sugar industries. Being a biological and renewable source
molasses continues to occupy a predominant position as a feedstock of alcohol production in the world, though other sources like food grains, dilute cane juice etc. are also widely used for this purpose.

In the current scenario, sugar manufacture is not seen in isolation, but as a vibrant sugar complex with facilities for production of rectified spirit, ENA, Fuel Ethanol, cogeneration, bio fertilizer, alco chemicals, CO2 etc. The different products of a sugar complex complement each other in improving efficiencies, reducing costs and earning higher revenues.

3.3 Different plant sections of the Ethanol distillery

Molasses Bulk Storage Tanks.

Fermentation Section -: Consisting of fermenter system which can operate on batch or continuous mode. This section shall also include molasses weighing, yeast propagation and activation, tank for fermented wash holding etc.

Multi Pressure Wash to ENA Distillation Section: Consisting of seven column distillation unit with columns operating on different pressures. Flexibility to draw Rectified Spirit (RS) and Extra Neutral Alcohol (ENA) as per requirement. This will be an automated plant with DCS based instrumentation.

Molecular Sieve Dehydration Section: Two bed molecular sieve dehydration units for the production of Fuel ethanol plant, based on pressure swing adsorption principle.

Raw Spent Wash Evaporation Section: Consisting of an independent falling film and forced circulation or only forced circulation evaporation system. This will achieve spent wash concentration of up to 55 - 60% w/w solids.

Condensate Treatment Section - Based on UASB, aeration, clarification and cross flow membrane technology to recover re usable water which can be used in process.
Concentrated spent wash incineration boiler and a matching turbogenerator.

Utilities for the above sections including cooling towers, cooling water recirculation pumps, water treatment plant and instrument air compressor etc.

Product Storage Section - Consisting of alcohol daily receivers, bulk storage, alcohol transfer pumps, delivery meters etc.

3.4 Raw material for alcohol production

3.4.1 Molasses

Molasses produced from the sugar process operations of GSML is the primary raw material that will be used for the production of alcohol. Molasses to be used for this project contains about 36.8% fermentable sugars, which include the sucrose and other fermentable monosaccharide like glucose. During the fermentation, yeast strains of the species Saccharomyces cerevisiae or Pombe are used as alcohol producing micro organism. This living micro-organism belonging to class fungi converts the monosaccharide sugars such as glucose into alcohol and carbon-di-oxide. The sucrose in molasses will be hydrolysed into glucose with water.

3.4.2 Yeast

Each yeast cell by itself is an independently existing living entity. Of the different types of yeast, Saccharomyces cerevisiae is the industrially important yeast for alcohol fermentation. Saccharomyces cerevisiae consists of different strains and varieties.

Criteria for Selection of yeast for molasses Fermentation:

- Fast fermenting
- High alcohol tolerance
- High sugar tolerance
- High salt tolerance
High temperature tolerance
Produce less amount of by-products
Resistance to contamination

Yeast can grow aerobically as well as anaerobically. Aerobic conditions favours yeast cell production, which is not of interest to ethanol producers. However, growth during anaerobic condition is very marginal and major reaction is conversion of sugar to ethanol for energy production. For growth and multiplication, yeast requires utilizable organic carbon (sugars), nitrogen source, and various organic and inorganic trace growth factors. Proper nutrition, like for any other living organism, is the key to making yeast thrive and to obtain optimum performance. The two most important nutrients for growth are nitrogen and oxygen. In addition to this, optimum environmental parameter i.e. temperature is also required. The ethanol production process from glucose is an exothermic reaction and this heat is to be removed to maintain the optimum temperature for high yeast activity. At lower temperatures the yeast becomes dormant and at higher temperatures the yeast loses its ability to produce alcohol and dies.

Propagation of yeast culture

Culture yeast is grown in the laboratory during the plant start up. Yeast propagation section has hygienically engineered yeast culture vessel equipped with heating, cooling and air sparging facilities. The Purpose of propagation is:

For Cultivation of yeast culture in pure form
To obtain yeast culture in required amount
Required to reduce the time for fermentation
To have Maximum viability & vitality of yeast
To Improve ethanol tolerance of yeast.

Yeast propagation method:

Initially yeast is developed in the laboratory from the single cell yeast culture. Laboratory propagated cell mass is scaled up in a series of culture vessels. Sterile air from air blower is sparged in pasteurised and cooled media in the Culture Vessels for optimum
growth of culture yeast. Temperature is maintained at 30°C-32°C by cooling water. Yeast development in laboratory is as follows.

Flask contains the sterilized molasses media solution. It is necessary to adjust the pH of the molasses solution in the range of 4.5 to 5.0, add nutrients such as ammonium sulphate or urea, DI-ammonium phosphate etc. Each stage of development of yeast from 10 ml to 500 ml and 500 ml to 5000 ml requires 8-12 hours in the laboratory. On the plant side, there are again 3 stages of propagation viz., 100 litres, 500 litres and 5000 litres, boiling molasses solution in order to sterilize it and cool to bring it to the 32°C. Heating and cooling of the molasses and introducing culture etc. is done in aseptic manner. Further stages of yeast propagation are done in tanks. i.e. in the pre-fermenter which requires about 8 hours in order to build up necessary concentration of yeast in them.

3.5 Distillery Fermentation Area

3.5.1 Molasses storage weighment and distribution

Based on the daily requirement of molasses for the plant, molasses is received from bulk storage tanks to the day storage tank. From the molasses storage tank the molasses is transferred to the molasses receiving tank using transfer pumps through load cell type molasses weighing scale. Weighed molasses is collected in the weighed molasses tank and then distributed to cell mass propagation, yeast activation and fermentation section using weighed molasses pumps.

3.5.2 Plant Fermentation Section

As the yeast cannot survive in the high sucrose molasses, the molasses needs to be diluted with water to give a sugar concentration of 14% to 18%. Yeast will find this sugar concentration conducive for ethanol production. This molasses is usually not sterilized, although in certain cases it has been
An initial pasteurisation is carried out which results in a slight increase in efficiency. The mash is adjusted to a pH of 4 to 5 with Sulphuric acid, if required. Although the optimum pH for maximum efficiency varies with the molasses used, an initial pH of 4.8 to 5.0 is usually considered the best.

The fermentation process converts the fermentable sugars in feedstock into alcohol using yeast. During fermentation, sugar molecules are broken down into alcohol and carbon-di-oxide. Significant heat release takes place during fermentation. However, the fermentation temperature is maintained at around 32°C by forced recirculation flow of mash through mash coolers using fermented mash recirculation pumps.

The enclosed Drawing No.1-15003-800-0001, titled "Process Flow Diagram for Fermentation Section" gives the Fermentation scheme proposed for the project.

**Fermentation time:**

Fermentation begins promptly after the fermenter is filled and usually active after 2 to 4 hours. Fermentation time vary with the molasses used, but blackstrap fermentation is usually complete in 36 hours while some molasses require 48 hours and 72 hours, respectively. After fermentation is complete the fermented mash known as "beer" and containing 8% to 9% alcohol is pumped to a temporary storage tank or also known as wash holding tank prior to distillation.

**Contamination:**

The mash in molasses fermentation is usually not sterilized, the chief defence against contaminants being the adjustment of the acidity to pH 5.0 or slightly below. Many contaminants will not grow readily at such pH levels. The fermentation is usually so vigorous that anaerobic conditions are quickly established and the alcohol produced tends to inhibit those lactic and butyric organisms that do develop. Molasses itself usually contains a relatively small flora consisting of spores of moulds, bacteria, and yeasts. Many common species of bacteria will not multiply to any extent in molasses mashes containing 15% sugars.
When spent wash recirculation is employed, care must be taken to avoid contamination of the mash with bacteria from spent wash lines and coolers, incrustations on values', dead ends etc, since these parts of the equipment can build up residues and thus act as foci of infection, harbouring bacteria acclimatized to and capable of growing in molasses mashes. Good practice consists of daily washing and steaming of all mash and spent wash lines and coolers. When not in use these lines are preferably held under steam pressure.

**Spent wash recycling**

The spent wash recycle to the fermentation is a function of molasses quality and the operating parameters maintained in the fermentation. This recycle helps reduce the spent wash generation from the distillery process, as a percentage of the spent wash will be recirculated to the fermentation section for molasses dilution. The parameters like volatile acidity, butyric acid content are important parameters of molasses quality which are crucial for fermentation and hence the percentage recycling of spent wash to the fermentation section. Spentwash received from analyser column is cooled using spent wash recycle cooler and fed to fermenters so as to reduce the usage of fresh water for molasses dilution in the fermentation process. As this aspect of spent wash circulation is to be determined, looking at the molasses, during the operation, this report, for the present, assumes that there will be no spent wash recirculation.

### 3.6 Alcohol Production from sucrose

Yeast consumes fermentable sugar present in molasses and converts it into alcohol. Alcohol so produced in the yeast cells diffuses out of its body cell wall and get accumulated in fermenter. Alcohol yield varies with yeast strain and type of molasses. The biochemical reaction occurring in yeast cell and total amount of alcohol synthesized in process per metric ton of molasses is as follows:
Biochemical reaction:

I) \[ C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{Invertase}} 2C_6H_{12}O_6 \]

Sucrose \quad \text{Glucose + Fructose}

II) \[ C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2 \]

180 \quad 2 \times 46 + 2 \times 44

GLUCOSE /FRUCTOSE \quad \text{Ethyl alcohol + Carbon di-oxide}

Thus 180 gm. of sugars on reaction gives 92 gms of alcohol. Therefore, 1 mt of sugar gives 511.1 kgs of alcohol. The specific gravity of alcohol is 0.7934, therefore, 511.1 kg. of alcohol is equivalent to \( \frac{511.1}{0.7934} = 644.19 \) litres of alcohol. During fermentation, other by-products like amyl alcohols, glycerine, succinic acids etc. also are formed from sugars. In addition some of the sugar is consumed by yeast and hence the efficiency of fermentation in producing ethyl alcohol is taken only at about 90%. Therefore, actually 90% total fermentable sugars are available for alcohol conversion. Thus theoretically, one MT of sugar will give only \( 644 \times 0.9 = 579.6 \) litres of alcohol, under ideal conditions. Depending on the quantity of fermentable sugars in molasses the alcohol production per MT of molasses will vary and with 36.8% fermentable sugars the alcohol production will be 222 Litres per MT of molasses.

The process of conversion of sugar into alcohol, as seen above, is an exothermic process. The amount of heat liberated during the fermentation of a gram mole of glucose is given by the following formula.

\[ C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 26 \text{ Kilo Calories} \]

The heat produced from a fermentation involving 100kg of glucose (monosaccharide) is 14,000 kilo cals.
3.7 Various by products of alcoholic fermentation

Fusel Oil:

The high boiling fraction (100 to 150°C) obtained in the distillation of fermented wash is known as fusel oil. It is generally 0.2-0.4 percent of spirit production. Fusel oil from molasses is a mixture of isopropyl and n-propyl, isobutyl and n-butyl, isoamyl and d-amyl alcohols. Over 50% of the total fusel oil consists of isoamyl and d-amyl alcohols. The ammonium salts depress the yield of fusel oil, since yeast preferentially uses the ammonium ion directly rather than delaminating amino acids. The use of acid to adjust the pH of the mash likewise decreases the fusel oil yield.

Carbon Dioxide:

Carbon dioxide will be available in large quantities as a by-product of the fermentation industry. From every 100 kg of monosaccharide fermented, approximately 51.1 kg of alcohol and 48.9 kg of Carbon-di-oxide are produced. Thus, from a fermentation process large amount of Carbon-di-oxide is formed. About 70% of the produced carbon di oxide can be recovered. Depending on the market conditions and seasonal demand for carbon dioxide the carbon di oxide could be sold in the solid form (dry ice) or in cylinders for carbonating beverages. Carbon-di-oxide is collected from closed fermenters after a vigorous fermentation has set in and the dissolved gases and air have been purged from the fermenter. The CO2 is taken to a scrubber where it is washed with water to recover the entrained alcohol. The scrubbed CO2 can be taken to either a CO2 plant or vented to atmosphere. The scrubbed water is transferred to mash holding tank. The gas at this stage while relatively pure (99.5%) contains traces of entrained molasses solids, aldehydes, alcohol and minute amounts of other impurities. These are responsible for an odour which must be removed before the gas can be utilized to carbonate beverages or be processed into solid Carbon-di-oxide. Of the total Carbon-di-oxide produced in the fermenter only 70% to 75% can be recovered as liquid or solid Carbon-di-oxide.
3.8 Distillation Section

When we consider distillation system employed in distillery on the basis of steam consumption and quality of spirit, multi pressure vacuum distillation will be the preferred choice. In multi pressure vacuum distillation best quality of Extra Neutral Alcohol at affordable steam consumption is possible to be produced. The potassium permanganate test time for Extra Neutral Alcohol produced by vacuum distillation easily achieved up to 45 minutes. In case of atmospheric distillation unit, steam and energy consumption will be at higher side & at the same time quality of Extra Neutral Alcohol produced is on the inferior side as compared to that produced by vacuum distillation.

One of the important reasons for selection of vacuum distillation is not only Quality but also great improvement in plant cleaning period. In case of atmospheric distillation, there arise a need to clean the analyzer column frequently. In vacuum distillation as boiling of fermented wash is carried out at low temperatures, calcium induced hard scale deposition is low and the cleaning requirements get reduced greatly.

3.9 Distillation Technologies

Distillation is a the process of separation of a multi product liquid into its components, by using the difference in the boiling points of the various constituents. This is achieved by boiling the liquid and condensing the various constituents at appropriate locations depending on the boiling temperatures and hence is an energy intensive process.

3.9.1 Multi pressure vacuum distillation:

After fermentation the next stage in the manufacture of alcohol is to separate alcohol from fermented wash and to concentrate it to 95% alcohol called as rectified spirit. For this purpose, distillation process is employed.

Distillation consumes a considerable amount of energy and is also a deciding factor in the quality of ethanol produced. Hence, in line
with the demand of the industry, efforts have always been made to minimize requirement of energy and to improve the basic quality of alcohol produced. Ease of operation, reliability, lower down time and flexibility of operations are other parameters considered during the design.

Three basic types of plant are designed:

One is to produce primary or the industrial quality of alcohol, usually referred to as 'Rectified Spirit' (R.S.) from the fermented wash. Such plants are also referred to as 'Primary distillation' plants.

Second is to produce a fine quality of spirit usually referred to as 'Extra Neutral Alcohol' (ENA) starting from R.S. Such plants are also referred to as 'secondary distillation' plants.

Third is to directly produce fine quality alcohol (ENA) from fermented wash. Such plants are referred to as ‘wash (mash) to ENA’ plants, where the two steps of primary and secondary distillation are combined. Such plants usually have lower consumption of energy than two separate plants.

Multi-pressure vacuum distillation system for production of Rectified Spirit / ENA consists of following distillation columns namely

- Degasifying cum analyzer column - Operation under vacuum
- Pre-rectification column - Operation under vacuum
- Rectification cum Exhaust Column - Operated under pressure
- Recovery column - Operated under atmospheric
- Extractive distillation column - Operated under vacuum
- Simmering column - Operated under atmospheric

In the proposed 60 KLPD project, ENA could be produced directly from wash. The concentrated vapours from the rectifier cum exhaust column will be fed directly to the ENA section of distillation columns (Extractive distillation and simmering column).
For ENA-distillation, columns will work on multi-pressure principle so that maximum heat economy can be achieved with improved quality of ENA.

3.9.2 Benefits of Multi Pressure Vacuum Distillation

Following are the advantages of pressure vacuum distillation.

Since the columns operate under different pressures, the vapours from one column could provide the energy required for driving the other column. As the system operates to some extent like a multiple effect evaporator system, good steam economy is achieved.

Since the analyzer column operates under vacuum, the formation of by-products such as acetal may be minimized there by improvement in quality of alcohol.

Pre-rectification column ensure removal of sulfur compounds/mercaptans and also reduces load of lower boiling volatile compounds passing on to Rectifier cum exhaust column.

The chances of scaling due to invert solubility of certain precipitating inorganic salts are minimized in vacuum distillation.

Vacuum distillation requires low steam consumption with reboiler

3.9.3 Integrated Multi-products Concept

It is now possible to install a distillation system, which can produce different products. In the proposed scheme; the production of Rectified spirit, ENA & Absolute alcohol have been considered. This allows flexibility of operation and various products can be manufactured depending on the market demand. This integrated multi-product system involves less capital investment as compared to independent system.
In this type of system, switching over from one product to another is quite easy and there is no chance of contamination of one product with another. The system can work under multi-pressure principle with few columns operating under vacuum and few under pressure/atmospheric. The process for wash to RS mode and wash to ENA mode is described below:

The Drawing No.1-15003-800-0002, titled “Process Slow Diagram for Distillation Section” gives the distillation scheme proposed for the distillery project.

**Wash to RS Mode**

The following distillation columns will be under operation

- **Analyser Column (Under Partial Vacuum)**
- **Degasifying Column (Under Partial Vacuum)**
- **Recovery Column (Atmospheric Pressure)**
- **Rectifier cum Exhaust Column (Under Pressure)**

Pre-heated fermented wash will be fed to Degasifying column. Fermented wash is stripped off alcohol by ascending vapors in Analyser column. Vapours of Degasifying column are condensed and appropriate TA cut is taken out from this column. The DG condensate is fed to the Recovery column. Analyser vapours are condensed and taken to Rectifier Feed Tank (which acts as Pre-Rectifier Column Feed Tank in Wash to ENA mode). Rectifier column, which operates under pressure, concentrates the condensate of Analyser column to 95% v/v concentration. Fusel Oil Draws are taken from appropriate trays and fed to Recovery Column. Recovery Column concentrates the fusel oil streams. A suitable impure spirit cut is taken out from this column. Rectified Spirit draw of 95% v/v is taken out from the upper trays of Rectifier Column and taken to storage after passing it through a cooler. RS produced in this mode of operation can be taken to storage and later be fed to the MSDH unit or directly be fed to the MSDH unit.
Wash to ENA Mode:

The following distillation Columns will be under operation

Analyser & Degasifier Column: Operates under partial vacuum.
Pre-Rectifier cum Exhaust Column: Operates under pressure.
Extractive Distillation (ED / Purifier) Column: Operates under partial vacuum.
Rectifier cum Exhaust Column: Operates under pressure.
Recovery Column: Operates at atmospheric pressure.
Simmering Column: Operates at atmospheric pressure.

Pre-heated fermented wash is fed at the top of the Degasifier column. Analyser Column is provided with re-boiler. Top vapours of Analyser column containing all the alcohol in the wash are sent to Pre-rectifier column after condensation. Rest of the fermented wash flows down the Analyser column and is taken out as spent wash from Analyser column bottom. Low boiling impurities are concentrated in the Pre-rectifier column. A draw of impure alcohol is taken out from the top of the Pre-rectifier column. RS draw is taken from the top of Pre rectifier column, which is further sent to Extractive Distillation (Purifier) column.

Dilution water in the ratio of 1:8 to 1:9 is fed to this column. The Extractive Column operates on the principle of inversion of relative volatility. Low boiling impurities are separated in the purifier column & bottom is sent to Rectifier cum Exhaust column. The Rectifier / Exhaust column concentrates the alcohol to 96% v/v. The high grade spirit is drawn from the upper trays of the rectification column. Fusel oil build up is avoided in the Rectifier cum exhaust column by with drawing side streams (fusel oils). Purifier condensates, Degasifier condensates & fusel oil draw from R/E column are sent to Recovery column where these fusel oils are concentrated and then sent to decanter where these streams are diluted with water and fusel oil rich layer is separated. Washing are sent back to the column to recover alcohol.

The High Spirit Draw from the Rectifier Column is sent to the Simmering Column where methanol is separated in the form of a cut from the top and ENA is taken out from the bottom. ENA
drawn from the Simmering Column is taken to the receiver after cooling in ENA cooler.

3.10 Manufacture of absolute/anhydrous alcohol

Anhydrous alcohol is an important product required by industry. Alcohol as manufactured by distilleries is rectified spirit, which is 94.68 % alcohol, and rest is water. It is not possible to remove remaining water from rectified spirit by straight distillation as ethyl alcohol forms a constant boiling mixture with water at this concentration and is known as azeotrope. Therefore, special process for removal of water is required for manufacture of anhydrous alcohol.

The various processes used for dehydration of alcohol are as follows.

Azeotropic Distillation
Molecular Sieves

As azeotropic distillation calls for an entrainer like cyclohexane or Benzene and needs some make up and also the steam requirement for this process is comparatively high, this process is not as widely used as the molecular sieve dehydration. It is proposed to go with molecular sieve dehydration for the proposed distillery project.

3.10.1 Dehydration with Molecular Sieve Process

Molecular sieve dehydration technology is commonly used in Indian distilleries for dehydration of rectified spirit to produce fuel ethanol because of easy operation and low steam requirement.

The Drawing No. 3-15003-800-0003 titled "Process Flow Diagram For Molecular Sieve De-hydration Section" gives the proposed Anhydrous Alcohol production scheme for the proposed Distillery.

Rectified spirit containing 94.68% to 95% v/v alcohol is pumped from RS collection tank to dehydration section. Rectified spirit is preheated in feed pre heater with the help of product vapours and fed to top tray of evaporator column. The objective of evaporator column is to evaporate the rectified spirit. Evaporator column
operates under pressure. Energy is supplied to evaporator column by evaporator column re-boiler with steam condensing on the shell side. Overhead alcohol feed vapours from evaporator column are pass through super heaters where the alcohol vapour is superheated. Energy for super heating is supplied by steam condensation on the shell side of the super heater.

Superheated hydrous alcohol vapours are sent to twin Adsorbent Beds. The twin Adsorbent Beds operate in cyclic manner. Twin beds are provided to allow for bed regeneration in continuous operation. While one bed is in dehydration mode, the other is in regeneration mode. Depending on feed and product specification, dehydration regeneration exchange takes place approximately every few minutes. The feed alcohol vapours are passed through the bed under dehydration mode. The Adsorbent Bed will absorb moisture present in feed vapours and dehydrated product alcohol vapours are obtained from bottom of the bed. The dehydration is done by adsorption by the desiccants which has pore sizes of 3 Angstrom units. The water molecules having a size of 2.5 Angstrom units are adsorbed in the pores and the alcohol molecules with the size of 4 Angstrom units go through the desiccant bed in a dehydrated condition.

The product alcohol vapours are then passed through Regeneration preheater for heat recovery. The Product alcohol vapours are then passed through Product Condenser where product vapours are condensed with the help of cooling water. Condensed product alcohol is collected in product receiver. The Product alcohol from Product Receiver is pumped to Product Cooler where it is cooled with the help of cooling water and then sent for anhydrous alcohol storage. The life of molecular sieve may be around five to seven years. However, the operating cost is considerably less than azeotropic distillation.

3.11 Raw material and utilities requirement for the 60 KLPD multi product distillery

3.11.1 Molasses

Molasses requirement (36.8% F.S.) for proposed 60 KLPD distillery will be 270 MT/day (222 litres of alcohol can be obtained from 1
ton of molasses). Proper care should be taken during storage to cool down molasses before it goes to molasses storage tank. The molasses storage tank should have a suitable pump for recirculation of molasses. The molasses tank should also be equipped with water spraying circumferential header on top of the tank. Higher molasses temperature could lead to internal combustion of molasses and will result in the loss of the entire quantum of molasses stored in the tank. The molasses specification is given in Section 2 of this report under clause 2.4.1.

Assuming that both the sugar mill and the distillery start operation simultaneously, the in house molasses storage shall be adequate to meet with the number of operation days of the distillery after the closure of the cane crushing. It is estimated that the requirement could come to about 32000 MT of Molasses. There will be a total storage of 33,360 MT for molasses. This includes the already existing storage tank of 25,860 MT capacity in the sugar mill. The balance of the storage will be made up by adding one number of 7,500 MT capacity within the new distillery complex.

3.11.2 Raw Water

The raw water requirement is 1500 cu.m per day for the operation of the distillery in wash to ENA mode. The water is required for the distillery process in the fermentation section, cooling tower make up for the distillery cooling towers. The raw water specification is given in Section-2 under Clause 2.6. The above quantities are based on the usage of fresh raw water for meeting all the needs without any consideration for the condensate recycle. If water recycling from the condensate treatment and polishing plant is considered, the raw water required will be 700 cu.m/day.

To optimize the water usage the 60 KLPD distillery section will have a process condensate and spent lees treatment and polishing unit, the recovered water of which will be used for process make up or cooling tower make up. The DM water requirement for the distillery and for the boiler is approximately 300 cu.m per day.

In another section of this report, the condensate and spent lees treatment and polishing unit is dealt with in detail.
The drawing No.1-15003-800-0010 titled "process flow diagram for cooling water system" gives the proposed cooling water scheme for the distillery.

The drawing No.3-15003-800-0011 titled "Process Flow Diagram for Raw water & DM Water system" gives the proposed raw water and DM water scheme for proposed distillery.

3.11.3 Steam Requirement

The steam requirement for production of RS from fermented wash is about 5.5 TPH at 2.5 bar (a) saturated. The steam requirement for production of ENA from fermented wash is 8 TPH at 2.5 bar (a) saturated. The steam requirement for production of AA from RS is 1.5 TPH at 4.5 bar (a) saturated. The steam requirement for Spentwash concentration from approximately 14% w/w solids to 60% w/w solids in the stand alone evaporation system is 6 TPH at 2.5 bar (a) saturated. In addition to the above the Spentwash fired boiler is provided with deaerator which requires steam for deaeration purposes and also for heating the combustion air in the steam air pre-heater.

Considering all the above, the spent wash fired boiler is sized for this project to have a MCR output of 20 TPH at 45 bar (a) 400°C. The steam produced in the boiler will be fed to the turbo alternator for power generation. The extraction steam of turbine shall be slightly superheated and shall have a pressure of about 3.5 bar (a), which will be used for meeting the distillery plant steam requirements.

3.11.4 Power Requirement

The total power requirement (at 415V, 3 PH, 50 Hz level) for the distillery and co-generation plant is given below:

- Distillery Process requirement : 775 KW
- Spentwash concentration plant : 330 KW
- Condensate/lees polishing unit : 100 KW
- Boiler and other utilities : 620 KW
- Lighting and Misc. : 25 kW
- Total (operating reqt.) : 1850 KW
The connected power will be higher than operating requirement. The distillery power requirement will be generated by a 2.2 MW backpressure type which will be supplied with steam from the Spent wash fired boiler. However the boiler and turbogenerator will be operating in synchronization with the Cogeneration plant operating in the sugar mill, so that the surplus power could be exported to the sugar mill and then to the grid. The actual power requirements and the actual steam requirements will vary depending on the output product and the sections of the distillery that will be in operation and the total power and steam consumption discussed earlier are the maximum consumptions. The power generation is at 415 V level from the 2.2 MW turbo generator.

3.11.5 Chemical Requirement

The distillery fermentation section requires Sulphuric acid, anti foaming agent, nutrients and yeast for the process. In addition, the condensate and spent lees polishing unit requires chemicals for neutralization, membrane cleaning etc. The following is the daily tentative requirements of major chemicals when the distillery is operating at its rated capacity.

- Sulphuric acid : 400 Kg/day
- Nutrients (DAP/ Urea) : 170 kg/day
- Anti foaming agent : 60 kg/day
- Caustic (47% w/w) : 800 kg/day

The composition of the above chemicals is given under clause 2.5 in section - 2 of this report. In addition, the process requires in process cleaning chemical like caustic, sodium meta bisulphite, Nitric Acid, cooling water treatment chemicals etc., for the process cooling towers, cleaning of the columns and RO membranes etc. However, the usage of these chemicals is not on a continuous basis and the quantity requirements is also much less.

3.12 Output from the Distillery

The proposed distillery will be designed to give a total output of 60 KLPD of total spirit. As finished product the plant will produce 47 KLPD of rectified Spirit or 56.32 KLPD of Extra Neutral Alcohol or
56 KLPD Anhydrous Alcohol (fuel ethanol). In addition the impure spirit production will be 3 KLPD. The recoverable Carbon-di-oxide production will be 35 TPD from the fermentation section of the distillery.

### 3.13 Effluent production from the distillery

The proposed 60 KLPD distillery is designed as a "Zero Effluent discharge" unit. The spent wash generated in the distillery is concentrated in an independent evaporator station with the 2.5 bar(a) heating steam supplied from the turbine extraction. The concentrated Spent wash will be fired in a boiler of 20 TPH capacity to be installed in the distillery which along with the 2.2 MW co-generation power plant supplies steam and power to the distillery.

About 600 TPD of Spent wash at a concentration level of 14% to 15% w/w will be concentrated to 175 TPD of 60% w/w concentration in an independent evaporator station. This quantity of about 175 TPD (8.7 TPH) concentrated spent wash along with 5 TPH of bagasse, as the auxiliary fuel, will be used in the boiler for steam generation.

The general characteristic of raw spent wash indicates that it is dark brown in colour with low pH and high BOD and COD, total solids, volatile solids etc. The tentative composition of spent wash is given below.

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>PARAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume, lit./LIT. of Alcohol</td>
<td>11-12</td>
</tr>
<tr>
<td>Colour</td>
<td>Dark brown</td>
</tr>
<tr>
<td>PH</td>
<td>4.0-4.3</td>
</tr>
<tr>
<td>COD PPM</td>
<td>1,10,000-1,30,000</td>
</tr>
<tr>
<td>BOD PPM</td>
<td>55,000-65,000</td>
</tr>
<tr>
<td>SOLIDS -</td>
<td></td>
</tr>
<tr>
<td>Total (mg/l)</td>
<td>1,30,000-1,60,000</td>
</tr>
<tr>
<td>Total Volatile (mg/l)</td>
<td>60,000-75,000</td>
</tr>
</tbody>
</table>
The details of the effluent treatment, condensate polishing, spent wash fired boiler and the 2.2 MW Turbogenerator etc., are furnished under Section - 4 and Section - 5 of this report.

### 3.14 List of equipment

The following gives the typical list of plant and machinery in each section of the distillery process. It is possible that depending on the supplier, there could be some marginal changes in the list of equipments.

#### 3.14.1 Fermentation Section

**Molasses Bulk Storage Tanks.**
**Molasses Bulk Storage Tank Transfer Pump with motor**
**Molasses Day Storage Tank Transfer Pump with motor**
**Molasses Strainers**
**Molasses Weighing System**
**Weighed Molasses Pump with motor**
**Molasses Diluter Culture**

**Vessels**
- Air Sparger for Culture Vessel
- Cell Mass transfer Pump

**Fermenters**
- CO₂ Scrubber
- Mash Cooler for Fermentor
- Fermented Mash Recirculation / Transfer Pump with Motor
- Mash Transfer Pump with Motor
Safety System for Fermentors
Molasses Broth Mixer for Fermentors
Cooler for Prefermentor
Recirculation cum Transfer Pump
Air Sparger for Prefermentor
Molasses Broth Mixer for Prefermentor
Agitator for Nutrient Dosing Tank with motor
Air Blower with Motor
Air Filter
Liquid separator for Air Blower
Antifoam Dosing Pump with Motor
Acid Dosing Pump with Motor
Nutrient Dosing Pump with Motor
Nutrient Dosing Tank
Spentwash Recycle Cooler
Spentwash Recycle Pump with Motor
Piping, Valves, Fittings, supports etc
Field Instruments for Fermentation Section
Electrical Equipment MCC / Cables etc., lighting, earthing, for fermentation section

3.14.2 Distillation Section

Mash / Analyzer Column
Degasifying (DG) Column
Pre-Rectifier Column
Rectifier cum Exhaust Column
Extractive Distillation (ED) Column
Recovery Column
Simmering Column
Alcohol scrubber
Fermented Mash Preheater
Mash Column Reboiler
Pre-Rectifier Column Reboiler
ED Column reboiler
Rectifier cum Exhaust Column Reboiler
Simmering Column Reboiler
DG Condensers
Impure Spirit Cooler
Mash Column Vent Condenser
ED Column Condensers
Recovery Column Condensers
Simmering Column Condensers
Vent Condensers for Simmering Column Reboiler
Pre-Rectifier PCV Condenser
Rectifier PCT Condenser
Simmering Feed Cooler
Product Cooler
Rectifier LFO / HFO Cooler
Pre-Rectifier LFO / HFO Cooler
Recovery LFO / HFO Cooler
TA Mixing Bottle
ED Mixing Bottle
Rectifier Feed Preheater
Pre-Rectifier Feed Preheater
DM Water Feed Preheater
Pre-Rectifier Feed Tank
Pre-Rectifier Feed Pump with motor
CIP Pump with motor
Mash column Bottom transfer Pump with motor
Pre-Rectifier Reflux Tank
Pre-Rectifier reflux Pump with motor
Rectifier Reflux Tank
Rectifier Reflux Pump with motor
Pre-Rectifier Spent Lees transfer Pump with motor
Steam Condensate Pump with motor
Rectifier Spent lees Transfer pump with motor
ED Column bottom transfer pump with motor
Fusel oil washing tank
Fusel oil washing pump with motor
Recovery Feed Tank
Recovery Feed Pump with motor
Vacuum Pump with motor
Fusel Oil Decanter
Flash tank for Mash Column Reboiler System
Vapour bottles
Piping, Valves, Fitting & Supports
Field instruments and Cabling
Plant electrical, MCC, Cables, plant lighting, earthing, etc.
3.14.3 MSDH Section

Feed Pump.
Feed Filters.
Evaporator Columns.
Superheater
Molecular Sieve beds.
Regeneration condenser
Regeneration Preheater.
Feed Preheater.
Regeneration Receiver.
Regeneration Pump
Vacuum Eductor.
Regeneration Cooler.
Product Condenser.
Product Receiver.
Product Pump with motor.
Product Cooler.
Product filter.

3.14.4 Standalone Evaporation

- Falling Film Type / forced circulation Evaporators & finishers
- Vapour Liquid Separators
- Process Condensate Pot
- Spentwash Feed Tank
- Spentwash Feed Pump with motor
- Recirculation Pumps with motors
- Product Transfer Pump with motor
- Process Condensate Pump with motor
- Steam Condensate Pump with motor
- CIP Pump with motor
- Vacuum Pump with motor
- Piping, Valves, Fittings & Instrumentation
- MCC and other Electricals

3.14.5 Product storage tanks with pumps, valves and piping

3.14.6 Day tanks & issue tanks with pumps, valves and piping
3.14.7 Air compressors & compressed air system

3.14.8 Cooling towers for the various sections of the distillery

3.14.9 DCS system for the plant control

3.15 Laboratory Instruments & Glassware

The distillery should have a laboratory with testing instruments, glass wares etc. The co-generation plant water treatment plant laboratory could also be integrated with the distillery laboratory. The suggested list of distillery laboratory equipment is given below.

- Anton Paar densitometer
- BOD incubator
- Constant temperature water bath
- Hand Refractometer
- Hot Air Oven
- Karl Fischer Moisture Titrate
- Lab Centrifuge (Table Top Model)
- Magnetic Stirrer
- Muffle furnace
- pH Meter
- UV Visible spectrophotometer
- Vacuum Oven Attached with Vacuum Pump
- Weighing Balance

- Autoclave
- Laminar Air - Flow unit
- Microscope

- Refrigerator
  - Vortex

- Mixer
  - Nichrome Wire - Loop
  - Petri Plate holder
  - Test Tube Rack
  - Dispenser with Plastic disposable tips
  - Distillation Assembly (Glass Ware)
  - Necessary Glassware
3.16 Fire Fighting System for the distillery

The fire fighting system for the distillery shall comprise of the following.

- Fire hydrant system for the entire distillery plant
- Foam system for Alcohol & Ethanol storage tanks
- Automatic fire detection and alarm system for MCC rooms
- Portable fire extinguishers for the entire distillery plant

3.16.1 The alcohol & ethanol storage tanks shall be protected with water spray system in the form of a ring along the top edge of the vertical face of the tank. The foam system shall be designed as per latest edition of NFPA 11 & water spray system shall be designed as per Regulations. The water required for foam system shall be taken from the nearest hydrant main. If the water requirement for foam system exceeds 410 cum/hr, then the fire hydrant pump capacity shall be revised accordingly.

3.16.2 The MCC room for the fermentation plant, distillation plant and effluent treatment plant shall be provided with automatic fire alarm and protection system. The automatic fire detection & alarm system for MCC rooms shall be designed as per existing regulations.

3.16.3 Two Nos. of pumps (one working & one standby) shall be envisaged for fire hydrant system. Main pump shall be electrical motor driven and standby pump shall be diesel engine driven. In addition to the above, jockey pump shall also be envisaged to maintain the pressure in the system. The pump and electric motor shall be mounted on a common base frame with ‘tyre’ type coupling, coupling guard, foundation bolts and nuts.

3.16.4 The under ground piping shall be applied with PYPKOTE tar based polymeric corrosion protection tape of 4 mm thk. for the protection of external surface of the pipes.

3.17 Product Storage

3.17.1 The distillery products will be stored in the tanks to be located in the product storage yard. As the storage and distribution will
come under the control of the Government authorities, there will be strict control on the quantity of alcohol produced, stored and distributed. Based on the practice elsewhere the scheme given in Drawing No. 1-15003-800-0007 is proposed. The produced alcohol will be received in the daily receiver tanks and after certification will be transferred to the bulk storage tanks. There will be receiver and bulk storage for the RS, EN and AA There will be receiver and bulk storage for the technical alcohol but only a bulk storage is proposed for the fusel oil. The issue will be from the bulk storage tanks through certified flow meters to the trucks. If found necessary, the bulk storage of RS, ENA, and AA could be interchanged after rinsing with appropriate alcohol.

3.18 DM Water Plant

To cater to the DM water requirements of the distillery and the power, a water treatment plant (WTP) based on the Reverse Osmosis (RO) is proposed. The WTP will be provided with a pre-treatment system, the RO based water treatment system and DM plant (downstream of Ro) for ensuring the quality of the DM water. As the source of raw water is bore well, the pre-treatment system will be just a Multi Grade Filter. The capacity of the water treatment plant will be 20 Cu.m/hr.

The raw water from the water reservoir will be pumped by the raw water pumps to the Multigrade Filter. The outlet water from the MGF will be taken to reverse osmosis skid & DM plant, through the Micron Cartridge Filters, and then stored in a DM water storage tank.

The Drawing No.3-15003-800-0011 gives the Process Slow Diagram for raw water and DM water system.

The treated and de-mineralized water will be stored in a rubber lined or epoxy coated 1 no. Of 200 Cu.m capacity storage tank.

3.19 Compressed Air System

The requirement of compressed air for instruments and the control systems of the proposed distillery complex will be supplied by three (3) instrument air compressors with two (2) working and the
other standby. Each of the compressor shall be rated for 750 N.Cu.m/ hr at 7 kg/sq.cm (g). All the compressed and service air requirements of the distillery process plant, spent wash concentration plant, the effluent treatment and polishing plant and the power plant will be met by these compressors.

The air compressor shall be provided with accessories like Inter cooler, After cooler, Moisture separators, Air driers, Air receivers and control panel.

The service air requirement of the plant, being very low will also be met by the instrument air compressors. However the service air will be directly tapped off from the air receiver bypassing the dryer units.

### 3.20 Air Conditioning System

The main plant control rooms housing the controls for the Distillery, concentration plant and the power plant shall be air conditioned with ductable package air-conditioners, which will be located in a plant A.C. room, adjacent to the control room. The condensers will be located above the plant A.C. room and the conditioned air will be distributed by means of ducting in the control room. Suitable humidity control devices shall be provided. A temperature of 22.2°C ± 1.1°C and a relative humidity of 55 ± 5% will be maintained in the control rooms.

### 3.21 Ventilation System

The ventilation requirement for various area in the TG building and Electrical panel room in TG building, Panel rooms in the Fermentation section of the can be broadly classified under two sections:

- Area which need positive pressure to avoid outside air infiltration, which is to be achieved by continuous fresh supply.

- Area which need exhaust ventilation and have adjacent sufficiently large wall to fix exhaust fans.
The areas which require to maintain the positive pressure are the Electrical panel room. The temperature inside shall not increase considerably (not more than 4-5 Cunder maximum load conditions) due to the equipment load inside; further area where infiltration is to be avoided shall be maintained at slight positive pressure to ensure the same. Frequency of door opening in these areas can be considered to be minimum.

The areas which require to maintain the exhaust ventilation system are the TG hall at various levels and toilets. Exhaust fan of sufficient size and numbers shall be installed in these areas which need exhaust by propeller fans. These areas shall have sufficient air intake opening in the opposite wall where fans are to be fixed. These opening will enable drawing air from the TG bay.

3.22 Green Belt Development

Green belt development for the project shall be considered with ecological perspectives taking into consideration the nature of pollutants, availability of space and dominant wind directions. The inter-spaces within the plant are to be laid with shrubs/grass bed. The green belt or tree plantation around the proposed project will help to arrest the particulate, matter in the area and hence attenuate the pollution to a great extent. The following characteristics would be taken into consideration while selecting plant species for green belt development and tree plantation.

They should be perennial and evergreen.
Fast growing and tall trees
They should have thick canopy cover.
They should have large leaf area index. They should not have any noticeable effect on the plant yield due to gaseous pollutants.
The planting should be in appropriate alternate rows around the proposed site to prevent lateral pollution dispersion.
The trees should maintain regional ecological balance and conform to soil and hydrological conditions. Indigenous species would be preferred.
4.0 ENVIRONMENTAL IMPACT AND EFFLUENT DISPOSAL

4.1 General

4.1.1 A molasses based distillery is considered as a highly polluting industry and the environmentalists look at the distillery with a lot of suspicion. Environmental protection and the control of discharge of the solid, liquid and gaseous effluents are the key elements in the design of the distillery. The emissions from the industries are tightly regulated by Governments and applicable specific rules and requirements controlling the emissions are constantly changing. At present, the most significant of these emissions, concerning the distillery are, spent wash and waste water effluents with high BOD and COD, oxides of sulphur (SO\textsubscript{x}), fine airborne particulate, and sludge from Fermentation.

4.1.2 Environmental control is primarily driven by Government legislation and the resulting regulations at the local and National levels. These have evolved out of a public consensus that the real costs of environmental protection are worth the tangible and intangible benefits now and in the future.

4.1.3 A molasses based distillery conventionally has three major sections, which let out pollutants. One is the fermentation section, the second is the Distillery Section and the third is the power plant section which generates the steam and power required for the distillery operations. The emissions discharged from the distillery fall under the three categories of atmospheric air borne emissions, aqueous emissions and solid emissions.

4.1.4 Atmospheric air borne emissions arise primarily from the by-products of the combustion of the fuels in the boiler like SO\textsubscript{2}, NO\textsubscript{x}, particulate fly ash, volatile organic compounds (VOC) and some trace quantities of other materials and are exhausted from the stack. A second source of particulate is fugitive dust from fuel handling equipment. A third source of air emissions is the cooling tower and the associated thermal rise plume which contains heat and some trace materials along
with the water vapour. Another pollutant, under today's context of reduction of green house gases is the carbon-di-oxide emissions from the fermentation section of the distillery.

4.1.5 Aqueous discharges from the distillery are the most worrisome of all the pollutants. Primary of these emissions is the spent wash generated in the fermentation process and separated in the distillation process. A second source of aqueous emission is the discharges from the distillation column bottoms, called spent lees. The third source include other waste water and these include cooling tower blow down, sluice water from the bottom ash handling system, boiler chemical cleaning solutions, CIP waste solutions, as well as a variety of low volume wastes including ion exchange regeneration solutions from the Demineralized Water Plants, boiler blowdown, sewerage system discharges from buildings and plant floor drains.

4.1.6 The solid effluents generated in the distillery are the sludge from the fermentation section, yeast spent residue and the boiler ash.

4.2 GSML's Distillery Effluents and Disposal

4.2.1 GSML's 60 KLPD distillery is designed on the "Zero Effluent Discharge" concept. The design philosophy being that the effluents will be used within the distillery or treated and let out as a non-polluting discharge. The new concept of spent wash concentration and incineration is adopted in the design which ensures that the discharge from the distillery is devoid of the dark, acidic high BOD and COD effluent. Even the streams with lesser pollutants are properly treated and let out.

4.2.2 The enclosed Drawing No.4-15003-800-0006, titled "Block Diagram for Effluent Generation and Treatment", summarizes the various effluent generation and the proposed treatment in the distillery.

4.2.3 Fermentation Section:

4.2.3.1 The fermentation section is where the molasses is fermented by yeast to alcohol. As a by product of this fermentation process carbon-
di-oxide is produced. After the completion of every batch of fermentation, the fermenters are cleaned and the water used for cleaning is taken to spent wash lagoon through effluent collection pit. There will be no wash water generation from the fermentation section under the normal operation. Whenever any infection occurs, the fermenters are washed with caustic solution and the washed caustic solution is taken to the CIP tank for reuse. After a few cycles of reuse, the pH of the caustic solution comes down and the same is taken to spent wash lagoon through effluent collection pit. The Caron-di-oxide generated in the process will be let out to the atmosphere. At a later date, GSML may add a CO₂ bottling plant to capture and sell the CO₂ in the market. However the CO₂ emission is only a fraction of the CO₂ sequestered by the sugar cane during its growth. Hence the emission of CO₂ from the distillery will not add any net green house gases to the atmosphere. In the proposed batch fermentation section there will be no yeast separation and the wash along with the yeast will be taken to the distillation section for processing. Similarly there will be no sludge separated in the proposed batch fermentation section. Everything from wash goes into the distillation section and is later taken out as spent wash and concentrated for incineration.

4.2.4 Distillation Section:

4.2.4.1 The distillation section is where the alcohol is separated from the fermented wash. The fermentation in addition to ethanol, also produces, depending on the fermentation process and impurities, higher alcohols and other organic compounds. These organic compounds and higher alcohols are separated out in the distillation section along with traces of ethanol and sold off as Technical spirit and Fusel oil. The two major aqueous effluents from the distillation section are the spent wash and the spent lees. Spent wash is the fermented wash devoid of the alcohol.

4.2.4.2 In some cases, where the spent wash recycling is employed, some percentage of the spent wash generated in the process will be recirculated to the fermentation section for the dilution of the molasses. This recirculation depends on the quality of the molasses and hence could be decided only at the time of plant operation. Hence
the distillery is designed with no recirculation of spent wash to the fermentation section and the entire quantity of about 600 MT of spent wash generated with the solid concentration of 14% will be available for disposal. It is proposed to concentrate the spent wash to 60% w/w solids in the evaporation plant and then incinerate the same in the specially designed boiler. Firing some supplementary fuel like bagasse with concentrated spent wash, this boiler will meet with the entire steam and power requirements of the distillery. The spent wash concentration and incineration system proposed for this project is dealt with in greater detail in the Section-5 of this report.

4.2.4.3 The spent lees are the bottoms collected from the various distillation columns and this is essentially water with small traces of alcohol and other organic compounds. All these spent lees streams will be collected from the distillery for disposal. The Molecular Sieve De-Hydration (MSDH) system for the dehydration of the industrial alcohol to produce Anhydrous Alcohol will also generate some spent lees and this also will be treated with the spent lees generated in the distillation section. It is estimated that the total spent lees to be treated will be about 2.25 Cu.m/hour.

4.2.4.4 The multiple effect evaporator system used for the concentration of the spent wash generates a lot of condensate which will be contaminated with organic elements. In the independent evaporator systems proposed for the concentration of the spent wash, it is expected that there will be a generation of 480 Cu.m/day of condensate with organic loading. As this will be polluting in nature this cannot be discharged out and hence is to be treated internally. The multiple effect evaporator system of the spent wash is susceptible for scaling and CIP using caustic will be made depending on the scaling. The caustic solution after a few cycles of usage will be taken to spent wash lagoon through effluent collection pit.

4.2.4.5 Two streams of liquid discharges from the distillery, with the spent wash evaporation system are the evaporator condensate and the spent lees from the distillation section. These two streams are proposed to be treated in a system with the combination of UASB, extended aeration system, membrane bio reactor (MBR) and Reverse osmosis
(RO) system and is designed for removal of organic acids, COD and BOD. The condensate treated by such system can be reused in the alcohol manufacturing process as process water or cooling water make-up thereby reducing the requirement of fresh water as well as solving the problem of waste disposal to a great extent.

The proposed treatment methodology is based on following principle operating systems:

1. Up flow Anaerobic Sludge Blanket Reactor
2. Extended Aeration
3. Membrane bio reactor (MBR)
4. Reverse Osmosis (RO)

Up flow Anaerobic Sludge Blanket (UASB) reactor is provided for the primary anaerobic treatment of Condensate & Spent lees effluent. The UASB reactor shall be constructed in MS with suitable epoxy coating inside the tank. The reactor consists of three zones viz. Influent distribution zone, Reaction zone, Gas solid liquid separation zone. The liquid to be treated enters into the bottom through influent distribution zone and uniformly distributed in the tank. In the reaction zone the anaerobic bacteria are maintained in the form of sludge blanket. When the upward rising waste water penetrates through the sludge blanket, the organic matter in the waste water comes in contact with the bacterial population and is degraded anaerobically to methane rich biogas, the end product of anaerobic digestion. The biogas so produced is bubbled through the effluent and is separated out in the third section i.e. Gas-Solid-Liquid separation zone. The suspended solids, rich in bio-mass, are also separated to prevent escape of solids from the reactor. In gas solid liquid separation a hood fabricated in Mild Steel and duly painted with corrosion resistant paint is provided. The hood separates the solid from the overflowing reactor content. Gas collectors are provided for collection and conveyance of gas. The treated effluent overflows through a launder and will be taken to a secondary treatment system.

4.2.4.6 The secondary treatment consists of extended aeration, membrane bio reactor (MBR) and Reverse osmosis (RO) system. The permeate of
the RO system, will be collected in a tank and used as the process water or make up water for the process cooling towers. The sludge generated from UASB, extended aeration and MBR system will be collected in the sludge pit and taken to decantation system for separation of solids and the separated solids will be disposed off suitably. The filtrate from the decantation system will be recycled to equalisation tank/clarifier. The drawing No. 3-15003-800-0005 gives the process flow diagram for the above described effluent treatment plant.

4.2.5 Boiler Section:

The proposed boiler for the distillery will be firing the concentrated spent wash and bagasse. The entire concentrated spent wash quantity of about 175 TPD generated will be consumed in the boiler. However, for the expected steam generation of 20 TPH from the boiler, the spent wash quantity alone is not sufficient and hence the spent wash needs to be supplemented with an auxiliary fuel which in this case will be bagasse.

4.2.5.1 The air borne pollutants that are discharged from the proposed boiler unit are,

- Dust particulate from fly ash in flue gas
- Sulfur-di-Oxide in the flue gas.

4.2.5.2 Bag (Fabric) Filters are proposed as the gas cleaning equipment for the boiler, to contain the dust emissions from plant to a level of 50 Mg/Ncum under all the fuel firing conditions. While firing 8.7 TPH of spentwash and 5 TPH of bagasse, the ash quantity generated will be equal to 37 TPD and out of that 80% will be go out of the boiler furnace as fly ash. Balance of 20% will be discharged as grate ash. The grate ash will fall on the water impounded belt conveyor and will be discharged into a trailer for disposal. Some amount of this fly ash will be captured in the hoppers of the horizontal pass of the boiler and the balance will be captured in the fabric filter. A suitably designed dense phase ash handling system will be provided for the collection and transportation of the fly ash to the fly ash silo. The
ash collected from the boiler is very rich in potash and hence will be a good fertilizer. Out of 1.2 TPH of ash in the 37 TPD of spent wash fired+Baggase, 0.55 TPH will be potassium Oxide. Both the grate bottom ash and the fly ash could be disposed off as fertilizer to the farmers. Depending on the demand, at a later date, the ash could be bagged and marketed. The height of the stack for the 20 TPH boiler, which disburses the pollutants, has been fixed at 55 meters, based on the sulphur-di-oxide emissions from the chimney.

4.2.6 Cooling Tower Blow Down water

The Distillery will be designed with a few cooling towers for meeting specific requirements. The fermentation section, Distillation Section, MSDH section, the spent wash evaporation and the Cogeneration plant will have individual cooling towers. The blow down water will be let into the neutralizing pit of the DM plant and will be pumped after neutralization for gardening.

4.2.7 Steam generator blow down

The salient characteristics of blow down water from the point of view of pollution are, the pH and temperature of water since suspended solids are negligible. The pH would be in the range of 9.8 to 10.3 and the temperature of blow down water will be 100 Deg.C The quantity of blow down is only about 2% of the boiler capacity (0.4 TPH) and it is proposed to put the blow down into the DM plant neutralizing pit, after running it through the open drains, for disposal.

4.2.8 Sewage from various buildings in the plant

Sewage from various buildings in the power plant area will be conveyed through separate drains to the septic tank. The effluent from the septic tank will be disposed in soil by providing disposing trenches.
There will be no ground pollution because of leaching due to this. Sludge will be removed occasionally and disposed-off as land fill at suitable places.

4.3 Thermal Pollution

A close circuit cooling water system with cooling towers has been proposed for various applications in the Distillery. This eliminates letting out of warm water into the canals and prevents thermal pollution. Blow down from the cooling tower will be trenched out to the existing DM plant neutralizing pit and disposed off the sugar mill effluent treatment plant. The water evaporated form the cooling tower will be discharged through the fan stack as water vapour. As this vapour quantity is small and also it is let out at a higher temperature there will be no thermal pollution on account of this.

4.4 Noise Pollution

The rotating equipment in the Distillery and the Cogeneration plant will be designed to operate with a total noise level of not exceeding 85 to 90 db(A) as per the requirement of Occupational Safety and Health Administration (OSHA) Standards. The rotating equipment is provided with silencers wherever required to meet the noise pollution. The frequently blowing safety valves will also be provided with silencers to meet with the norms for the noise levels.

4.5 Monitoring of Effluents

The characteristics of the effluents from the proposed distillery plant will be maintained so as to meet the requirements of Pollution Control authorities and the minimum national standards for effluent from Distillery. Air quality monitoring will also be undertaken to ensure that the dust pollution level is within limits.
4.5.1 Monitoring Programme

The purpose of air quality monitoring is the acquisition of data for comparison against the prescribed minimum standards and thereby, assures that the air quality is maintained within the prescribed levels.

The following will be monitored from the stack emissions.

- Suspended Particulate Matter.
- Sulfur-Di-Oxide.

The Laboratory attached to the Power plant will be equipped with the necessary instruments for carrying out air quality monitoring. It is also proposed to monitor the particulate emission at the stack to keep a continuous check on the performance of the bag filter. Adequate sampling openings will be provided in the stack.

Also the aqueous samples will be collected and tested periodically in the laboratory, to ensure that there is no pollutant discharged outside the plant.

4.6 Impact of the Pollution on the Environment

The GSML's distillery is designed such that there will be no pollutant discharged from the distillery. As discussed above all the pollutants normally expected out of the distillery will be adequately treated and used internally within the distillery. Only the aqueous discharges from the DM plant, cooling tower blowdown and the boiler blowdown which are neutralized are discharged out for gardening and dust suppression. Any way these are not pollutants and they are let out only after neutralization. The only solid waste will be the ash which has enormous value as a fertilizer and hence cannot be treated as an effluent. On the whole the Distillery at GSML will not affect the environment and ecology of the surroundings.
5.0 SPENT WASH CONCENTRATION AND INCINERATION SYSTEM

5.1 General

5.1.1 The fermentation of the sugar in the molasses results in the production of a large quantity of wastewater containing all the inorganic substances, other than the fermentable sugars, that were contained in the molasses. This waste water also contains some organic compounds not fermented. This wastewater separated in the analyser/stripper column of the distillation process is called the Spent Wash. This is also called as slop or vinasse. The fermented molasses leaving the fermenter, for distillation, is called the wash and the wash after all the alcohol is stripped off is called the spent wash.

Spent Wash is a dark brown acidic liquid with the pH of 3.5 to 4.5 and with a high BOD and COD content of 55,000 and 130,000 respectively. Spent Wash derives its darker colour from the caramels developed during the sugar production and contains chlorides, sulphates and calcium salts apart from other dissolved solids and minerals. The expected solids concentration in the Spent Wash from the distillation process of the fermented molasses for this project will be 14% w/w. The expected quantity of raw Spent Wash produced with the design molasses will be approximately 11 to 12 Litres per Litre of Total spirit produced.

Any favourable F/N (Fermentable solids to Non Fermentable solids ratio) in the design molasses gives the advantage of recycling some of the spent wash to the fermentation vessels, which reduces the addition of the dilution water to the molasses. This reduces the actual Spent Wash quantity to be disposed off, but however for this project it is proposed that no spent wash will be recirculated for molasses dilution.
With the concentration and incineration technology proposed, the Spent Wash hitherto considered as the worst of the pollutants, with a dark brown colour with acidic characteristics and high BOD and COD, will be looked upon as a fuel that could meet a substantial part of the steam and power requirements of the distillery. Other than the ash generated, there will be no pollutant left, but even the ash with its high potash content will be sought after as a good fertilizer.

5.2 Spent Wash Characteristics and Disposal

5.2.1 Spent Wash derives its characteristics from the molasses, used for fermentation. The molasses is expected to be with 36.8% fermentable sugars, with a total solids content of about 90 % w/w and with the total in-organics at 11 w/w. The raw Spent Wash is expected to be with the total solids of about 14% w/w with the above molasses, as the feed stock. The high BOD and COD content in the Spent Wash along with the dark brown colour makes the liquid to be feared as one of the worst pollutants and the disposal becomes a major problem in the distilleries. Discharging of the Spent Wash into rivers and lakes results in eutrophication of the water bodies and results in the elimination of the aquatic lives. The Spent Wash produced contains residual sugar in the form of glucose and polysaccharides and alcohol. These organic matters start putrefying if the spent wash is left in the open. In addition the presence of sulphur reducing bacteria results in the generation of hydrogen sulphide gas and the foul smelling gases released in the process affects the environment.

5.2.2 To ensure a sustainable development it is imperative that the Spent Wash generated in the distillery is disposed off in an appropriate manner. Based on what had been done so far, the world over, the following are the disposal methods available and out of these the incineration method appears to be the most effective of disposal of this effluent.
a. Fertirrigation

b. Composting as Fertilizer

c. Anaerobic Digestion to produce Bio-gas and subsequent composting.

d. Spent Wash concentration and Incineration

Fertirrigation is not an option for this project as this method of disposal is prohibited. GSML’s Distillery project is being designed to consume part of the in house molasses generated in the sugar mill. There will always be a large mismatch between the press mud quantity available and the spent wash to be consumed. Because of this mismatch the composting option cannot be used here. Even bio-methanation is not a viable option as the effluent from the anaerobic reactor cannot be disposed off through the composting route and a lot of filter mud is required for this purpose. Bio-methanation could be considered as an option if it is decided to go with the concentration and incineration of the effluent discharged from the anaerobic reactor. Going through Bio-methanation and then incineration is neither technically superior nor economically attractive compared to raw Spent Wash concentration and incineration and hence for the GSML project the option of raw Spent Wash concentration and incineration is proposed. Apart from the above discussions on the suitability of the various methods of disposal, due to Government of India’s Clean Ganga Mission, the pollution control authorities are very particular about the use of concentration and incineration as the only method of disposal of the spent wash from the distilleries.

5.3 Concentrated Spent Wash and its Analysis

5.3.1 The raw Spent Wash as extracted from the analyser/stripper column of the distillery with the solids concentration of 14% w/w will
approximately have combustible content of around 6.5 to 7% carbon and about 0.6% hydrogen. The estimated gross calorific value of the raw spent wash is hardly 500 kclas/kg. With the water content of almost 85% and with this low gross calorific value there is no possibility of any sustained combustion. However, when the Spent Wash is concentrated to a solids content of 60% w/w, the carbon and hydrogen percentages in the Spent Wash increase to 22.93% and 2.21% respectively. With these combustible products the gross calorific value of 60% w/w solids Spent Wash increases to around 1705 kCal/kg, which can support combustion. The following gives the ultimate analysis of the Spent Wash concentrated to a solid content of 60% w/w.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>% by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>22.93%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>2.21%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>15.22%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.91%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.63%</td>
</tr>
<tr>
<td>Moisture</td>
<td>40%</td>
</tr>
<tr>
<td>Mineral Matter</td>
<td>17.11%</td>
</tr>
<tr>
<td>Gross Calorific Value</td>
<td>1705 kCals/kg</td>
</tr>
</tbody>
</table>

One of the serious problems in firing the Spent Wash is the high fouling and corrosive tendency of the fuel ash due to the presence of alkalies like Potassium and the presence of Sulphates and Chlorides. These form complex compounds on the high temperature components of the boiler like the superheater and results in corrosion. Unless adequate precaution is taken in the design of the boiler, the boiler could face serious fouling and corrosion, resulting in the failure of the superheater within a few months of operation. The following gives the analysis of the ash in the Spent Wash. It may be seen that the extent of potassium is 47% in the mineral matter in Spent Wash. The presence of Sulphates to the extent of 20% and Chlorides to the
extent of 6% is the main reasons for the corrosive tendency of the ash. In addition the presence of calcium and sulphates could cause hard scales on the heat exchanger areas in the evaporator system used for the concentration of the Spent Wash.

**Ash Analysis**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>% by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica as SiO₂</td>
<td>Nil</td>
</tr>
<tr>
<td>Iron Oxide as FeO₃</td>
<td>2%</td>
</tr>
<tr>
<td>Calcium Oxide as CaO</td>
<td>14.0%</td>
</tr>
<tr>
<td>Magnesium Oxide as MgO</td>
<td>6.5%</td>
</tr>
<tr>
<td>Sulphate as SO₃</td>
<td>20.0%</td>
</tr>
<tr>
<td>Phosphate as P₂O₅</td>
<td>10.0%</td>
</tr>
<tr>
<td>Potassium Oxide as K₂O</td>
<td>47.0%</td>
</tr>
<tr>
<td>Sodium Oxide as Na₂O</td>
<td>0.5%</td>
</tr>
<tr>
<td>Chlorides</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

### 5.4 Proposed Scheme of Spent Wash Concentration and Incineration

GSML's multi product distillery will be based on the batch fermentation of in-house and bought out molasses with Saccharomyces Cerevisiae yeast. Based on the molasses quality specifically from the point of view of the ratio of the Fermentable solids to the Non fermentable solids, it is possible that the fermentation process could allow recycling of the Spent Wash from the distillation section. Recycling the Spent Wash to fermentation increases the non fermentable solids in the fermenter and the limit of the quantity of spent wash recirculated is decided from the ability of the yeast to withstand the higher osmotic pressure. The estimated quantity of Spent Wash produced in distillation is about 600 MT per day. It is proposed that there will be no recirculation of the spent wash in the system and all the spent wash generated will be sent for concentration prior to incineration.
This quantity of 600 TPD will be with the solids concentration of 14% w/w and this will be concentrated to a solids concentration of 60% w/w. This concentration is proposed to be done in a single stage multiple effect evaporation plant using low pressure steam as the heating medium. The above quantity of Spent Wash will be concentrated to a quantity of 175 TPD with the solids concentration of 60% w/w and this concentrated Spent Wash will be fired in a specially designed boiler along with bagasse to generate all the steam required for the distillery process and Spent Wash concentration. Thus all the Spent Wash produced in the distillery will be incinerated to generate part of the process steam required by the process. The details of concentration system and the incineration boiler proposed for this project are furnished in the subsequent sections.

5.5 Spent Wash Concentration System

5.5.1 The high organic loading makes the Spent Wash a possible fuel for firing in the boiler. However the gross calorific value of the raw Spent Wash as produced in the distillery is not adequate to sustain combustion and hence the Spent Wash need to be concentrated to give an acceptable gross calorific value. It has been found that the Spent Wash concentrated to 60% w/w solids will have a GCV of around 1705 kCals/kG is capable of sustained combustion in a boiler. It is proposed to concentrate the Spent Wash in a multiple effect evaporation system, which will optimize on the heat energy requirements for the concentration.

The inorganic loading in the Spent Wash is also quite high and one of the major problems faced in the concentration of the Spent Wash is the rapid scales formed on the heat transfer tubes of the evaporators. Here again the scaling tendency of the Spent Wash depends on the quality and the inorganic salt content in molasses. The higher quantity of calcium used in the sugar making process leaves a lot of calcium in the molasses and that gets carried to the Spent
Some of the calcium salts precipitate inside the tubes during the evaporation process and leaves a hard scale in the tubes. In case the scales are very hard and are difficult to remove with CIP, it may be necessary to resort to mechanical cleaning of the tubes. In order to limit the scale formation, the evaporation temperatures are kept low as some of the calcium salts like calcium sulphates have lower solubility at higher temperatures and hence tend to precipitate. Another important point in evaporation is to go in for forced circulation and flash evaporation in order limit the chances of scaling inside the heat transfer tubes.

5.5.2 As seen elsewhere in this report, the raw Spent Wash generation, without Spent Wash recirculation for fermentation, is 600 TPD. The solids concentration in the raw Spent Wash is expected to be 14% w/w. When concentrated to 60% w/w, the quantity of Spent Wash that will be available comes down to 175 TPD. This concentration involves the evaporation of almost 480 MT of water per day (22.92 MT of water per hour) in the concentration plant. The energy generally available for concentration will be in the form of heat and steam will be medium that supplies this heat energy. Indirect heating of the Spent Wash to evaporate this quantity of water in a single effect evaporator will call for the supply of around 20 TPH of steam at low pressure of around 2.5 ata. In order to effect economy on the steam consumption, the concentration is proposed to be done in a multiple effect evaporation system.

5.5.3 The evaporation system will be an independent evaporation system for the final concentration of the Spent Wash to 60 % and to achieve this concentration saturated steam at a pressure of 2.5 bar(a), will be used.

5.5.4 The drawing No. 1-15003-800-0004 titled "Process Flow Diagram for Spent Wash Evaporation System" gives the scheme of the Spent Wash evaporation system. The raw Spent Wash with the concentration of 14% w/w from the analyser/stripper column bottom
will be used to heat the incoming fermented wash coming to the analyser column. The Spent Wash from the outlet of the wash pre-heater will be sent to the raw spent wash storage lagoons to ensure the settlement of part of the sludge. The partly decanted spent wash, with the solids concentration of 14% w/w, will be pumped to the evaporator station.

5.5.5 The independent evaporator system consists of five / six evaporator bodies with the first few effects being falling film evaporator bodies followed by forced circulation evaporator bodies. The driving force in the independent evaporator is provided by the heat energy in the low pressure steam supplied to the first effect. The falling film evaporator will be designed with a vapour separators. The recirculation pumps provided with the falling film bodies ensure that the wetting rates inside the falling film body tubes are maintained at the required levels. The Spent Wash will be heated in a plate type heat exchanger before admission into the falling film evaporator. The spent wash could be fed through a mixed flow arrangement which judiciously optimizes on the heat energy input to the system.

The forced circulation evaporators use high fluid velocities through the tubes and it is ensured that there will be no evaporation within the heat transfer tubes. The Spent Wash circulated through the tubes, with the slight increase in the temperature is flashed in the flash vessel attached to each of the evaporators. The high circulation of the Spent Wash is effected by the recirculation pumps taking suction from the bottom of the flash vessels. The condensate in the evaporator bodies is cascaded to use the flash steam effectively. The vapours from the last effect are condensed in the surface condenser. The non-condensable gases along with some vapours from the surface condenser are again condensed in a vent condenser. Both the condenser and the vent condenser are supplied with adequate quantity of cooling water. The condenser and the vent condenser operate under vacuum created by the mechanical vacuum pumps. The condensate from the system is finally pumped by the condensate pumps from the.
condenser to the effluent treatment plant. The final draw off of the 60% w/w solids concentrated Spent Wash is made from the delivery side of the recirculation pumps of the last effect. In order to limit the head requirements of the recirculation pumps of the final effect a separate booster pump is used to pump the Spent Wash to the product storage in the boiler area.

5.5.6 For the GSML’s project, the Spent Wash leaving the independent evaporator system will have a solids concentration of 60% w/w and the quantity of the concentrated Spent Wash leaving the evaporation plant will be approximately 175 TPD. Steam will be supplied to independent evaporator system at the first body of the falling film evaporator calendria and the quantity of steam thus to be supplied is estimated to be 6.0 TPH at a pressure of 2.5 ata at the calendria. The vapour generated in the various bodies is judiciously used in the next bodies of the evaporator system, except for the vapour from the last body is sent to the condenser.

5.5.7 The Spent Wash concentrated to 60% w/w solids will be stored in a stainless steel tank of 100 Cu.m capacity. The Spent Wash feed pumps will pump the concentrated Spent Wash to the spray guns in the boiler for combustion.

5.6 **Spent Wash Incineration and Steam and Power Generation**

It is proposed to dispose of the concentrated Spent Wash by incinerating the same in a boiler along with imported coal or bagasse. The steam generated in the boiler will meet with the steam requirements of the distillery and the evaporation plant. As the steam required by the distillation process and the evaporation plant is at a lower pressure of 2.5 bar(a), the potential for possible Cogeneration is exploited and electrical power for meeting with the distillery and the evaporation plant will also be generated using the steam generated in the boiler. Thus an effluent, hitherto regarded as a highly polluting,
has been converted to a fuel for meeting the energy requirements, at least partly, of the distillery complex.

Section 5.3 above gives the analysis of the concentrated Spent Wash. With 60% concentration, the gross calorific value of the 60% w/w concentrated Spent Wash will be 1705 kCal/kg and this GCV is adequate for sustaining the combustion of the Spent Wash. However as the concentration could vary, depending on the distillery plant and the evaporation plant performance, the GCV also could vary and this could affect the combustion of the Spent Wash. In order to ward off such difficulties, it is always recommended that the Spent Wash is fired with a supporting fuel.

The concentrated Spent Wash has about 17% mineral matter and the composition of the mineral matter is also furnished under Section 5.3. Because of the presence of high alkalies (potassium and sodium) the Spent Wash ash will exhibit a higher fouling tendency and there could be problems of ash build up in the superheaters of the boiler. With the presence of sulphates and chlorides the ash will also cause serious corrosion problems in the superheaters and it is essential that the steam and gas temperatures at the superheater are limited to ensure that there is no corrosion of the superheater tubes. Based on the extensive analysis made on such fuels, it is recommended to go with the final steam temperature of 400 +5, -0 Deg.C from the boiler and ensure that the gas temperature entering the superheater section is limited to a value lower than 550 Deg.C.

The presence of sulphur compounds and chlorates could also cause serious low temperature corrosion in the economizer and the air heater. To eliminate such low temperature corrosion in the economizer, we need to increase the feed water temperature entering the economizer to a value higher than the dew point temperature. As air heater will be susceptible to corrosion it is proposed to eliminate the air heater altogether and go with a steam heated air heater to increase the under grate air temperature suitable for high moisture
fuel firing. Alternatively an air heater could be provided, if the air is heated in a steam air-preheater to a temperature of 130 Deg.C at the inlet of the air heater. The final choice between the use or elimination of the air heater could be decided at the time of detailed engineering of the boiler, depending on the confidence level and experience of the boiler contractor.

The ash generated from the combustion of the Spent Wash will be fine and a suitable ash collection arrangement shall be provided to limit the particulate emission from the plant to less than 50 mg/N.Cu.m of gas leaving the chimney. Considering the fineness of the ash and the high ash resistivity, it is proposed to employ a fabric filter as the dust collection equipment for the boiler. The ash generation by the combustion of the bagasse will be a small quantity and the proposed fabric filter is well suited for the collection of the bagasse ash. With the presence of almost 47% potassium Oxide in the ash, the ash makes a very good fertilizer. At a later date it may even be worth putting up a bagging plant to bag the ash generated in the boiler and sell the same as fertilizer for field applications.

5.6.1 Spent Wash fired Boiler

The proposed boiler shall be of the travelling grate type and most of the bagasse and part of the dried spent wash will burn on the grate. The concentrated Spent Wash will be sprayed inside the furnace at a height of about 8 to 10 meters above the travelling grate to ensure that the Spent Wash particles are flash dried in the furnace environment and a substantial part of the spent wash particles burn in suspension. Depending on the boiler design and if required, a refractory lining will be provided at the location of the Spent Wash spraying point such that the temperature of the furnace in the location is high and the Spent Wash particles get heated up and get incinerated within a short period, from the time the particles leave the spray guns. The boiler will be a balanced draft design with adequate Effective Projected Radiant Surface (EPRS) to cool the
gases to the required level before the gases enter the superheater region.

The Drawing No. 1-15003-800-0008 titled "General Arrangement of Boiler (Elevation)" enclosed to this report gives the side elevation view of a typical boiler. This drawing indicates the arrangement of the pressure parts and all the major equipment of the boiler.

The proposed boiler will be of 20 TPH MCR capacity with the steam outlet parameters of 45 ata and 400 Deg.C at the superheater outlet.

The following are the basic technical requirements for the steam generator:

- The steam generator, all associated piping and systems shall be designed, manufactured, inspected, tested, erected and commissioned to well established engineering practices and safety codes.

- Basically the boiler shall be a radiant furnace, single drum, natural circulation, outdoor type with two stage superheater. The boiler shall be designed with water cooled membrane / fin welded walls. The refractory work as required for the efficient combustion of the fuel shall be provided and the design and application shall be with adequate reinforcement to ensure that premature spalling of the refractory work is eliminated. The material of the refractory shall be suitable for the application.

- The boilers shall be top supported with adequate provisions for the thermal expansion of the boiler in all directions. The supports and thermal expansion guides (could be common for wind and seismic load transfers) shall be suitably located so as to direct the thermal expansion in the pre-determined directions.
- The complete pressure parts tubing, piping and headers shall be of seamless construction, as per reputed international material specifications and bought from renowned Suppliers. The Circulating system essentially comprising of the drums, water walls, furnace tubes, evaporator banks, down comers and relief tubes shall be designed to provide an adequate circulation ratio in the system and to prevent DNB. The downcomers and the relief tubes shall be sized and routed to offer minimum pressure drop and to help in improving the circulation ratio.

- The steam drum shall be provided with internals of proven design, shall be bolted type, and of size that will enable removal through the manways. The system of internals consisting of the primary and secondary separators shall ensure steam of highest purity with dissolved silica carry over limited to a maximum of 0.02 ppm, at all loads of the boiler. All the components of the internals, except the dryer screens, shall be carbon steel and the dryer shall be of 304 stainless steel.

- The Furnace envelope shall be constructed of fully water cooled membrane / fin welded walls and adequately supported. The design shall be such as to prevent distortion of steel work due to thermal expansion. The construction shall be fully gas pressure tight, and the furnace shall be strengthened by providing buckstays and tie-bar system. The buckstay system shall be adequately designed to stiffen the furnace walls against the internal and external pressures and also to transfer the wind and seismic loading from the boiler envelope to the boiler structures through suitably designed guides. The minimum design pressure for the buckstay system shall be ± 400 mm WC, with the buckstay members reaching 60% of the yield strength.
- The furnace EPRS should be so selected to give acceptable furnace outlet temperatures, not exceeding 600 Deg.C, while firing Spent Wash or Spent Wash with other fuels.

- The superheater (SH) system shall be of Two (2) stage design with inter stage desuperheating to achieve the rated steam temperature over 60 to 100% load range. The superheater shall be of convection type arranged to give a minimum metal temperature. The superheater pressure drop, the inlet and outlet header sizing, arrangement and sizing of their respective inlet and take off connections shall be so as to give minimum unbalance and the tube element material selection shall be based on the actual metal temperature calculations.

- The inter stage attemperator system of the variable orifice type to control the temperature of the final superheater outlet steam temperature within the specified value shall be provided in between the two stages of the superheater.

- The Economiser shall be located downstream of the convection heat transfer section. The design shall be of bare tube construction with inline, counter flow, and drainable arrangement. The economiser shall be designed for an inlet feed water temperature of 150 Deg.C. The economiser shall be arranged such that there is space for the future addition of about 10% of the installed heating surface area without disturbing the existing economiser coils and headers. The coil arrangement shall take care of proper calculated end gaps to avert gas bypassing and the consequent erosion of the element tubes. No gas side or waterside bypass arrangement shall be provided. The number of parallel paths shall be so chosen to give a water side velocity of a minimum of 0.6 meter per Sec.
- The flue gas velocity over the economiser tubes shall be limited to a maximum of 10 metres/sec. Suitable number of soot blowers shall be located in the economiser for effective cleaning of the heat transfer areas.

- A steam coil air heater to heat the combustion air to the required level shall be added in the air outlet ducting upstream of the air-heater. If the design does not incorporate the air heater, the steam air pre heater shall be designed to give an air temperature required for the combustion. This steam coil heater will be operated continuously to prevent the corrosion of the main air heater. Sufficient straight length shall be provided in the air duct for installing Steam coil air pre heater at the airheater air inlet side. The condensate from the steam coil heaters will be taken to the deaerator.

- The steam coil airheater shall be of finned tube construction with the steam on the tube side and air flowing over the tubes. The tubes shall be of carbon steel material with carbon steel fins/aluminium LL fins. In case of carbon steel tubes with carbon steel fins the tube and fins shall be hot dip galvanized to eliminate the possibility of corrosion of the tube/fins. In case of LL fin construction the LL fins shall have sufficient overlap to cover the tubes completely and thus prevent any corrosion of the tubes. The tubes shall be expanded and welded to tubes sheets on either side. Semi circular headers with end covers will be welded to the tube sheets to form the inlet and outlet headers. The headers will be provided with nozzles for supplying steam and draining the condensate. The finned tube bundle shall be covered with casing and end flanges shall be provided for connecting to the ducting.

- The boiler shall be provided with a complete system of soot blowers and wall blowers, to effectively dislodge deposits from the heat transfer areas. The soot blowers could be of type
using steam as the blowing medium. The blowers shall be provided with sealing and purge air to prevent the gases entering the idle lance tubes and causing corrosion damage.

- The fuel firing system for the boiler shall be of the travelling grate type. The boiler is to be designed for firing the individual fuels and fuel combinations as specified earlier. The layout of the fuel feeding systems shall be such that each system is easily approachable and maintainable. All nozzles, feeders and distributors shall have independent drive arrangement. The distillery slop at an average of 60% solids concentration will be made available for firing in the boiler. The spent wash will be pumped by the feed pumps to the spray gun located in the furnace through a suitable flow meter. The flow to the spray guns shall be manually adjusted and the excess spent wash pumped to the nozzles shall be returned through the return line to the storage tank.

- For the Bagasse feeding suitable silos, extraction feeders and screw conveyors and distributors shall be furnished. There shall be a minimum storage of the fuel in the bunkers/silos and the fuel shall be fed through appropriately designed feeders and distributors.

- The draft system for the boiler shall be suitable of producing a balanced draft with sub-atmospheric pressure conditions in the furnace. There shall be, One x 100% capacity Induced Draft Fans, One x 100% capacity Forced Draft Fans and One x 100% capacity Secondary Air Fans making up the complete draft system for the boiler.

- All The fans shall be suitable for outdoor installation. The fan impellers shall be dynamically balanced at the fan manufacturer’s works. The first critical speed of the fans shall
be at least 30% above the normal running speed of the respective fans.

- The fans shall be basically sized using the following margins over the calculated values of the flow volume and the pressure using the maximum continuous rating condition with bagasse.

- Required Fan Margins:

<table>
<thead>
<tr>
<th>Fan</th>
<th>Margin on Volume</th>
<th>Margin on Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary air fan</td>
<td>10 %</td>
<td>15 %</td>
</tr>
<tr>
<td>Forced draft fan</td>
<td>15 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Induced draft fan</td>
<td>25 %</td>
<td>30 %</td>
</tr>
</tbody>
</table>

- All ducts shall be rectangular in cross section and will be of welded construction, properly stiffened and reinforced. All the air ducts shall be fabricated from steel plates of minimum 5 mm thick, and all flue ducts shall be of minimum 6 mm thick. The duct plate material shall conform to ASTM A 53 or equivalent. Carbon steel plates shall not be used for ducting system if the operating temperature of flue gas exceeds 427°C. The duct corners shall be stitch welded internally and full welded on the outside.

- All ducts, exceeding 600 mm width or depth, shall be suitably stiffened and reinforced on the outside and designed to withstand the pressures encountered, but however the minimum design pressure for the ducts shall be ± 400 mm wc. The
stiffening shall be with Indian standard section conforming to the applicable Bureau of Indian standards.

- The ducting expansion joints are provided to take care of the duct expansions and all expansion joints in the flue gas and air ducting shall be of stainless steel (SS 304). The thickness of the sheets used for the fabrication of the expansion bellows shall be 1.6 mm. The ducts shall be supported adequately, either from the ground or from the boiler structural steel works depending on the location of the ducting support. The ducting system, consisting of the ducts, dampers and expansion joints shall be analysed as a single unit and the locations of the expansion joints, supports and restraints shall be finalized based on the ducting flexibility analysis calculations.

- One (1) Deaerator of deaerating capacity equal to Twenty percent (20 %) higher than the gross MCR steam generation capacity of the boiler with a deaerated water storage tank of net useful capacity (normal water level to Low water level) equivalent to twenty minutes (20 minutes) of MCR generation capacity of the boiler shall be provided. The deaerator shall be mounted on the structure in front of the boiler. The material of the deaerator, deaerated water storage tank shall be SA 515 Gr.70 or equivalent. The Deaerator and the Deaerated water storage tanks shall be designed with a minimum corrosion allowance of 3 mm.

- The deaerator shall be of either spray-cum-tray type or spray type with counter current flow of steam and water. The material of trays shall be stainless steel, conforming to a minimum of AISI 316. The deaerator and the storage tank shall be complete with all the fittings and mountings like vents, controlled vent, drains, gauge glasses, pressure indicators,
relief valve, steam and water inlet and outlet nozzles, overflow nozzle etc.

- Two (2) Nos. Of 100 % capacity boiler feed water pumps with LT motor suitable for the application shall be provided to supply feed water to the boiler.

- The design margin for the calculation of the rated pump capacity shall be 10 % of the feed water requirements (inclusive of the boiler blow down of 3%) for the peak load operation of the boiler.

- The design margin for the calculation of the rated head of the pumps shall be 5% of its maximum discharge pressure requirements, to be calculated, as given below.

- The boiler integral piping consists of all the interconnecting piping between the economiser inlet stop valve and the main steam stop valve on the superheater outlet piping. The number off, size and the arrangement of these integral piping shall be based on the permissible pressure drops in these pipes and the distribution required in the respective headers of the various sections of the boiler. These piping shall be properly supported and provided with the required tapping, stubs and thermowells for measurements.

- Air pollution control system comprising of One No. Bag (Fabric) Filter with all its accessories shall be provided. The Bag Filter shall be designed to provide an outlet dust concentration level of 50 mg/Ncum with the boiler operating with both Spent Wash and bagasse as a fuel.

- Steam generator shall be provided with High pressure (HP) dosing and Low Pressure (LP) dosing system. The HP dosing system shall be based on 'trisodium phosphate' dosing and this
shall be dosed in boiler water to take care of the ingress of the hardness salts and to increase the boiler water pH. The LP dosing system shall be based on 'hydro quinine' dosing and this is dosed in the feed water to scavenge the last traces of oxygen and to increase the feed water pH.

- Boiler refractory, insulation and inner and outer casing with all fixing material for boiler, ducting, piping, valves, fittings and equipments, etc.

- Handling system including mono rails, lifting tackles, support structure for monorails, etc. for handling ID fan, SA fan, FD fan, Feed pumps and drive motors, etc.

- Supporting structures, steel work, platform, ladders, galleries, and staircases with fabricated floor grating including complete roof, side cladding above the drum operating floor level along with cladding structures for protection against rain and other climatic conditions.

- The boiler instrumentation and control system shall be based on the Distributed control system philosophy as discussed in another section of this report. All the control, monitoring and interlock functions will be taken care of by the DCS system.

5.6.2 Steam Turbines and Auxiliary System

The Turbogenerator proposed will be of extraction backpressure type with the generation capacity of 2.2 MW with the inlet steam parameters of 42 ata and 395 Deg.C. The steam Turbine shall be a reliable and efficient system with state-of-the-art proven design with good performance over a long period. The Turbine shall have the following design and engineering features:
Highest possible thermal and energy efficiency.

State-of-the-art technology and well proven in actual operation over a long period.

Rugged, conservatively designed, proven components and systems.

Minimum outage for field maintenance and routine inspection.

Better operability at various load conditions.

Advanced instrumentation, control systems, shut-down and protection system, very reliable online supervisory and surveillance system, with diagnostics.

Minimum requirement of operating and maintenance man-power and amenability to unattended automatic operation.

Suitability for harsh tropical ambient conditions prevailing at site.

Simple design and ease of installation.

The turbine shall be horizontal, single cylinder, back pressure type. The extraction shall be controlled and the extraction steam pressure at the port will be at 3.5 bar(a).

All casings and stator blade carriers shall be horizontally split or otherwise and the design shall be such as to permit examination of the blading without disturbing shaft alignment or causing damage to the blades. The design of the casing and the supports shall be such as to permit free thermal expansion in all directions. The casing shall also permit the inspection of the bearings without dismantling of the
casing. The exhaust ducting shall be located on the lower half of the casing.

The turbine shall have solidly forged and machined rotor with integral disks. The rotor after fully machined and bladed shall be dynamic balanced accurately in the shop and shall be given an over speed test under vacuum. None of the critical speeds of the rotor shall fall within the range of 20% above and 20% below the normal running speed of the rotor. The material of construction shall be consistent with proven practices and standards.

The blading shall be designed to withstand all vibrations, thermal shocks, and other loading that may be experienced during service and system disturbances. The blades shall be machined from forged bars or die forged and the materials used shall be chromium steels suitable for the temperatures encountered, resistant against corrosion and erosion and consistent with proven experience and standards. In the low pressure stages, if warranted where the moisture percentage is higher, additional protection against erosion shall be provided.

The blading depending on the staging shall be adequately fastened, with proven methods of fixing. The rotating blades are either shrouded or tied with lacing wires depending on the stresses and the excitation frequencies.

The glands shall preferably be of labyrinth type and sealed with steam. The gland packing shall be of 13% chromium stainless steel. The labyrinths shall be of multi-section spring backed type which would allow for any temporary deformation of the rotor shaft without overheating the rotor due to friction. The complete piping, valves, pressure gauges, regulators etc. required for the end seals shall be provided.

The Turbine shall be provided with liberally rated hydrodynamic radial and thrust bearings. The radial bearings shall be split for ease of
assembly, and of the sleeve or pad type, with steel shell backed, babbitted replaceable pads. These bearings shall be equipped with anti-rotation pins and shall be positively secured in the axial direction. The thrust bearings shall be of, Mitchell tilting pad type, the steel backed babbitted multiple segment, designed for equal thrust capacity in both directions. A liberal flow of lube oil under pressure shall be supplied to all the bearings for lubrication and cooling.

All bearings shall be accessible without having to remove cylinder covers. The metal temperatures of all the bearings shall be monitored by thermocouples with extension right into the white metal layer. Provision shall be made for measuring the temperature of the oil leaving the bearings.

A pressure lubrication and control oil system shall be furnished for the turbo generator unit to supply oil at the required pressure to the steam turbine, gear box, generator and governing system. The lubrication oil system shall supply oil to the turbine generator under all the load conditions, including the turning gear operation. The oil system of the turbogenerator shall be designed with adequate redundancy and emergency provisions such that a failure of a single active component will not prevent the safe operation or a safe shutdown of the turbogenerator. Oil in the reservoir shall be maintained at an appropriate temperature when the TG set is idle by providing suitable electric heaters and temperature controls if required.

- One hundred percent (100%) capacity centrifugal/gear type, Main oil pump shall be driven by A.C electric motor driven main oil pump.

- One (1) No. of one hundred (100%) capacity A.C motor driven auxiliary oil pump of centrifugal type, arranged to cut in automatically if the oil pressure falls to a preset value. This
pump shall also meet the requirements during the start up and shutdown.

- One (1) D.C motor driven, centrifugal type, emergency oil pump of adequate capacity to provide adequate lubrication in the event of a failure of the A.C motor driven pump(s). This pump also shall cut in automatically at a pre set value of the oil pressure. The minimum capacity of this pump shall be to ensure a safe shutdown of the turbogenerator.

- All the above pumps shall be provided with mechanical seals.

- Two 100 % capacity (one working and one standby) water cooled oil coolers.

- Two 100 % duty oil filters arranged in such a way that it is possible to clean one oil filter while the other is in service. The filters and the coolers shall be arranged with continuous flow transfer valves.

- Oil storage and settling tank with adequate reservoir capacity, strainers, level indicators with float switches and alarm contacts, vent and oil mist eliminators and 2x100% capacity vapour exhaust fans.

- Flow and temperature indication for oil from every bearing.

- Centrifugal oil purifier with drives, interconnecting piping and valves.

- Emergency gravity lubricating oil system

If the system envisages separate control oil circuit from the lube oil system, there shall be independent two nos. of control oil pumps and 2 x 100 % duplex oil filters for the control oil circuit.
The auxiliary oil pumps and the emergency oil pumps shall be arranged to have flooded suction.

The oil coolers shall be water cooled with a duplex arrangement and changeover valves. The coolers shall be of shell and tube type with removable tube bundle. The coolers shall be constructed in accordance with TEMA class C. The provided surface area shall be adequate to cool the oil with the inlet cooling water temperature indicated in the design basis, even with 20% of the tubes plugged. The cooler shall be of vertical type.

The sizing of the coolers shall consider a tube side (water side) fouling factor of 0.0002 Hr.Sq.M.Deg.C/Kcal. The water velocity shall be not less than 1.5 M/sec. A corrosion allowance of a minimum of 3 mm shall be applied to the design thickness of each of the component, other than the tubes.

Full flow twin oil filters shall be used, for the lube oil, downstream of the coolers and shall be piped in a parallel arrangement with a continuous flow transfer valve with necessary two way change over valves. Filter size shall be 40 microns nominal for the lube oil. Filter cartridges shall have a minimum collapsing differential pressure of 3.5 Kg/Sq.cm. The minimum design pressure for the filters shall be the maximum discharge pressure of the oil pumps. Differential pressure gauge with alarm shall be provided across the filters.

The filters shall be either common or separate for the lube and control oil circuits. The filter grade for the control oil shall be 10 Microns nominal. If a common filter is used for lube and control oil, the filter grade shall be 10 microns nominal.

A centrifugal type oil purifier shall be provided for the removal of water, sediments and other oxidation products from the Lube oil system on a continuous basis. The purifier shall be a separate
complete package, mounted on a skid, complete by itself with drive motor, piping, valves and fittings. The capacity of the purifier shall be at least two (2) percent of the rate of normal flow through the reservoir. Feed to the purifier shall be from the drain end of the reservoir and its operation shall be independent of the oil system.

Emergency gravity lubricating system shall be provided to assure the lubrication at the time of an emergency due to the failure of the DC operated lube oil pump. This system shall draw lube oil from an overhead tank, under gravity, and shall be designed to supply oil for the coasting down period of the machine. The overhead tank shall be SS lined and the complete piping to and from the tank, shall be of SS 304 material. The tank elevation shall be finalised based on the oil pressure requirements at the bearings.

The turbine governing system shall be electro-hydraulic designed for high accuracy, speed and sensitivity of response. The electrical/electronic and hydraulic components of the control system shall be selected on the basis of reliability over a wide range of operating conditions. All components used shall be well proven to assure overall system reliability and shall be designed for easy and quick replacement when necessary. The governor shall be configurable in the field.

The governor shall ensure controlled acceleration of the turbo generator and shall prevent over speed without tripping the unit under any operating condition or in the event of maximum load rejection. The governor shall have linear droop characteristics with a suitable range for stable operation and shall have provision for adjusting the droop in fine steps.

The governing system shall have the following important functions:

- Speed control
- Over speed control
- Load control
- Inlet Steam pressure control
- Backpressure steam Control

The turbine control shall be through the centrally located Distributed Control System, described in another section of this Report. The control system shall provide redundancy for key functions by use of separate sensors and monitors. The control system shall include all the standard control monitoring and alarming. Only proven equipment that has been used in similar systems before shall be provided. Control panels shall be supplied fully wired and complete with all necessary special wiring for interconnection of panels. Vibration detectors/ proximity meters/ axial position detectors monitors shall be provided for all bearings including the bearings of the generator. Solid state annunciation units wherever located shall be of the first out type. Individual alarm windows shall be provided for all critical points parameters. The alarm sequence shall be as per international standards. Separate windows shall be provided for pre-alarm and shutdown with simultaneous alarm.

The steam turbine and the other high temperature parts, including piping supplied, shall be insulated with low conductivity inert material, where required, reinforced by stainless steel wire net between applied layers. The insulation shall be so arranged that it can be removed for access to the flange bolting, control valves and other parts that require periodic maintenance. The insulation shall be designed, such that the outer surface temperature of the insulation does not exceed 20 Deg.C above the ambient temperature.

All the electrical equipment of the plant including the generator is described under the section on "Plant Electrical Systems".
5.7 Cogeneration Scheme at the Distillery

The enclosed Fig.1.0 gives the scheme of the Cogeneration plant proposed at GSML's Distillery. The boiler with the MCR capacity of 20 TPH at 45 ata and 400 +5, -0 Deg.C, firing the concentrated Spent Wash and imported coal/bagasse. The boiler will be designed for firing 7.0 TPH of spent wash along with 5 TPH of bagasse to generate 20 TPH of steam. The entire steam will be fed to the 2.2 MW extraction backpressure Turbogenerator. The extraction will be at a pressure of 5.5 bar(a)just for meeting the requirements of the deaerator and the steam air preheater of the boiler. While the plant is producing anhydrous alcohol, the requirement of the 4.5 bar(a) will also be taken from the extraction. The turbine will be operating with a back pressure of 3.5 bar(a). With 20 TPH of input steam the Turbogenerator generates a gross power generation of 2150 kW. Out of the steam quantity exhausted from the turbine, 8.0 TPH will be supplied to the distillery process, 7.0 TPH will be supplied to the evaporation plant and the balance to the AA plant. From the extraction 1.3 TPH will be supplied to the steam air heater and 3.01 TPH will be supplied to the deaerator. About 80% of the condensate of the steam supplied to the distillery process and the evaporation system returns back to the Cogeneration plant at 60 Deg.C. A make up of 3.7 TPH is added to the deaerator at 30 Deg.C. The deaerated water temperature is maintained at 150 Deg.C, to eliminate the possibility of low temperature corrosion in the economizer. A steam air-preheater is proposed and the steam consumption in the same will be 1.3 TPH and the steam is drawn from the turbine extraction. The condensate from the steam air-preheater returns to the deaerator.

The drawing No.3-15003-800-0009 gives the Process Flow Diagram for the Plant Steam System at the Distillery.

The Fig.2.0 gives the power balance for the plant. Out of the 2150 kW of power generated 1230 kW is supplied to the distillery including the evaporation plant, process cooling towers, utilities, condensate and
lees polishing system etc. And the balance of 620 kW is supplied to the Cogeneration plant including the boiler, TG, cooling tower and other auxiliary systems of the Cogeneration plant. There will be a surplus of about 300 kW which could be exported to the grid through the sugar mill.

5.8 Bagasse handling system

The bagasse handling system will consist of the conveyors, boiler front bagasse silos, extraction feeders, screw conveyors and pneumatic distributors.

5.9 Ash Handling System

As the boiler is a travelling grate fired boiler, the ash from the boilers will be collected at the grate discharge point as coarse ash and as fly ash at the various hoppers provided in the economizer, air-heater and the fabric filter. It is proposed to handle the grate discharge ash from the submerged conveyor outlet through wheel carts as this ash will be wet. The fly ash will be collected in a silo. All the ash collected at various hoppers will be transported through dense phase ash handling system to a storage silo. As seen elsewhere in this report, all the ash collected in the boiler could be used as fertilizer, because of its high potassium oxide presence. The collected ash from the silos could be carted away to be applied as fertilizer in the fields.

5.10 Balance of Plant Systems

All the balance of plant systems like the DM water system, compressed air system are common for the distillery and the Cogeneration plant and hence are covered under Section-3 describing the “distillery process and the mechanical systems”.
6.0 DESCRIPTION OF PLANT ELECTRICAL SYSTEMS AND EQUIPMENT

6.1 Proposed System

6.1.1 The distillery shall be planned with its own generating plant to meet with the power requirements of the plant auxiliaries. The boiler of 20 TPH, 45 ata, 385 deg. C and TG of 2.15 MW shall be installed to meet the plant’s power requirements. The plant’s auxiliary load shall be around 1450 kW. The electrical scheme of the distillery plant will consist of one no. 415 V, 50 Hz, 3 Phase, 0.8 pf synchronous generator having nominal capacity of 2.15 MW. The generator will operate in parallel with the 30 MW co-generation plant. One (1) no. of 2.5/3.15 MVA, 11/0.415 kV distribution transformer shall be installed as a stand-by supply, which in turn receives supply from co-generation plant at 11 kV voltage level. The drawing titled "Protection, Metering & Control Schematic Diagram" (Drg. No. 1-15003-900-0453, Rev-0) attached to this report, depicts the electrical scheme planned for the proposed 2.15 MW Cogeneration plant at the Distillery.

6.1.2 The power generated by the turbogenerator will meet the auxiliary power requirements of the co-generation plant and the distillery plant. The surplus power, if any after meeting the plant auxiliaries shall be exported to the 11 kV switchboard of the 30 MW co-generation plant.

6.2 Generator

6.2.1 The generator will have nominal rating of 2.15 MW with the generation voltage of 420 V, three phase, 50 Hz, at a rated power factor of 0.8 (lag). The saturated rated direct axis sub transient reactance of generator should not be less than 18% and not more than 22%. The machine will run at 1500 rpm, and will operate with the voltage and frequency variation of ±10 % and ±5 % respectively, with a combined voltage and frequency variation of ± 10%. The enclosure will be of dust, vermin and water proof. The generator will meet other requirements as stipulated in IEC:60034. The generator will be complete with base frame, closed air circuit
water cooled (CACW) cooling system, brushless exciter, automatic voltage regulator, relay, metering and control panels, instrumentation control and safety devices and other accessories, spares and special tools that will be required for satisfactory erection and efficient operation of the station. The generator coupled to the steam turbine will be suitable in all aspects for operating in parallel with grid. The generator will match with the turbine in respect of speed, over speed, moment of inertia, overload capacities, coupling and other relevant requirements.

6.2.2 The stator and the rotor of the generator will have class 'F' insulation but the temperature rise will not exceed the limits specified for class 'B' insulation. The generator will be fitted with RTDs, space heaters and temperature indicators. RTDs as mentioned below shall be provided:

a. Coil sides : 4 Nos. per phase
b. Stator core : 4 Nos.
c. Bearings : 2 nos. each for DE and NDE
d. Cold & Hot air : 2 Nos. per stream

6.2.3 The generator terminals will be suitable for connecting to switchgear panel (PCC) through busduct. The current transformers for metering and protection will be housed in the main switchgear panel and busduct. The drawing enclosed to this report gives the protection scheme for the generator.

6.3 Excitation System & Synchronizing Panels

6.3.1 The excitation system will be of brushless type and will be provided with the following features:

a. Generator voltage control
b. Excitation current control
c. Excitation build up during start up and field suppression on shutdown
d. Limiter for the under excited range and delayed limiter for overexcited range
e. PT fuse failure detection and auto changeover
f. Auto power factor control
6.3.2 The system will have double auto and manual channels, with bump less changeover facilities. Alarms will be arranged for AVR fault, AVR automatic changeover to second auto channel / manual mode and for diode failure.

6.3.3 Synchronising panel complete with running and incoming voltmeters, running and incoming frequency meters, synchronoscope, synchronizing check and guard relays, no volt relays, synchronizing cut off switch, lamps etc. will be provided. Automatic synchronizing with inputs to governor and AVR control will be made possible.

6.4 Unit Control Panel

6.4.1 The unit control panel will comprise of control and metering system, synchronising system, protective relays, start / stop system, alarm / annunciation and temperature measurement system. The control panel will have provision for closing / synchronising through the generator breaker and tie breaker. Dead bus closing arrangement will also be provided in the control panel. The panels may be split up into control panel, metering panel and relay panel for convenience.

6.4.2 Each panel will have digital / electronic PQM, ammeters, voltmeters, frequency meter, power factor meter, kW and kVA meters. The following minimum protections will be provided for the generators:

a. Over voltage, under voltage relay
b. Voltage restrained over-current relay
c. Field failure relay
d. Reverse power (active & reactive) relay
e. Differential protective relay
f. Stator earth fault relay
g. DC failure trip relay
h. Under/Over frequency relay
i. Stator and rotor winding temperature trip relay for alternator.
6.5 Standby Power Distribution

6.5.1 It is proposed to add one (1) number of 2.5/3.15 MVA, 11/0.415 kV distribution transformer to receive stand-by supply from co-generation plant and the same transformer shall be used to evacuate surplus power from distillery plant to co-generation plant. The transformer will be of the following rating:

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Rating</td>
<td>2.5/3.15 MVA</td>
</tr>
<tr>
<td>Cooling</td>
<td>ONAN/ONAF</td>
</tr>
<tr>
<td>Voltage Ratio</td>
<td>11/0.415 kV</td>
</tr>
<tr>
<td>Highest system Voltage</td>
<td>12 kV</td>
</tr>
<tr>
<td>Power frequency Voltage</td>
<td>28 kV rms</td>
</tr>
<tr>
<td>Impulse Withstand</td>
<td>75 kV peak</td>
</tr>
<tr>
<td>Voltage Taps and Range</td>
<td>On load tap changer,</td>
</tr>
<tr>
<td></td>
<td>±12.5% in steps of 2.5%</td>
</tr>
<tr>
<td></td>
<td>(suitable for bi-directional power flow)</td>
</tr>
<tr>
<td>Voltage Vector</td>
<td>Dyn11</td>
</tr>
<tr>
<td>Impedance</td>
<td>18% @ 2.5 MVA base</td>
</tr>
<tr>
<td></td>
<td>(without negative tolerance)</td>
</tr>
<tr>
<td>Neutral Earthing</td>
<td>Solid Earthing</td>
</tr>
</tbody>
</table>

6.5.2 11 kV XLPE Power Cable shall be considered for connecting the HV side of the transformer to 11 kV switchgear of co-generation plant. 1.1 kV grade, LT XLPE cable shall be used to connect the LV side of the transformer to PCC.

6.5.3 The transformer will be protected by Restricted Earth Fault (REF) relay. The neutral bushing CT before bifurcation of neutral will be provided for REF protection of secondary winding of the distribution transformers. The drawing enclosed to this report gives the protection scheme for the generator.

6.6 LT Distribution System and Interconnection

6.6.1 The LT distribution panels conforming to the latest revision of IEC:439 will be of dust & vermin proof construction, sheet steel clad, totally enclosed, floor mounted, self standing single front
type, with both front and rear access for PCCs and front access for MCCs. All panels will be of single bus bar type with bottom cable entries. The MCCs shall be of compartmentalised design with cable alleys at the sides. PCCs shall have the cable chambers at the rear. The busbars shall be of electrolytic grade aluminium alloy, designed for 85°Cend temperature with an ambient of 45°C. All panels shall have neutral bus, sized to carry half the phase current. All panels shall be designed for 50 kA for 1 sec.

6.6.2 PCCs shall have ACBs for ratings of 630A and above. All breakers shall be of draw-out type with spring charged motor operated closing mechanism for incoming feeders and manual draw out type breaker for motor and other outgoing feeders. For ratings less than 630A, MCCB shall be provided.

6.6.3 MCC feeders shall be envisaged with MPCB and contactor for motors of rating up to 30 kW. For ratings beyond 30 kW, MCCB, contactor and microprocessor based Overload relay shall be provided. Ammeters of suppressed scale (above 5.5 kW) and indication lamps, suitable for remote operation shall be envisaged.

6.6.4 Motors feeders of rating less than 37 kW will be provided with DOL starter in MCC. Higher sized motors may be provided with star / delta starter depending on application.

6.6.5 Busduct of rating 5000A, 50 kA for 1 sec. shall be provided for connection between the generator terminals and the PCC. The busduct shall be with aluminium enclosure and aluminium alloy conductors. The busduct shall be of non-segregated phase busduct type interleaved design and shall be complete with flexible, bellows, vertical & horizontal bends, seal-off bushing, outdoor hoods, etc.

6.7 Motors

6.7.1 All motors shall be of squirrel cage type conforming to IEC:34, totally enclosed and fan cooled. Motors shall be of 'premium energy efficient (IE3)' type as per IS 12615-2011. The windings will be insulated by class 'F' insulation material and maximum temperature rise shall be limited to class 'B' insulation limit over an ambient of 50 Deg. C.
6.7.2 Motors to be located in hazardous area shall be of flame proof, Ex(d) type suitable for zone - 2 area of classification.

6.8 Plant Start-up

6.8.1 The plant shall be started with power from co-generation plant through the distribution transformer will be provided at distillery plant

6.9 Earthing System

6.9.1 Neutral point of the distribution transformers and neutral of the TG set generators shall be effectively connected to individual earth pits and shall be interconnected, as per IEEE:80 recommendations. The neutral of LV of side of transformer shall be kept open, when the TG is running in parallel with co-generation plant.

6.9.2 Non-current carrying parts of all electrical equipments viz. generator, PCCs, MCCs, distribution boards, control panels, and motors shall be earthed rigidly, to ensure safety. The armour of the cables, steel structures cable supports and all lighting fittings shall also be earthed.

6.10 Cables

6.10.1 The outer sheath of all cables in the hazardous area shall be of FRLS type.

6.10.2 All cables shall be selected to carry the load current under site conditions, with permissible voltage drop. In addition, high voltage cables shall be sized to withstand the short circuit current. The following types of cables shall be used.

6.10.2.1 Power cables for 11 kV system will be with three core aluminium conductor, XLPE insulated, screened, armoured and overall PVC sheathed confirming to IEC:502.

6.10.2.2 The power cables of 1.1 kV grade will be XLPE insulated, aluminium conductor, inner sheath PVC taped strip / wire armoured with
outer sheath of PVC compound conforming to latest version of IEC: 227.

6.10.2.3 The control cables for control / protection / indication circuit of the various equipment will be of 1.1 kV grade, PVC insulated annealed high conductivity stranded copper conductor, inner sheath PVC taped, flat/round wire armoured with outer sheath of PVC compound conforming to latest version of IEC:227.

6.11 DC supply system

6.11.1 Battery, battery charger and DC distribution board unit will be provided in common for the power house DC load requirements (viz. turbine emergency oil pumps, control & protection).

6.11.2 Valve regulated lead acid battery (110V) with 2V cells along with accessories shall be provided.

6.11.3 The battery sizing will be on the basis of the following type of loads:

- Momentary load for 1 min.
- Emergency load for 2 Hrs
- Continuous load for 10 Hrs.

6.11.4 The battery charger will be of SCR controlled with dual float cum boost charging (FCBC) equipment housed in a free standing, floor mounting cubicle having hinged half doors made out of 14 SWG CRCA sheets.

6.12 AC Auxiliary Supplies

6.12.1 AC supplies of single and three phase, needed for internal use for several functions such as Illumination, Battery charging, UPS, Excitation supply, communication equipment and generators space heater shall be arranged from minimum two supply sources one from the main switchboard of the distillery and other from LT distribution of the existing sugar plant. For extremely critical AC loads, UPS supply system will be envisaged.
6.13 Lighting System

6.13.1 Good lighting in the distillery plant will be ensured to facilitate normal operation and maintenance activities and at the same time to ensure safety of the working personnel. The lighting system would comprise of normal and emergency power supplies. Main lighting system shall receive supply from reliable supply sources and the emergency lighting system will be supplied from battery units. Emergency lighting will be provided at strategic points in the power station, switchyard area and in control rooms.

6.13.2 Light fittings provided in the hazardous area shall be of flame proof type suitable for zone-0 with class duty of IIA/IIB.

6.14 Lightning Protection

6.14.1 Building lightning protection system will be provided as per IS: 2309. The protections consisting of roof conductors, air terminals and down conductors will be provided for the power house.

6.14.2 All tall structures of the distillery plant including tanks shall be protected against direct lighting strokes, by providing air finials / horizontal conductors and down conductors up to the earth electrodes, as per IEC standards.

6.15 Plant Communication system

6.15.1 Existing communication facility at sugar plant shall be extended for the Distillery plant.
7.0 INSTRUMENTATION AND CONTROL SYSTEM

This Section of the Report gives the general philosophy of the Instrumentation and Control system proposed for the 60 KLPD multi product distillery plant and 2.15 MW cogeneration power plant.

7.1 The plant will be complete with the basic instrumentation and control system necessary for its safe and efficient operation.

7.2 Comprehensive instrumentation and control equipment will be provided for each major area of the plant.

7.3 The control system shall be based on the State-Of-The-Art DISTRIBUTED CONTROL SYSTEM (DCS) technology with Data Acquisition and control for controlling / monitoring the different sections of the distillery plant and the concentrated spent wash fired boiler & 2.15 MW co-generation plant. The Data Acquisition and control of the entire plant shall be achieved by a popular DCS package.

7.4 The centralized control / monitoring of the plant shall be from a Remote Central Control Room where the DCS and its sub-systems including the operator console shall be located.

7.5 The Instrumentation and control system of the distillery plant and co-generation power plant shall be realized as given below and the drawing “Overview of the control system” for the plant is given in Drg. No: 3-15003-800-0013.

7.6 Distillery section and its auxiliaries control

The control of the total Distillery section operation start up / shutdown / trip shall be realized directly through DCS. The distillery controls will be for the manufacture of RS, AA and ENA products.

Flow measurement for remote monitoring includes Process steam flow, Inlet molasses flow, cooling water flow, Condensate flow,
Products output flow from the process and Flow of products outlet from the plant. In addition to the above flow measurement, Mechanical weighing system (Tip measurement) shall also be considered for Inlet molasses to the process.

The major controls of Distillery plant include the following:

- Fermented wash Flow Control
- Level control for analyser column
- Level Control for Rectifier column and its reflux tank
- Level Control for Pre Rectifier column and its reflux tank
- Level Control for Fuse oil reflux tank
- Level Control for extractive column
- Level Control for Simmering column and its reflux Tank
- Level Control for recovery column and its reflux tank
- Steam flow Control for Simmering
- DM water flow Control of Purifier Column
- Soft water flow Control for Flash tank
- Flow control for pre-rectifier RS draw control
- Flow control for rectifier RS draw control

### 7.7 Boiler and its auxiliaries control

The control of the entire boiler operation / Start-up / Shut-down / Trip shall be realized directly from the DCS. All the signals required for controlling the boiler operation shall be processed by the DCS and necessary actuating signals or the various final control elements shall be driven from the DCS.

The Major control of the boiler includes the following as a minimum:

- Drum level (3 element) control
- Combustion control
- Deaerator level control
- Deaerator pressure control
- Furnace Draft pressure control
- Superheated Steam Temperature Control (2 element)

Signals from the following shall be taken to the DCS for monitoring / interlocking purpose.
Boiler Feed Pumps

Deaerator
   Chemical dosing
   Boiler safety and protection interlocks

7.8 Turbine and its Auxiliaries control

Turbine control shall be performed by the DCS. Turbine Protection and safety interlocks shall be performed by DCS. Signals from the following major equipments shall be taken to DCS for monitoring / Interlock purpose.

   Lube oil system
   Control oil system
   Generator cooling system
   Turbo supervisory system

Dedicated independent micro processor based systems shall be considered for the following systems of the TG and shall be interfaced with the DCS through serial communication for monitoring / interlocking purpose:

   Turbine Vibration Monitoring system
   Turbine Governing system

The turbine shall be provided with and electro-hydraulic governing system. The system shall be designed such that the governing of the turbine shall be automatic and provides for safe operation.

The information of the following shall be monitored by the DCS for Data logging / Interlocking purpose:

   Power generation details
   MOP/ AOP / EOP status
   Temperature of turbine bearings
   Temperature of windings / Bearings of Generator
The following details on the electrical signals shall be processed / monitored by the DCS for interlock / data acquisition purpose:

Safety Relay status
Breaker status
Generated Voltage, Current, Kilowatt, KVAR, Power factor, Frequency
Line Voltage, Current, Kilowatt, KVAR, Power factor, Frequency

7.9 Various electrical inputs from the transducers and the digital signals from MCC panels shall be processed in the DCS system for monitoring and achieving the necessary interlocks / controls.

7.10 The control and monitoring of the Instrument Air Compressor shall be realized directly from the DCS.

7.11 The operation and control of Ash Handling System shall be from DCS only.

7.12 The operation and control of Fuel Handling System shall be from DCS only.

7.13 The PRDS functions shall be directly processed by the DCS.

7.14 The control and monitoring of auxiliary cooling water System shall be realized directly from the DCS.

7.15 The operation and control of water treatment system shall also be directly processed by the DCS. Dedicated operator station and respective IO panel shall be envisaged for the same.

7.16 The design of the total control system will be such that the following sub-system’s functions will be handled by the respective equipment:

a. Data acquisition, Display and logging sub-system for monitoring, display, logging and printing of process parameters like flow, temperature, pressure, level, current, voltage, analytical and status will be performed by the operator station
b. **Start / Stop Sequence & Interlock** sub-systems consisting of the safety interlocks, Sequence of starting and stopping of the distillery plant and alarm generation will be achieved through the DCS.

c. **Closed loop control** sub-system consisting of the continuous monitoring of the operational parameters like Level, Pressure, Flow etc., and controlling of the same using the PID functions will be achieved by DCS.

d. **Engineer / Operator interface** sub-system consisting of setting / changing the operational parameters based on the experience of the operator and as a reaction to emergency situations will be achieved by the computers used as the operator station.

e. **Communication** sub-system for interconnecting all the above systems.

f. **Data highway and network** for connecting the control and data acquisition sub-systems, operator interface sub-systems to a duplexed data highway such that there will be information exchange among each one of them.

g. **Auxiliary units** such as system cabinets, printer consoles, marshaling cabinets and power supply distribution cabinets.

7.17 The Distributed Control system is proposed for Control and Instrumentation system, keeping in view the safety, reliability and availability for comprehensive presentation of plant operation status, trends and essential operator interaction facility.

The Distributed Control System based plant control will have the following inherent advantages:

- Integration of information from different individual controls provides centralized data on plant operation.

- Increased reliability due to the use of Large Scale Integrated (LSI) components.
Increased flexibility for modification at any stage due to software configuration capability.

Modular design concept provides easy expandability for future in hardware and software.

Higher maintainability due to improved self-diagnostic and display features.

Less number of operating personnel.

The major design aspects of the system will be as follows:

Control will be of the type which normally relieves the operator of continual regulating duties and will be backed up by interlocks and safety systems that will take pre-planned action in cases where unsafe trends and/or conditions develop faster than the operator’s ability to respond.

Continuous self checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.

All the closed loop analog signals, open loops, safety and interlock signals and digital signals shall be processed by the DCS.

Redundancy will be provided in the Central Processing unit, power supply and Communication modules (both between the controller & the operator station and between the I/O modules and the controller).

Redundancy will also be provided for the communication cables.

Power supply used for interrogation with field devices shall also be redundant.
The Input/Output modules will be provided with noise filter and galvanic / opto isolation from external control source.
All analog signals from distillery area to DCS and from DCS to distillery area shall be routed through signal barriers.

The Inputs / output module shall also be provided with protection against reversal of polarity of supply voltage.

The input modules shall be suitable for processing the field signals. The outputs will be short circuit proof and protected by fuses.

The memory will be non-volatile or battery backed up as required.

The control logic building shall be user friendly based on windows based software.

The graphic displays on the operator station shall be developed using windows based software.

On-line replacement of modules shall be possible without affecting the process.

Auto boot up facility for the DCS shall be within 2 minutes.

Display response time shall be less than 2 Sec.

Data communication network response time shall be less than 100m Sec.

Closed loop control task execution (Control response time) shall be done within 250 msec.

Sequence control / Interlocks scan time should be within 100 msec.

Display update time shall be less than 1 sec.
The system shall be designed so that the failure of any
monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.

- All equipment/systems located in the field shall be suitable for continuous operation without loss of function, departure from the specific function or damage at the ambient temperature and humidity conditions.

- The control system software shall have all the essential capabilities to perform advanced control algorithms as a minimum. It shall be user friendly, easily programmable and have excellent Data acquisition, Graphic display and logging capabilities.

### 7.18 The field instruments those are primarily responsible for measuring the process parameters will be having the following major design features:

All the field instruments/equipment that are used shall be of the same make for ensuring the smooth & optimal maintenance including efficient spare parts management.

All field instruments used for sensing, transmission and measuring shall be of electronic smart type with local indication & signal transmission in current mode of 4-20 mA.

All control valves and control damper drives will be of pneumatic type because of their fast response and ease of maintenance.

All the field instruments, control valve positioner and Junction boxes shall comply explosion proof/ intrinsically safe requirements.

Cable glands used in hazardous area shall be of double compression, flame proof type.
Materials of construction of instruments shall be consistent
with temperature, pressure and corrosion conditions.

Appropriate derating of electronic components and parts.

Important plant parameters, that are required to assess the plant efficiency, must be serially communicated to the operator station for the purpose of display / logging.

All solid state systems/equipment shall be able to withstand the electrical noise and surge as encountered in actual service conditions and inherent in a distillery plant, and shall meet the specification requirements of surge protection.

All solid state electronic system/equipment furnished shall meet the requirements of Burn-in and Elevated temperature test.

All the instrumentation cables shall be flame retardant low smoke type.

The instrumentation cables and wires shall function without breakdown for surges experienced in the control system. Voltage class and insulation level shall be compatible with the signals they convey.
8.0 PROJECT CIVIL & ARCHITECTURAL REQUIREMENTS

This section of the report covers the basic requirements of civil work to be executed in the distillery project. More detailed specifications are to be drawn at the time of Project engineering stage, depending upon the nature of the soil and based on the soil investigations for the project execution.

8.1 Geo-technical investigation

The Geo-technical investigation shall cover the entire distillery area. Required and adequate field tests in the form of test boring including drilling through rocks (if required), direct load tests, trial pits, tests for dynamic properties, electrical resistivity tests etc. and necessary laboratory tests shall be conducted to determine soil and sub-soil characteristics required for site preparation and foundation design. Soil Investigation tests shall be conducted at all major structure / foundation / building locations within the battery limits of the plant. A comprehensive report on soil investigations shall be prepare incorporating all the data collected and firm recommendations with regard to the type of foundations shall be given supported by calculations.

Contour mapping of the site with proper surveying should be obtained by taking spot level of ground at every 5 meter intervals in both directions. Bench marks with co-ordinates and reduced level for the site should be established. Based on the preliminary contour survey, the level difference across the distillery plant is around 17 to 20 meters.

8.2 Equipment Foundations

8.2.1 Foundation for rotating machinery

The foundation design will take into considerations all the loads from the machine including dynamic loads as per the manufacturer’s loading data. The design and construction will be done as per provisions laid down in applicable Indian Standards. The Grade of concrete for the complete foundation including the top deck shall be at least M25 (specified characteristic compressive
strength of 25N/sq.mm for a 150mm test cube at 28 days). The High strength deformed reinforced steel bars used for reinforced concrete shall conform to Indian standards.

Detailed static and dynamic analysis shall be done for the foundation. The static analysis shall include all the operating condition loads as well as abnormal loads. A fatigue factor of at least 2 shall be considered for all dynamic loads. The mass of the foundation block shall be not less than three times the mass of the machine.

Dynamic analysis shall be carried out to calculate the natural frequency and mode shapes and to evaluate the dynamic response of the foundations to the applied dynamic loads. Unbalance loads for the normal operating conditions as given by the manufacturer or VDI 2060, whichever is more conservative shall be used for calculating the dynamic response. Transient dynamic analysis shall be carried out for the short circuit condition with an appropriate forcing function.

The detailed design and vibration analysis shall be carried out to:

The determination of the natural frequencies of the system, to ensure that at least 20% frequency separation exists.

Ensure the suppression of vibration amplitudes to acceptable limits.

The provision for adequate foundation bearing capacity and settlement, limited to acceptable amounts.

The reinforcements shall be designed to the working stress methods for the worst load combinations of static and dynamic loads.

All necessary provisions by way of cut-outs, embedment and foundation bolt assemblies shall be incorporated into the foundation block to meet the functional requirements.
The foundation shall be isolated from adjoining parts of buildings and other foundations for vibration control. Joints at floor / grade shall be suitably sealed.

For foundations supporting minor equipment, weighing less than One Tonne or if the mass of the rotating parts is less than one-hundredth of the mass of the foundations, no dynamic analysis need be done. However, if such minor equipment is to be supported on buildings, structures etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolations system shall be designed suitably.

8.2.2 Static Equipment Foundations

All the static equipment foundations shall be constructed with cast-in-situ reinforced concrete. All foundations shall be extended to a depth, which conforms to the allowable bearing pressure of the soil.

The design of foundations will take into account all the loads from the equipment as per the equipment manufacturer's loading data. The design and construction will be done as per provisions laid down in Indian Standards. The grade of concrete shall be at least M20. (Specified characteristic compressive strength, of 20N/ sq.mm for a 150mm test cube at 28 days). The High strength deformed reinforced steel bars used for reinforced concrete shall conform to applicable Indian standards.

The design of foundations shall be carried out by Limit State Method. All necessary provisions by way of cut-outs, embedment, and foundation bolts assemblies shall be incorporated into the foundation block to meet the functional requirements. The foundations will be isolated from building foundations and superstructures.

8.3 Buildings

8.3.1 General

All buildings will be designed and constructed as per applicable Indian standards and codes. Loads shall be calculated based on IS
875, and Earthquake loads shall be as per IS 1893. The analysis and design of structures shall be carried out by Limit state method and by using standard computer programs as per technical specifications and using reinforced concrete Grade of concrete M20 (specified characteristic compressive strength of 20N/ sq.mm for a 150mm test cube at 28 days). The High strength deformed reinforced steel bars used for reinforced concrete shall conform to relevant Indian standards.

The buildings shall be designed to suit the climatic conditions of the region. Roofs of all the buildings shall be weatherproof and leak-proof under all conditions. Proper drainage arrangement will be made and these are connected to main storm water drains. All buildings shall be provided with suitable approach roads connecting to main plant roads. The buildings will be properly ventilated and illuminated to meet their functional requirements.

8.3.2 Non Plant Buildings

Non Plant Buildings like, Laboratory building, MCC Rooms, Pump house, excise authority building, security cabin, office building etc., will be of concrete shallow foundations and superstructure with reinforced concrete / Structural steel frame work, reinforced concrete cast in situ / Plastic coated steel sheeting roof. External walls shall be of 230 mm thick brick masonry and internal walls will be of 115 mm thick brick masonry depending upon the functional requirement of the buildings.

Exterior and interior walls, ceiling shall be plastered and painted with approved colour and brand. Doors and rolling shutters with steel frame and adequate windows / ventilators with steel frame with 6 mm thick glass shall be provided. Flush doors and glazed windows shall be provided as per requirement. Exhaust fans shall be provided as required. Around the buildings a 10 m wide smooth finished concrete walkway and necessary steps and ramps shall be provided.

8.4 Distillery plant civil works

The molasses tanks and bulk storage tanks shall be open to atmosphere with suitable foundation. Covered area is required for
fermentation section (fermenters wash settling, yeast and molasses handling area), distillation section, daily receiving section, etc. These buildings can be of MS steel structure buildings with plastic coated steel sheet roofing on MS trusses and purlins. The structural steel buildings shall have civil work up to plinth + 0.3m above ground. Platforms at 3m intervals shall be provided. The daily receiver building shall have brick masonry up to 2m height and RCC grill above the masonry wall. The tank and equipment foundation will be in concrete. The floors of the building shall be of steel platforms and wherever required they should be of removable type. Some of the operating floors will be of chequered plates to avoid spillage reaching the floors below. The flooring at ground floor shall be hardened concrete flooring 50 mm thick.

The bulk storage section shall have Uncrushed Rubble masonry in plinth, chain link fencing of 1.2 M high above the wall all around and gate for entry purposes. The excise authority office, security cabin and distillery office will be of RCC construction with floor slabs and RCC roofs.

The construction of impervious storage tanks for spent wash should meet the pollution norms. It shall be constructed of masonry / brick work with impervious one using composite PVC lining duly finished and Sulphate resistant cement shall be used. Since spent wash is highly acidic corrosion resistant epoxy painting shall be used.

### 8.5 Tank Foundations

Flat bottomed steel tanks are extensively used for storage of liquids such as water, products and molasses in the distillery. These are placed directly on grade; by just levelling the ground if the strata below are firm or improving the strata by compacting the soil to desired density or replacing the top layer by well compacted sand layer. The foundations for steel storage tanks supported directly on firm grounds can be economically constructed by allowing larger settlements than permitted for framed structures or equipment foundations. Since the loading on soil resulting from these tanks is necessarily uniform hydrostatic load the settlements are also uniform over well prepared grade.
Loose soil under the tank area is first removed and the soil below is compacted using 10 T rollers after watering at optimum moisture content. The prepared grade is overlain by well compacted sand layer of min 150mm thicknesses. The area under the tank is enclosed in concrete ring wall. The diameter of this ring wall is approximately 2m more than the tank diameter. The tank is placed entirely on soil. The purpose of the ring wall is to confine the soil under the tank and take care of the resultant hoop tension resulting from tank load and lateral pressure from soil. The tank is then placed on 50 mm thick Bitumen mastic layer with 6 mm stone-grit and coarse sand mixed with 80/100 grade bitumen.

The tank shall be supported on well designed foundations, installed in the open and surrounded by wall or embankment not more than two meters high and made of earth, steel, concrete or solid masonry capable of withstanding full hydrostatic load. Ground within the enclosure shall not be lower than the level of the ground outside the enclosure and shall be finished to form a slope of not less than half a percent from tank to drain or sump.

The drainage from the enclosure shall be controlled by a valve which shall be accessible in fire conditions and capable of being operated from outside the enclosure. Where Petroleum class A (Ethanol) or Petroleum class B is stored in an enclosure, the capacity of the enclosure shall be hundred percent of the capacity of the largest tank in the enclosure after deducting the volume upto the height of the enclosure wall of all other tanks in the same enclosure.

8.6 Cooling Towers

The basin underneath the cooling tower for the collection of the cold water shall be of grade M25 concrete. The raft slab shall be checked for uplift forces considering empty condition of the basin with ground water table at the maximum level. A minimum factor of safety of 1.2 shall be ensured for the condition that the basin walls are constructed up to finish ground level and there is no water in the basin and superstructure columns are not constructed and the ground water table is at the maximum level. The basin shall be water tightness, to prevent mixing of the ground water with the cooling water in the basin.
Water proofing admixture (plasticizer cum water proofing compound), shall be added to the concrete for basin, channels, drain pits, hot water basins etc. Two (2) Nos. of Stairs, one at each gable end shall be provided. The stairs shall be of steel construction with galvanized step treads and hand railing.

8.7 Pipe Racks

Pipe rack supporting structure will be of structural steel columns with interconnecting longitudinal & transverse beams, properly braced with vertical & horizontal bracings. All structural steel members will be painted suitably. Width and tier of the rack shall be as per the system requirements. Access ladders at suitable places will be provided.

The steel columns will be resting on RCC pedestals / footings (grade M20). The analysis and design of structures and foundations will be done as per provisions laid down in the codes.

8.8 Cable / Pipe Trenches

Cable trench walls and base slab will be of cast in situ reinforced concrete (Grade of Concrete M20) (specified characteristic compressive strength of 20 N/sq.mm for a 150mm test cube at 28 days). The High strength deformed reinforced steel bars used for reinforced concrete shall conform to relevant Indian standards.

Trenches shall be covered with precast RC cover slabs of standard design. Suitable slope in the longitudinal direction shall be provided and to be connected to nearby plant drainage system. Necessary embedment and edge protection angles shall be provided as per functional requirements.

8.9 Roads and Pavement

All roads within the plant shall be either double lane roads with 6.0 m black topping or 2.5 wide shoulders on either side of the roads or shall be single lane roads with 4.0 m black topping and one meter wide shoulders on either side of the road. Roads geometry and construction shall be in accordance with applicable Indian
standards for road construction. All the roads shall be designed to withstand the largest expected loads. Minimum longitudinal slope of the road shall be 1 in 200 where there are curbs on each side. Without curbs the roads may be laid flat. Slope from crown to edge should be 1 in 50 generally on straight stretches. Super elevation shall be provided on curves.

The sub grade shall be compacted to the levels, falls, widths and cambers as per the grade requirements. Sub base will be laid on a prepared sub grade. Base and final road surfacing shall be of bitumen macadam. Seal coat will also be provided. Precast RC kerbs on both sides of road shall be provided. The rainwater shall be collected in road side gullies and let into the plant surface drainage system.

Paving areas shall be properly graded and compacted to required grade and slopes before providing the base layer. Reinforced concrete paving (grade M 15) shall be done in alternate panels not exceeding 3.0 m x 3.0 m in size. Construction joints shall be filled with sealing compound. Around equipment foundations / columns isolation joint shall be provided up to full depth of the pavement. Expansion joints shall be provided at a spacing of 15m (max)

Top surface of the pavement shall be provided with adequate slopes as required for the surface drainage.

8.10 Surface Drainage

All the paved and unpaved areas shall be adequately drained. The surface drainage system shall be designed for surface washings and / or rain / fire water as the case may be.

Contaminated area surface drainage shall be collected and discharged through catch pits. The catch pits shall of RCC construction and shall be covered with CI / MS gratings. Uncontaminated areas surface drainage shall be done through rectangular RCC drains to be connected to open storm water drains.

The catch pits, interconnecting pipes and rectangular / trapezoidal drains shall be sized for carrying the design discharge when
running full. Adequate bottom slope shall be provided to maintain minimum velocity. The paved areas shall be sloped towards the catch pits drains. At the road and other crossings suitable pipe / open RC culverts shall be provided.

8.11 Plumbing and Sanitary System

Plumbing and sanitary system shall serve all toilets, showers, bathrooms, kitchens and laundry room. Wherever possible all discharge pipes shall be fully vented. The design, installation, testing and maintenance of all plumbing systems & sanitary appliances shall comply with latest applicable Indian Standards.

Toilets shall have western style water closets. All piping shall be concealed. Floor drains shall be designed in such a way that their taps are always filled with water to guard against odours as well as insect and rodent infiltration.

All wash basins shall be equipped with pop up drain stops. All sinks shall have water taps.

All urinals and water closets shall have flush valves. The minimum acceptable mounting height of a shower head shall be 1.8 m from the finished shower floor.

8.12 Sewerage Drainage System

The sewerage drainage system consists of connecting the sanitary waste disposal from different buildings to the Septic tank through necessary pipeline. All the pipes shall be of RCC material. Minimum size of pipe at a service connection shall be 100 mm and the minimum size of pipe for sewers shall be 200 mm. Minimum slope in service connections shall be 1 in 40 and in sewers 1 in 400. All sewers shall be located along with roadways or public open spaces. Manholes shall be provided at the head of each sewer, at all changes in slope, direction or pipe size or at junctions of sewers. Maximum distance between manholes shall be 50m.
8.13 Site Clearance

All the materials and equipment employed for construction purpose shall be taken away from the site. All the rubbish and unwanted plant material shall be cleared and dumped away from the site. All areas within and outside the site which have been used during the construction shall be cleared and the ground surface shall be left in a safe and aesthetically good condition.

8.14 Fencing / Compound Wall

The storage area, loading, unloading area etc should be provided with suitable Compound wall / Fencing for a height of 2.5 m and steel gate with security room. Compound wall shall be provided wherever necessary for isolation of specific plant areas.
9.0 SITE FEATURES AND PLANT LAYOUT

9.1 Location and Features of the Plant Site

The proposed Distillery at GSML will be located at a distance of about 250 meters from the sugar plant complex, on its eastern side. The land on which the distillery complex will be located belongs to GSML and is presently being used as a farm land. However part of this farm land is presently being converted as bagasse storage area with conveyor interconnections, for carrying the bagasse from and to the sugar mill. This farm land complex will house the distillery along with the bulk bagasse storage yard and the distillery complex will be located on the northern side of this farm area. The Drawing No. 0-15003-600-0016 gives the overall plant layout for the complete sugar and distillery complex and Drawing No.0-15003-600-0017 gives the Unit Plot Plan for the Distillery Complex. The layout is made for the complete distillery including the fermentation, distillation, evaporation, Condensate and spent lees treatment system, spent wash incineration based Cogeneration plant and the product storage (daily and bulk). The distillery complex occupies and area of approximately 7.8 acres.

The following specific features of the site have been discussed in this section of the report.

- Availability of adequate space for locating the Distillery and associated plants and adequate space for the construction activities.
- Suitability of the site from topographical and geological considerations.
- Availability of rail and road connections for material movements.
- Availability of adequate quantity of water for meeting the plant’s water requirements.
- Availability of adequate fuel and its transport.
- Availability of Raw materials.
- Ecological Impact.

9.1.1 Space Availability

Adequate land is available within the identified area premises for locating the Complete Distillery including all the sections like the Fermentation, Distillation, Evaporation, Condensate treatment, Product Storage etc. The Distillery is an independent plant and could be located anywhere as long as adequate space is available for the installation of all the sections. However the whole lot of logistics have to be developed for accommodating the plant with all the associated plants. There are definite advantages in locating the plant close to or within the sugar mill considering the transportation and storage of molasses, transportation and storage of fuel, arranging for water for the plant operation, providing construction power and water etc. The proposed distillery complex is just about 250 meters away from the sugar mill and is very convenient for the interconnections for bagasse, molasses, steam water and power. Even though the distillery will be developed as a standalone unit the interconnections with the sugar mill for power and steam always gives flexibility in the continuous operation of the distillery complex.

The turbogenerator in the distillery would be paralleled with the proposed 30 MW Cogeneration plant in the sugar mill. This will ensure a backup power supply to the distillery in case of non-availability of the distillery power plant for any reason. Also during the commissioning of the distillery this will come in handy as commissioning and stabilizing both the distillery and the spent wash incineration based power plant at the same time will pose some interruptions during the commissioning and running in.

Considering the various advantages as discussed above, it has been decided to locate the Distillery on the eastern side of the existing
sugar plant, in the location identified in the overall layout. The main plant consisting of the Distillation Section, Fermentation section and the product storage Section will be located on the western side of the distillery complex. The 2.2 MW Cogeneration power plant and the spent wash incineration boiler will be located on the southern side of the distillery complex. The boiler will be laid out with its axis in the east west direction. The building housing the 2.2 MW TG will be located on the eastern side of the spent wash fired boiler. The raw water storage tank, WTP, effluent treatment and polishing plant and the spent wash lagoons will be located on the eastern and north eastern side of the complex.

9.1.2 Topographical and Geological Aspects

The proposed distillery complex is a plain area used as the cane farm of the sugar mill. Filling will be required to raise the ground level for locating the plants.

The soil is good and the Soil bearing capacity is around 12 Metric Tonnes per Sq.M at a depth of two (2) meter into the virgin soil. Piling will be required for most of the equipment foundations and building column foundations.

9.1.3 Rail and Road Facilities

The nearest railway station is the Town of Lakhimpur-Kheri. All plant and machinery can be transported only by road. Approach road near the proposed area needs to be made for bringing in the equipment.

9.1.4 Water Availability

Distillery plants are water intensive. The water required for the distillery also varies in quality requirements for different applications. Process water that is required for molasses dilution should be bacteria free and a higher TDS in the water is not a problem. The
cooling tower make up water need to be at least filtered and treated to bring the TDS to some acceptable level. The DM water is required for Extractive Distillation and for boiler make up. GSML’s distillery is being designed as a “Zero Effluent Discharge” plant and some of the aqueous effluents will be treated and used as process water or cooling tower make up water. Nevertheless there will still be requirements for a large quantity of water from the raw water source. It is proposed to get this water from the bore wells to be located within the distillery complex. There could be interconnections between the sugar mill bore wells and the distillery complex bore wells so as to ensure continuous availability of the raw water and also to make use of the bore wells effectively.

9.1.5 Availability of Fuel

As the proposed Distillery will be having its own Cogeneration plant, there is no need for any steam supply from external sources. However, interconnection arrangement is provided between the existing sugar mill’s cogeneration plant and the distillery for any emergency situation. The new technology of spent wash concentration and incineration is adopted in the plant design and hence part of the fuel requirements for steam generation will be met from the concentrated spent wash generated within the distillery. As the concentrated spent wash cannot meet the full steam generation, the plant needs a supplementary fuel in the form of bio-mass or coal. For the GSML’s distillery it is proposed to use the in-house generated bagasse as the supplementary fuel. The bagasse requirement will be about 5 MT per hour for the normal operation of the plant, with the availability of 60% w/w concentrated spent wash. The bagasse will be stored on the southern side of the distillery complex and will be fed to the boiler through a system of conveyors.
9.1.6 Availability of Raw Material

The raw material for the distillery operation is, mostly the molasses generated in GSML's sugar mill. However the plant will be designed to operate with bought out molasses also in case GSML is able to procure molasses at a reasonable price. For the purpose of this Detailed Project Report it is assumed that GSML will be able to procure about 15,000 MT of molasses per annum from nearby sugar mills.

9.1.7 Ecological Impact

A molasses based Distillery is considered as highly polluting. However the GSML's Distillery is designed as "Zero Liquid effluent Discharge" plant and hence no pollutant is let out. On account of this there is no impact on the ecology consequent to the implementation of the distillery.

9.2 Distillery Plant Layout

9.2.1 As seen elsewhere, the layout enclosed to this report gives the location of all the sections of the distillery. The proposed Distillery Plant will be located on the eastern side of the sugar plant complex at a distance of about 250 metres. The Main plant consisting of the fermentation section, Distillation section and the product storage section is located on the western side of the complex. The fermentation section, distillation section and the product storage section are arranged in a row in the North-South direction with the fermentation section on the southern side and the product storage section on the northern side. of the Spent was incineration boiler and the 2.2 MW Cogeneration plant. The product storage section will include all the daily receiver tanks and bulk storage tanks. The new molasses storage tank will be located west of the proposed fermentation section and the incineration boiler. The cooling towers are located east of the distillation section and the product storage tank farm. The water treatment plant and the condensate and spent
lees treatment plant are all located east of the product storage tank farm and the distillation section.

9.2.2 Another important plant in the distillery is the spent wash concentration plant. This plant is basically a multiple effect evaporation plant to evaporate the water in the spent wash so as to concentrate the spent wash to a final solids content of 60% w/w. It receives the raw spent was from the lagoons and sends the concentrated spent wash to the boiler for incineration. This plant will be located near the boiler, on the northern side of the boiler. Locating the plant close to the boiler ensures that the concentrated spent wash is piped only for a short distance. The complete concentration plant with all the evaporator bodies, pumps, condenser, vacuum pumps concentrated spent wash storage tank are all located in the same area.

9.2.3 Another major section of the Distillery is the spent wash incineration boiler and the turbogenerator which provide the required process steam and the power for the operation of the distillery. As seen elsewhere in this report, the boiler will be firing concentrated spent wash and bagasse for the generation of steam required for the operation. The evaporation section mentioned earlier will concentrate the spent wash to 60% w/w solids and supply to the boiler for combustion. It is proposed to have a 100 Cu.m capacity concentrated spent wash storage tank near the boiler from where the spent wash will be pumped to the spray guns in the boiler. The boiler, which will be of 20 TPH MCR capacity and will be located on the southern side of the distillery complex. The TG house to accommodate the 2.2 MW back pressure TG will also be located in the same area east of the proposed new boiler. All the electrical and instrumentation systems related to the power generation and distribution to the distillery will be located within the TG building.

The boiler Drawing No.1-15003-800-0008 gives the general arrangement of the boiler. It may be seen that for the MCR capacity of 20 TPH, the boiler is quite big. This is mainly because of the spent
wash firing which puts restriction on the gas temperature entering the superheater of the boiler. The boiler will be provided with only an economizer and air heater is not provided mainly from the point of view of low temperature corrosion. Bag filter will be used for dust separation from the flue gases and the same is located between the boiler economizer sections and the ID fans. The boiler will be provided with a new RCC chimney of 55 m height.

An ash silo will be located in the area of the new boiler chimney. All the ash from the discharge points shall be stored in this silo for disposal to the fields as fertilizer.

9.2.4 The most important section of the distillery which is the product storage is located separately from the main distillation plant. The location of the product storage is also decided based on the requirement of easy accessibility for the excise authorities. Adequate approach roads shall be provided. The product storage will have the daily receiver tanks and the bulk storage tanks for industrial alcohol, Extra Neutral Alcohol, Anhydrous Alcohol and Technical Alcohol. There will also be a small bulk storage tank for the Fusel oil. The product from the distillation section will be pumped to the daily receiver tanks. Each of the daily receiver are designed to accommodate the production made in a day. Once the daily receiver tank is filled at the end of the day and after inspection by the excise authorities, the product will be pumped to the bulk storage. All the pumps required for pumping the product to the bulk storage tank and for the final issue to the tankers will be located in the same area. This product storage area will be fenced and the daily receiver tank area will be kept in a lockable space.

9.2.5 Three raw spent wash lagoons of RCC construction and will be provided east of the east of the distillation section and the product storage section. These lagoons will also act as settling tanks for the raw spent wash received from the distillation section. In case of
cleaning of the evaporator bodies the spent wash could be temporarily stored in this tank.

9.2.6 Another important point to be considered in finalizing the layout is that the Distillery plant construction activities pose minimum disturbance for the operation of the sugar plant. This is very important in an operating sugar plant as the distillery construction and the sugar mill operation may for some time go simultaneously. By locating the Distillery plant in the identified area, which is at a distance from the sugar mill complex, this point is adequately taken care off.

9.2.7 Adequate construction space is available for the storage of materials of the various contractors and for them to carry out pre-fabrication work. Specific areas to be identified at the time of start of the site activities.
10.0 OPERATION AND MAINTENANCE REQUIREMENTS

10.1 General

10.1.1 This section of the report outlines the operation and maintenance philosophy to be adopted for the new 60 KLPD distillery with spent wash fired boiler and a 2.2 MW TG. These broad outlines given here will provide useful guidelines for the basic and detailed engineering of the plant, so that all the requirements of the operation and maintenance of the Distillery plant are met and provided for in the engineering stage itself.

10.1.2 The production of alcohol from molasses involves the interaction of several major sections of the distillery. The fermentation section supplies the fermented wash at the appropriate concentration of alcohol to the distillation section for further processing into RS or ENA or AA. The MSDH section purifies the RS to absolute alcohol (AA) through molecular sieve dehydration system. The independent evaporation section of the distillery concentrates the spent wash to a level of solids concentration of 60% w/w. The spent wash fired boiler and turbo generator supply the steam and power requirement of the distillery for the various conditions of operation. The 2.2 MW TG will operate in parallel with the new 30 MW TG in the sugar mill’s Cogeneration plant. The incoming molasses and the product should be measured and stored appropriately for further distribution. The water treatment plant supplies the DM water required for the process and for the power plant. Different cooling towers circulate cooling water for maintaining appropriate temperature of the process fluids in the various sections of the distillery.

10.2 System Design Philosophy

10.2.1 The main O&M objective is the high availability and reliability of the plant. In order to achieve the main objective, the following principles would be adopted.

Optimum margins on the operating parameters of all important equipment and auxiliaries and systems to ensure operation of the plant at rated capacity under all modes of
operation.

Providing redundant and standby capacity for all critical equipment.

Use of Equipment and systems with proven design, performance and have a high availability track record under similar service conditions.

Selection of the equipment and adoption of a plant layout to ensure ease of maintenance.

Strict compliance with the approved and proven quality assurance norms and procedures during the different phases of the project.

10.2.2 The basic and detailed engineering of the plant will aim at achieving high standards of operational performance especially with respect to the following key parameters.

Optimum efficiency of the equipment.
Low Auxiliary power consumption.
Low make up water consumption.
Low process steam consumption
No effluent discharge (Zero Liquid effluent discharge)

10.2.3 The plant Instrumentation and control system should be designed to ensure high availability and reliability of the plant to assist the operators in the safe and efficient operation of the plant. It should also provide for the analysis of the historical data and help the plant maintenance engineers to take up the plant and equipment on preventive maintenance.

10.3 Operation Requirements

10.3.1 The operation of the plant starts with the Commissioning of the various sections of the distillery and the spent wash fired boiler. In broad terms commissioning can be defined as setting up of the plant to work safely and on program. It is necessary to ensure that all equipment is completely erected before operations begin. Although this may be considered difficult, the other extreme of
operating a plant with insufficient instrumentation, controls and alarms is very dangerous. Although some compromise can be made with regard to plant completion, the commissioning procedures should never compromise personnel and the system safety.

10.3.2 A proper checklist must be drawn up, which shall include all the sections of the plant and shall take into account, the contractual responsibilities, the technological relationship between the various sections, pre-commissioning, cleaning requirements, etc. The checklists procedure helps in the following:

a) To ensure that the necessary checks are carried out on each item of the plant before it is put into commercial service.
b) To indicate a contractor's commissioning requirements from the client or from other contractors.
c) To ensure that energy is supplied to equipment or a plant when it is safe to do so.
d) To facilitate the recording of the progress on the various commissioning activities.
e) To provide a basis for the plant history.

10.3.3 The Operation of the multi product distillery is an activity that must be co-ordinated well with the factory management and marketing section of the factory to decide on the product mix of the distillery. In addition the raw material input quality and product quality shall be recorded and ensured at all times of operation of the distillery.

10.3.4 The operation of a multi product distillery demands closely controlled operating conditions. The unit start-ups, shut-downs and even emergency shut downs must strictly follow the carefully laid down procedures given in the operational Manuals. Generally, the plant shall be sufficiently instrumented to permit close checks on such operating parameters of the various columns in the distillation section and the various parameters in the fermentation section.

10.3.5 An important feature of the modern DCS system for the distillery plant is the automatic safety lock-out devices. While sufficient thought goes into it at the design stage, it remains the
responsibility of the operating staff to ensure that the safety devices are set correctly and kept in operation.

While safety of the plant and personnel is the foremost importance in the operation, the efficient operation of the plant cannot be ignored. While operating, it is important to check the essential parameters of the plant and equipment to ensure that the plant performance is at the optimum level. Any variations in the operating parameters or any deviations from normal performance of the equipment or plant shall have to be analysed immediately to diagnose the problem and to take remedial measures to bring back the plant and equipment to its original parameters.

10.4 Distillery Operation

The detailed treatise on the operation of the distillery is beyond the scope of this report. However, the important areas are highlighted.

10.4.1 The factory should have a good quality control programme to establish product specifications, develop and implement sampling & testing methods and recording/reporting of results. Quality checks must be in place to maintain consistent quality of the raw materials to reduce the chances of down stream processing problems stemming from the use of sub standard materials.

10.4.2 Effective testing and monitoring of fermenters is important to maintain fermentation efficiency and finished product quality. The fermentation section plays a major role in ensuring the efficient operation of the distillery. The specific gravity of mash, pH, Acidity, temperature, bacterial level, yeast count, concentration of alcohol has to be closely monitored to ensure the quality of down stream products. Low pH in the fermenter usually suggests a thriving population of bacteria, which, if left unchecked can disrupt both enzyme activity and yeast growth. Proper control of process temperature in fermentation section is very important for maintaining performance and quality. Proper control of microbial activities in the fermenters is essential to maximising the efficiency of alcohol production and in maintaining the quality of distillate.
10.4.3 Continuous checks on the quality of molasses to assess its grade, total sugars, FS etc., laboratory test for fermentation characteristics and alcohol yield potential are important. The quality of water used for dilution of molasses should be good with out any bacterial contamination. Good scrubbing of CO$_2$ from fermenter outlet is necessary to arrest escape of alcoholic vapours. Wash feed rate into distillation column and product outflow rate should be monitored continuously. Precise control of multiple effect evaporation system in the distillation area and spentwash concentration area ensures steam economy and optimisation of the auxiliary fuel consumption.

10.4.4 A properly implemented sanitation programme is essential for the distillery operation. This should cover establishment of physical, chemical and bacteriological cleanliness standards covering all areas of production, house keeping, process and maintenance equipment cleanliness etc.,

10.4.5 Effluent generation should be controlled and proper usage of spent wash recycling, if used, condensate polishing etc., reduce the total water requirement for the distillery complex.

10.4.6 Ensuring good quality of water assumes greater importance for the distillery and the co-generation plant. Maintenance of water quality shall be ensured for both feed water and boiler water within limits for proper operation of the boiler and avoiding scale or deposit formation in turbogenerators. A routine check-up of the feed water quality during the start-up of the plant and also periodic check-ups result in the elimination of any serious problem due to the water quality. Similarly, the monitoring of water treatment plant and the water quality at DM plant outlet, the water quality at the inlet of the DM plant and cooling tower is of utmost importance.

10.4.7 The modern multi product distillery like the one envisaged for GSML cannot be effectively operated without proper instrumentation and control system. An effectively designed instrumentation and control system performs the following functions:

Provides operators with the indication or record of the
instantaneous, averaged or integrated value or condition of the various operating parameters such as temperatures, pressures, flows, levels, position of valves, switches, currents, voltages, power, etc.

It also provides at convenient locations either local, remote or automatic control system to control the above operating parameters and gives alarms and even ensures automatic trip outs, when operating parameters reach beyond the normal range to the unsafe or undesirable range.

Instrumentation is increasingly taking over many functions of the operator. Its response to changing and transient conditions, its ability to anticipate, detect and discriminate faulty conditions and act accordingly is quicker and for more accurate if well designed. With the ability of the microprocessor based systems to include data acquisition and processing capabilities, the systems’ ability, to log and process periodically the plant data, is also far superior and permits more timely corrective actions. Presently some of the responsibilities of the operation section are taken over by good instrumentation. The most difficult thing to be encountered in the initial stages of plant operation is the necessity to develop in the operation staff a faith in the instrumentation. Many times the operators’ first response to a meter reading too high or too low is to disbelieve it on the ground that it may be reading incorrectly. If instruments are not checked and calibrated frequently an operator will delay taking corrective actions.

The plant operator should follow the guidelines given below:

Frequent checking and calibration of instruments
Developing a habit of cross checking instrument indications with each other to determine whether the instrument is faulty or there is an abnormal operating condition; and
Developing a habit of analysing indicated data to determine accurately what could be wrong.

10.4.8 The distillery co-generation power plant has to operate in parallel with the sugar mill's co-generation plant. Co-ordination between the two plants regarding power supply should be ensured by the distillery plant operation.
10.5 Maintenance Requirements

10.5.1 The main objectives of the maintenance section are to keep the plant running reliably and efficiently as long as possible. Reliability is impaired when a plant is thrown to forced and unforeseen outages. This aspect assumes greater significance in the distillery, since the profitability of the distillery entirely depends on the product output and the quality of the product.

10.5.2 Efficient operation implies close control not only over the cost of production but also over the cost of maintenance. There are two components in maintenance cost, one is the direct cost of maintenance i.e., the material and labour and the other is the cost of production loss.

10.5.3 There are two categories of maintenance work. One is the irksome breakdown maintenance, which is expensive. Much as it is desirable to avoid or minimize this, its existence must be accepted. Secondly, it is the preventive maintenance with proper planning and execution of plant and equipment overhauls. This maintenance activity should be clearly planned with regard to the availability of material and labour. It is also essential to develop proper inspection procedures with non-destructive testing methods. Such inspections, by trained personnel reveal defects not necessarily detected by mere visual inspection.

10.5.4 The following help in reducing the breakdown maintenance and also help in planning for preventive maintenance.

   Careful logging of operation data/historical information from the DCS and periodically processing it to determine abnormal or slowly deteriorating conditions. Walk down checks of the plant.

   Careful control and supervision of operating conditions.
   Careful control of the raw material and products to ensure quality output.

   Regulate routine maintenance work such as keeping equipment clean, cleaning heat exchangers, filters,
effectively executed lubrication program, effective operating supervision over bearings, commutator or slip ring brushes, mechanical seals, vacuum systems etc.

Correct operating procedures.

Frequent testing of plant equipment to determine internal condition of equipment such as heat exchanger and pump performance tests, generator and turbine shaft vibration tests, turbine lube oil testing, etc.

Close coordination with the manufacturers to effect improvements in plant layouts and design, use of better material, introduction of such facilities as cathodic protection, use of better protective paints, etc.

10.5.5 It is extremely important that proper records are maintained not merely for the maintenance work done but also of the material used and actual man hours spent, etc. Some sort of a card system shall have to be introduced to keep records that are most useful in future planning of outages and providing for effective control.

10.5.6 Another important requirement of a good maintenance program is to ensure that spares are ordered in time and good stocks of the frequently required spares are maintained.
11. MANPOWER AND TRAINING

11.1 General

11.1.1 Growth of industrial activity in the country in general and in particular the growth in the sugar, distillery and power generation industry, has brought about shortage of skilled and trained manpower. Hence, it is essential that the manpower requirement for the new distillery plant is well planned and a proper program of recruitment and training is thought of at the beginning stage of the project itself. **The Plant, operating and maintenance personnel must be trained and available before the plant commissioning commences and therefore, it is essential that appointments are made well before the programmed plant commissioning date.** The staffing and the organizational structure should be decided considering the specific requirements of the plant operation and the company practices.

11.1.2 The recruitment of the personnel required must be based on the rational assessment of the following factors:

- a) The nature of the plant and machinery i.e modern distillery with multi product system, evaporation system, spent wash fired boiler, in house power generation and distribution etc.,
- b) Socio economic conditions.
- c) Availability of personnel with the right background and experience.
- d) Company’s policy regarding recruiting permanent labour and contract labour.
11.1.3 Once the staffing is finalized and agreed, a suitable training scheme shall be programmed and implemented. The objective of the training program must be to equip each and every individual to carry out his particular function with skill and confidence. The training program shall be based on the classification of the main functions as Operation and Maintenance, and within this main classification, designed to cater to engineers, supervisors, skilled workers, etc.

11.2 The organisation proposed for GSML’s 60 KLPD Distillery assumes that the distillery will have a Manager in charge of complete distillery operations, who will be assisted by the Senior Engineers in charge of process operation, Maintenance, Utilities, Procurement and administration. The Distillery Plant Manager will be reporting to the Factory Manager.

The staffing recommended here takes care of the operation, maintenance, procurement, administration and record keeping for the entire plant. There could be some overlapping of functions between the staff of various sections; however the responsibility of each group will be well defined. The drawing No.4-15003-800-0012 gives the organization chart proposed for this project.

11.3 The Senior Engineer process operation will be responsible for the various sections of the process plant operation for the three shifts, including the spent wash concentration system. The Distillery plant laboratory will be under the control of the Senior Engineer - process Operation. The Senior Engineer Utilities operation will be responsible for the operation of boiler & auxiliaries, water treatment plant, fuel systems, Turbo generator, cooling tower, compressed air system etc. Since the plant is having good amount of instrumentation, it is necessary to have one Instrumentation Supervisor, common for both process area and utility area, for each shift for the operation.
11.4 The Senior Engineer - process Operation will have the following persons assisting him for each shift operation.

- Supervisor - Instrumentation (1)
- Plant Operators - Fermentation Area (2)
- Plant Operators - Distillation and Evaporation area (1)
- Laboratory & ETP - Chemist - (1)

11.5 The Senior Engineer - Utilities Operation will have the following persons assisting for each shift operation.

- Boiler Operator - (1)
- TG and Electrical Supervisor - (1)
- Auxiliary system Operator - (2)

11.6 The Senior Engineer - Sales & Procurement will take care of the procurement of Molasses, Chemicals, Product despatch, procurement of fuel, procurement of spares etc. In addition he will be responsible for co-ordinating with Excise authorities, plant stores and also transportation of goods. He will be assisted with the following persons in the general shift. Contract labour will be utilized for loading, unloading operations of the materials coming into the plant and going out the plant.

- Store Keeper
- Loading Operator

11.7 The Distillery plant will have a separate Senior Engineer to take care of the maintenance of the plant. However, the facilities of workshop, electrical repair shop, instruments, tools, etc. could be common between sugar plant maintenance and distillery plant maintenance group. The Senior Engineer / maintenance will be assisted by the following persons for all the three shifts.

- Mechanical Technician (2)
Electrical Technician (2)
Instrumentation Technician (2)

11.8 The Quality Control and effluent monitoring cell is an important section, which serves both the operating and maintenance sections by providing useful feedback to the operating staff and valuable information to the maintenance staff on the performance and the healthiness of the various equipment. The major responsibilities of this cell are:

a) To collect the daily operating data from the DCS system in the control room.

b) To analyze the daily plant performance data to detect departures from normal expected performance and to keep track of trends indicating gradual deterioration.

c) To establish from the design and plant acceptance test data, as well as after-overhaul test data norms against which day-to-day performance can be monitored.

d) To carry out frequent tests on the plant and individual equipment to determine their internal conditions to help maintenance scheduling.

e) To investigate special problems as and when they arise.

f) To monitor the quality of product and advice the process section for adjusting parameters.

g) To monitor the effluents and advice the process section and utilities section for achieving zero effluent discharge.
The analysis and the data provided by the quality control and effluent monitoring cell, enables plant operation and maintenance personnel to take suitable corrective actions promptly and with proper priorities.

11.9 The documentation of the engineering office is in the charge of the Senior Engineer - Quality control and effluent monitoring cell reporting to the Distillery Plant Manager. He is responsible for maintaining the master copies of all the technical documentation of the process area and utilities area. The Senior Engineer in charge of quality control and effluent monitoring cell will be assisted by one Designer for the functioning of the section.

11.10 The distillery will have a full fledged plant laboratory for the process and utility area. The plant laboratory will analyse the raw material, products, water quality in addition to growth of culture etc. There will be one Chemist for each shift, discharging the function in the laboratory, reporting to the Senior Engineer - process Operation.

11.11 Few labour contractors could be registered with a Company for meeting the surge load requirements of the operating and maintenance group to handle major break down / maintenance work. In addition to the above, sufficient number of contract labourers may be required for assistance in ash disposal, fuel feeding, cleanliness operation, loading and unloading etc.

11.12 The GSML’s main plant complex Administration Officer will take care of the Administrative activities, Services, Accounts, Finance, Personnel, Legal, Security, Statutory authority cooperation etc. For the distillery, the proposed Organization does not consider a separate functioning of administration section, since it will be taken care of by the main factory. The service activities like Secretaries, Office Assistants, Security, Driver etc could be on contract basis to be administered by Administration Officer of the main factory.
11.13 It is necessary that GSML identifies the Plant Manager for the distillery at the start of the project itself so that he will be associated with the project during the initial stages of finalisation of the packages and the project execution by the Contractor. It is also necessary that the Plant Manager is assisted by Two Mechanical and One Electrical cum Instrumentation Engineer during the course of the project execution so that these Engineers could assume Senior Positions, later in the Distillery Operation. The other operating staff should be recruited three months before the scheduled commissioning of the distillery so that all the operating staff will be in position and will be ready to assume charges right from the commissioning of the project.

11.14 Training

11.14.1 The major objectives of the operational training shall be to acquaint the operators of the following:

- The nature, purpose and limitations of all plant and equipment.
- The detailed operating instructions of each section and equipment of the plant.
- Normal start up and shutdown program for the unit.
- The emergency procedures.

11.14.2 The basis for the training shall be the Plant's operating and Maintenance Manuals, which are compiled from the manufacturers' instructions, the contract documents and the drawings. In addition, the information gathered from the visits to the other operating plants and to the manufacturers works shall also be included in the training. Supervision and co-ordination of the training program requires full time attention of a senior executive of the plant, and the consultant's assistance may also be taken. The training program shall include lectures, expositions by experienced plant operators and maintenance personnel, informal discussions and visits to operating plants and manufacturer's works. The training programme shall
also include training provided by various vendors to the GSML's operating personnel, during erection and commissioning of the plant and machinery of the distillery plant.

11.14.3 The maintenance training program should be based on the requirements of the individual maintenance functions, like mechanical, electrical, instrumentation etc. The engineers and the technicians should be sent to the manufacturers' works to witness the production and be associated with the erection of the plant and machinery.

11.15 The plant should be equipped with proper measuring/testing instruments for the periodic cross checking of parameters displayed in the control room monitors and plant area local gauges. Logging of data and periodic review of the plant operation, review of failures, break downs, etc. should be done to improve the availability of the plant. The proposed DCS based control system takes care of almost all the above requirements.
12.0 PROJECT IMPLEMENTATION AND SCHEDULE

12.1 General

12.1.1 The most essential aspect regarding the implementation of this “Zero Liquid Effluent discharge” Distillery complex consisting of 60 KLPD multi product distillery with 2.2 MW Co-generation power plant is to ensure the project completion within the schedule, spanning for Sixteen (16) months from the date of ordering of the main distillery and the spent wash fired Boiler (1st December 2015) which are long lead items for the project. While financial closure, permits and statutory authority clearances are being processed, final tender documents could be floated for Distillery and the spent wash fired boiler after completing the basic design. The distillery project could be commissioned by 1st April 2017.

12.1.2 With the final Detailed Project Report available by end June 2015, GSML could initiate actions for the tying up of the finances for the project. It is expected that the financial closure, permits & statutory authority clearance could be obtained within a period of four (4) Months from the date of completion of the Project report. The basic design and the tender documents preparation for the long lead items could start in August 2015 so that the ordering of the main equipment could be done in December 2015. The layout of the plant and machinery has been so chosen that the installation of the equipment for the Distillery plant could be carried out in an independent area near the sugar plant.

12.1.3 A good planning, scheduling and monitoring program are imperative to complete the Distillery project along with 2.2 MW co-generation power plant on time and without cost overruns.

12.2 Project Team

12.2.1 The successful and timely implementation of the project and the avoidance of overspending and frustration depend on the performance of the project team. This project team shall be formed within the
company and will be assisted by the consultancy organisation. This project team shall be directed by a Project Manager, who has experience in the implementation of similar projects. The engineers from this group should be involved from the early stages of the execution of the project, right from the engineering and procurement stages of the project. This would give them ample opportunity to familiarize themselves with the equipment and the systems being procured.

12.2.2 Subsequently, at the time of installation at site, these personnel should be involved with the critical phases of installation and commissioning. These engineers should also be trained at the distillery plant & machinery manufacturer’s works and or at similar plants operating elsewhere. After the plant has been commissioned, these engineers would occupy key positions in the organizational structure for the operation and maintenance of the plant. This approach ensures a smooth transition from engineering and procurement to erection and commissioning and finally to operation and maintenance.

12.2.3 The responsibilities of this project team shall be:

a) Plan and program all the work and resources required for the project completion.
b) Project engineering and co-ordination involving the Design of the plant, plant support systems and the inter-package engineering.
c) Co-ordination with various vendors and furnishing data at terminal points.
d) Inspection of the major items and expediting.
e) Organize the construction and commissioning of the plant by progressively integrating individual systems.
f) Monitor and control the project progress with regular interactions and co-ordination.
12.3 Contract Strategy

12.3.1 The first step to be taken in the execution of the project is the constitution of an appropriate project organization, as discussed above, which would be responsible for the execution of the project. The development and the size of the project organization must be based on the tasks that need to be performed in the project. For a Distillery complex project the following are the identified important phases. These phases are not mutually exclusive and some degree of overlapping is envisaged.

Appraisal of the Project Report by Financial Institution.
Financial Closure
Statutory authority clearances.
Planning, marketing of the products and outlets.
Procurement of Packages including Inspection and Expediting.
Inter-package Engineering.
Project management
Construction Phase.
Commissioning and performance testing.

12.3.2 The plant should form an effective Project management group within their organization for the project execution involving the above mentioned phases of the project. The consultancy organization shall take care of the procurement, inter-package engineering, project engineering and will technically assist the project team in the other activities.

12.3.3 The nature of the project calls for the division of the project into recognizably discrete plant areas with specific terminal points that can stand alone for engineering and contract purposes. An appropriate contract strategy involves, the decision on the number and the type of contracts to be let, vendor evaluation, formulation of contract agreement defining respective obligations, the basis for discharging them and remedies for default.
The major points to be considered in packaging are:

The packages proposed are compatible, which ensures adequate competition in bidding and consequent procurement at optimum cost either within the country or from overseas vendors.

The packages include such combination of equipment and services that can be advantageously engineered for the preparation of specifications for bidding and subsequent design including manufacture/construction.

The packages formed are mutually exclusive as well as collectively exhaustive.

The number of packages and their sizes are optimum for effective implementation.

The terminal points of each of the packages are clearly defined and proper tie-ups of these points between the packages are ensured.

12.3.4 The following gives the tentative list of contract packages for this project. Each package is an EPC package, wherein, the responsibility of engineering, procurement and construction is left to the vendor with guarantees for each package clearly defined. The package route also gives an advantage in choosing the vendor considering the availability of after sale service, spare parts, factory preferences and technical support from the vendor.

Distillery process area with fermentation, distillation, evaporation, electrical within the process plant area and Product storage sections.

Condensate & Spent Lees treatment and polishing.

Spent wash fired boiler and auxiliaries

2.2 MW co-generation TG with its auxiliaries

Balance of plant mechanical system consisting of plant piping system, product and daily storage tank for the distillery,
distillery building structures, Air conditioning & ventilation system, piping from boilers/TG to distillery process area, utility piping up to distillery battery limit, fabrication of tanks for the utilities, fire fighting system etc.

Balance of plant electrical system consisting of transformers, Electrical distribution, MCC, PCC, cables, lighting & installation package
DCS for the process and utilities and Balance Of Plant (BOP) Instrumentation Package
Civil works package

12.3.5 Preparation of the Tender Specifications, obtaining offers from qualified bidders, technical and commercial evaluation of offers, finalization of the vendor, formulation of the contract agreement, contract reviews, vendor drawing review and approval etc. are the major activities for each of the packages. The scope of the package vendors will be the design and engineering, procurement, manufacturing, inspection, testing, transportation to the site, installation and commissioning & performance guarantee of the respective packages.

12.3.6 The specifications for major equipment like the spent wash fired boiler, turbogenerator, cooling towers, Distillery process area equipment etc., technical information of which is essential to the development of the plant design and in particular to the civil design, shall be drawn up at an early stage of the project. Program of design information submission from the mechanical and electrical contractors that satisfies the overall project schedule shall be drawn up. The most important among such information are the location of the individual plants, floor loading, support requirements etc. which are required for the civil design.

12.3.7 Since the project execution calls for closer coordination among the contractors, consultants and the power plant, proper contract coordination and monitoring procedures shall be formulated. Detailed bar charts or networks shall be made to plan and monitor the project progress. Contract drawings and documents requiring approval from
statutory authorities shall be clearly identified and scheduled so that the procedural formalities do not affect the project progress.

12.3.8 Procurement

12.3.8.1 Procurement is an important function in the implementation of the Project. The procurement of the systems equipment and services will be through a series of suitably packaged contracts as outlined earlier. The Project team with the consultants floats the enquiries with the appropriate commercial conditions, delivery requirements, guarantees etc. to renowned suppliers. The technical specifications for the procurement of the equipment and systems will be provided by the consultants.

12.3.8.2 Evaluation of the offers is done by the consultants, with coordination form other related members of the project team, based on the evaluation criteria stipulated in the tender documents. After evaluation and taking a decision on placement of the order, the contract agreement with commercial terms and conditions, delivery schedule and guarantees etc. are drafted and purchase order placed on the selected bidder. Once the purchase order is placed, the project team follows up regularly to ensure smooth and timely execution of the contract and for obtaining technical information for the inter-package engineering. The procurement activity includes the review of the vendor drawings by the consultant/project team, expediting, stage and final pre-delivery inspection, supervision of installation and commissioning.

12.3.8.3 When the contract for the packages are awarded, detailed program in the form of network are tied up with the contractor to clearly indicate the Owner’s obligations and the supplier’s responsibilities. The factory inputs are in terms of land availability, construction power and water availability, civil fronts, etc. while that of the contractors are in terms of drawing submission, manufacture, supply, transportation, erection and commissioning. The progress for each work package against the schedules drawn up is evaluated regularly. Such evaluation indicates the causes for the delay, if any, in meeting
the schedules and identifies actions to be taken for rectifying the delays.

12.3.8.4 To expedite supplies from the contractors, regular visits to the supplier's works will have to undertaken by the project engineers/consultants. The manufacturing program and the quality plans finalized at the time of contract award are utilized by the engineers for the monitoring of the manufacturing and quality status. Regular reports shall be prepared indicating the schedule variations, if any, their likely impact on the delivery schedule and the recommendations to meet with the schedules.

12.3.9 The Construction Phase

12.3.9.1 This is the critical phase of the project where work progresses in almost all the fronts. The erection and commissioning phase of all the contracts proceed simultaneously and it is important to ensure that the various contractors have adequate facilities and are established on the site in time to meet their programmed commitments. Adequate power and water shall be made available for the construction.

12.3.9.2 The construction manager from the Distillery plant side takes the overall responsibility of the site, assisted by the resident engineer from the consultant's side. The construction team's key task is to continuously monitor the site progress against the agreed program and to initiate whatever corrective action is necessary to maintain satisfactory site progress. During the execution stage of the project at site, quite a few of the various contracts progressing simultaneously are interrelated and hence, the delay in the activities of one contractor will invariably affect the progress of the other contractors and ultimately the project progress.

This aspect emphasizes the importance of progress review, project monitoring and timely remedial measures, for the smooth and 'within the budget' execution of the project.
12.3.9.3 Certain basic responsibilities of the construction management are:

a) The contractors shall be encouraged to give the earliest possible warning of actual or potential difficulties.

b) Ensure that the senior management in the contractors' organisation are made aware of the serious problems at an early date.

c) Provide a focus for early discussion of any potential problem and possible remedial measures, while clearly maintaining the contractor's responsibility for recovering delays.

d) Help to foster a climate among all concerned that no extension of site deliveries and erection schedule are allowable.

12.3.9.4 A fortnightly progress review meeting will be held with each contractor, where formal reports are tabled, giving an agreed progress statement. From these agreed progress statements, an accurate prediction of the state of the project is available which helps the construction team to adjust, if necessary, the activities of the particular contractor and also the activities of any affected contractor.

12.3.9.5 Major problems such as non-availability of drawings, clarifications, documents from various disciplines of engineering group, non-receipt of required materials from the various contractors, reasons for the default, remedial measures initiated, impact of such delays on the project progress will be taken up and resolved in the progress review meetings.

12.3.9.6 Interface problems among engineering, contracts and site groups of the Owner/Consultant and between the factory and the contractors affecting the project progress will also be reviewed and appropriate decisions taken to expedite the release of drawings, materials and such other requirements.

12.3.10 Plant Commissioning

12.3.10.1 The commissioning phase in a project is the one where the design, manufacturing, erection and quality assurance expertise are put to
test. The commissioning team for each plant will consist of representatives from the contractor, consultant and the power plant. As discussed earlier, it is essential to associate the staff identified to operate the plant in the commissioning stage itself.

12.3.10.2 When construction work is complete, the checklists, designed to ensure that the plant has been properly installed and appropriate safety measures have been taken are gone through and all the documentation pertaining to the statutory inspections and approvals are presented, the commissioning team shall take over. The commissioning team will follow scrupulously the commissioning and operating instructions laid down by the plant & equipment manufacturer/supplier, to prove that the plant/equipment is in every respect, fit for service. The plant shall be subjected to a performance test, after the stipulated trial operation and the reliability run. After the successful completion of the performance test the plant will be taken over by the power plant.

12.4 The Responsibilities of the Factory

12.4.1 Since the Distillery project is coming up adjacent to the sugar plant, it is important that the area identified for the Distillery plant is cleared for the early start of the civil work. The soil investigation and site grading shall be taken up in the very beginning so that the civil work can proceed without any hindrance. The site development shall include the levelling of site, clearing the site for construction of the Distillery process section buildings, identifying or constructing adequate storage space, providing lighting, water connection, construction power in the work area, etc.

12.4.2 It is essential that before the Zero Date of the project all the clearances from Government & statutory authorities are obtained. It is also essential that uninterrupted fund flow is ensured for the successful execution of the project on schedule.
12.5 Project Schedule

12.5.1 The Fig-12.1 gives the overall project schedule in the form of a bar chart. This schedule envisages the project commissioning and synchronization in Sixteen (16) months from the date of ordering of the Spent wash fired boiler and the distillery process plant.

12.5.2 For the major packages, the schedule includes the following applicable activities. The time period requirement for these activities has been included in the periods shown against each package.

a) Basic Study
b) Tendering
c) Receipt of offers, evaluation, discussions and Purchase order placement.
d) Manufacturing and delivery
e) Erection and other work at site
f) Commissioning, trial run and testing

12.5.3 In the Distillery plant and the Spent wash fired boiler are the long lead items and the planning of the schedule for the project implementation should provide adequate time period for the installation of these equipment.

12.5.4 Once the project gets started, it is essential that a more detailed bar or network chart is prepared incorporating all the contract activities, so that the planning and the monitoring is effectively carried out.
## GOBIND SUGAR MILLS LIMITED
**PROJECT SCHEDULE FOR MOLASSES BASED 60 KLPD DISTILLERY WITH SPENT WASH INCINERATION**

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
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<th>2017</th>
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13.0 PROJECT COST ESTIMATE

13.1 Methodology of Cost Estimate

This section of the Detailed Project Report gives the project cost estimate for the proposed 60 KLPD multi product distillery with spent wash concentration and incineration boiler system and a 2.2 MW Cogeneration power plant at GSML’s proposed distillery plant. This section also gives the financial analysis based on the cost estimate and expected revenues from the distillery operations. The distillery and the utilities will be located as discussed in the earlier sections of this report. The project will be executed through the package route and not through the EPC route. The cost estimates are based on the recently finalized orders for similar plant and equipment and from the data bank of Avant-Garde.

The costs indicated in this section include all taxes and duties and erection and commissioning.

Tables 13.1 and 13.2 give the estimate of the project cost. The Table 13.1 cover all the works costs for the project. Table 13.2 gives the total project cost inclusive of the pre-operative cost, interest during construction and the working capital margin.

The works costs are divided into civil, mechanical and electrical. All the commissioning spares required for the commissioning of the project are included in the cost. However as the two year operational spares are not capital items, they have not been included in the cost estimate. The cost of the two year operational spares will be approximately 2% of the equipment costs.

13.2 Cost of Civil Works

The cost of civil works include the cost of survey and soil investigation, cost of all the plant buildings, equipment foundations, pipe rack and conveyor foundations, cooling tower, RCC chimney for the spent wash fired boiler and its foundation and drains and trenches. The civil cost also includes the approach road to the
distillery plant equipment. Considering the topography of the proposed site, cost of site grading and levelling is included in the civil works cost.

Piling has been envisaged for critical and major foundations and the rest of the foundations are designed with footings. Separate raw water reservoir for the storage of the plant's requirement of the raw water is envisaged for the distillery. The water for the distillery will be drawn from the deep bore wells, the source from which water is drawn for the existing sugar mill operations and stored in the raw water storage tank.

The civil works cost does not include the cost of land for locating the complete distillery plant as adequate land is available near the sugar factory premises and is already identified for the location of the multi product distillery complex. The civil cost does not consider any non-plant buildings like a new administration office, temporary site offices and staff quarters, temporary stores, vehicle parking sheds, etc. No separate workshop or stores is considered in the project cost as the existing facilities of the sugar mill will be used for the distillery plant also. However, a separate laboratory has been considered for the distillery.

The civil work quantities and the cost of civil works given are only estimates and will have to be suitably modified and firmed up after the equipment supply is finalized and adequate data regarding the loading and dimensions of equipment are available from the manufacturers and suppliers during the engineering stage, and also on the actual soil conditions encountered at different stages of construction.

The Cost of civil works is estimated to be Rs.1463.40 Lakhs.
13.3 Cost of Mechanical and Electrical works

The cost of the mechanical equipment include the process sections of distillery, spent wash concentration plant, cooling towers and cooling water system, spent wash fired steam generator & back pressure turbogenerator, electrical panels, plant lighting, earthing, laboratory equipment etc. The distillery process plant, spent wash concentration plant, spent wash fired boiler and turbogenerator are the major ones in the project and have substantial influence on the cost of the project. The costs for the above are based on the recently finalized orders for similar equipment.

The distillery plant cost includes the cost for fermentation section, distillation section, spent wash concentration section and storage of the product and raw material. The distillery can produce RS, ENA and AA in any percentage mix depending on the market demand. The impure spirit or Technical Alcohol and fusel oil will be the by products. The CO₂ generated in the fermentation section could be utilised by installing a bottling plant consisting of cleaning and drying system for the Carbon-di-Oxide gas emanating from the fomenters. This carbon-di-oxide has a variety of uses in the food & beverage industry, welding and pharmaceutical industries etc. However, this report does not include the addition of the Carbon-Di-Oxide plant to the distillery. As such it is envisaged that the Carbon-Di-Oxide produced in the distillery will be let out to the atmosphere downstream of the CO₂ scrubber in the fermentation section.

Included in the cost of the spent wash fired boiler are the auxiliary systems like the fans, boiler feed water pumps, deaerator, dosing system, desuperheating system, pressure reducing and desuperheating stations (PRDS) for meeting with the process steam requirement, piping, instrumentation for the complete boiler package etc.

The cost of the turbogenerator includes the cost of all its auxiliary systems like lube oil system including the emergency lube oil system, governing system, turbine and generator control system, generator
protections etc., The power generation is at 415V from the turbogenerator for power distribution within the distillery.

The cost of the auxiliary fuel, which is bagasse in this case of GSML and the ash handling systems are separately included in the cost estimate. The fuel handling system will be with belt conveyors and slat chain conveyors and the fly ash handling will be based on the dense phase pneumatic handling system. The main fuel storage yard for the bagasse generated in the sugar mill be just adjacent to the distillery complex and hence the fuel handling system for feeding the bagasse to the spent wash fired boiler will be a simple system.

For the supply of the cooling water to other auxiliaries of the plant like the oil coolers, generator air coolers etc., a Cooling tower is included in the project. This cooling tower will be of RCC construction and will be of the counter flow type. The cost of the cooling tower, the cooling water pumps and the piping from the cooling water pumps, to the various equipment and the return piping from the equipment to the cooling tower are included in the cost estimate. This will be in addition to the process cooling towers which are already included in the process plant.

In the distillery and for the spent wash fired boiler, the supply of treated good quality water to the boiler and distillery is an important factor for the reliable operation of the plant. This calls for a suitable water treatment plant which will supply the treated water to the boiler and distillery to the required quality. The necessary membrane system based water treatment plant is included in the cost estimate.

Also included in the cost of the mechanical systems are the cost of the Air-conditioning and ventilation system, fire fighting system, compressed air system for providing the service and instrumentation air for the distillery, the piping system with in the battery limits of the distillery, all the tanks for the storage of the treated water, tanks for storage of final products (ENA, IA, Fusel oil and impure spirit), a hand operated overhead travelling crane for the maintenance of the turbogenerator etc.
At present GSML is having six molasses storage tanks with an aggregate storage capacity of 25860 MT. Another new tank with the capacity of 7500 MT will be added, in the distillery complex, for the molasses storage and the cost of this storage tank is included in the estimate.

The costs of all the electrical equipment are estimated, in the same way the cost of other mechanical systems is estimated. For the cost estimate for the electrical items in house data of Avant-Garde and the data based on similar projects have been used.

The power generation in the proposed back pressure 2.2 MW TG will be at 415 V level in the distillery. However, the turbogenerator in the distillery will be paralleled with the 30 MW Cogeneration plant in the sugar mill to have flexibility in the operation of the plant. The generated power will be stepped up to 11 kV for paralleling with the co-generation plant TG. The project cost estimates include transformer, cabling, protection system, etc. The internal power distribution for the distillery, spent wash evaporation etc., and plant is considered in the project cost estimate. All the cost towards the distribution transformers, Power control centres (PCC), Motor Control Centres (MCC), Variable Frequency Drives (VFD) for meeting the internal power requirements are included in the cost estimate. Judicious use of the VFDs have been made to reduce the internal power consumption of the plant.

The cost of cabling from the co-generation plant to the distillery and protection devices required are also included in the distillery plant cost estimation.

The plant operation and control is envisaged through a well designed Distributed Control System (DCS). All the field instrumentation is included in the scope of the individual package suppliers. The package suppliers will terminate the signal cables at the I/O rack of the DCS. The scope of the DCS system supplier will be to take the signals at the I/O racks, process the signals and give the output signals at the I/O racks for the individual package suppliers to take the same for operation of the control elements in the field. The cost of the...
complete DCS system along with the cost of the balance of plant instrumentation is included as part of the cost estimate for the project.

The cost of mechanical and electrical works are estimated to be Rs.6818.00 Lakhs and Rs.610.00 Lakhs respectively. The cost of the controls and Instrumentation works is estimated to be Rs.350.00 Lakhs. The miscellaneous fixed assets is estimated to be Rs.45 Lakhs. The total works cost for the complete 60 KLPD distillery plant with the spent wash incineration systems works out to be Rs.9286.40 Lakhs.

13.4 Contingency

The project implementation is expected to be completed in about 16 months. There could be some escalations in the cost because of the escalation in the price of the commodities. As the detailed engineering is not yet completed, the budgetary specifications used for getting the budgetary quotes are likely to undergo some changes when the purchase specifications are issued after the detailed engineering of the project. To accommodate all such variations, a contingency provision of 3% is made on the non-firm costs (all the costs estimated are non-firm at this point of time). The calculated contingency for this project is Rs.293.00 Lakhs.

13.5 Project Financing

GSML will be approaching some of the financial institutions and Sugar Development Fund (SDF) for the funding of this ethanol distillery and spent wash incineration Cogeneration projects. As GSML is part of the Adventz Group, many of the Financing Institutions may be interested in funding this project. The actual terms of the funding will have to be decided at that time of finalization of the funding agency. The funding norms of SDF are furnished in the policy laid down by SDF. For the purpose of this Detailed Project Report, GSML has assumed the following with regard to the funding.
For the molasses based ethanol distillery projects producing anhydrous SDF will fund a maximum of 40% of the equipment and civil costs.

The SDF loan will be available with an interest rate of 6.5 % and with a moratorium period equal to the term loan repayment period. The SDF loan will be repaid after the term loan is repaid and in ten (10) half yearly instalments.

The Debt Equity Ratio is assumed to be 1. The SDF loan will be considered as Quasi equity. The promoters' equity shall be a minimum of 10% of the project cost.

It is assumed that the interest rate on the term loan will be 12.5%.

The maximum loan repayment period inclusive of the moratorium will be eight (8) years. It is also presumed that the moratorium period will be two (2) years and the moratorium period starts from the first loan disbursement. The repayment will be in twenty four (24) Quarterly instalments.

It is also assumed that the disbursement of term loan and SDF loan will be made available only in the third quarter after the project "zero" date. As the processing of both the term loan and SDF loan takes time and based on the past experience, this assumption is made. To meet with the project fund flow requirement, apart from pumping in the equity, the company will have to make some arrangements for a bridge loan. It is assumed that the cost of bridge loan will be same as that of the term loan and the interest is included in IDC and capitalized.

13.6 Other costs

13.6.1 Preliminary expenses.

Preliminary expenses include the cost of the initial studies, Environment Impact assessment studies, statutory authority
clearances, project management, travel, third party inspection charges, training, plant start up and all such expenses prior to the start of the project itself.

The preliminary expenses also include the site clearances, arranging construction power and water requirements for the various contractors, arranging space (both open and covered) for the storage of the equipment and materials at the site and space for the prefabrication for the various contractors, arranging site communication facilities, accommodation for the visiting personnel related to this project. The estimated cost under this head is Rs.320.00 Lakhs.

13.6.2 Cost of Technical Know how and consultancy

The cost estimate provides the estimated Consultancy fees for the detailed engineering services and for the construction and commissioning supervision services for the distillery project. The estimate is Rs. 150.00 Lakhs.

13.6.3 Interest During Construction

The interest during the construction (IDC) period is capitalized to calculate the total project cost. The rate of interest considered in the computation of the IDC is 12.5% for term loans from the financing institution and 6.5% for the SDF loan. In the computation of the IDC, the project fund flow what is required for a project of this nature proposed for GSML is considered. The Table 13.3 gives the quarterly project fund flow and the IDC calculation, drawl of loan etc. The project construction period is taken as 16 months.

While calculating the IDC, considering the fact that the processing of the term loan and SDF loan takes some time, it is assumed that the drawl of the term loans from the Financing Institution and SDF loan sugar Development Fund will commence only from the third quarter of the project construction period. The project’s fund flow requirements for the initial period will be met with the Equity and a short term bridge loan. An interest rate of 12.5% is assumed for the bridge loan.
The IDC calculated for the proposed GSML project is Rs.390.91 Lakhs.

13.6.4 Working capital margin.

The working capital is required, to take care of the expenses, for the running of the Distillery plant, like purchase of fuel for the boiler, purchase of molasses for the distillery operations, and Repairs and Maintenance expenses. In addition the working capital is required to tied over the situation due to the non receipt of the receivables and holding the stock of finished product in the bulk storage tanks for a period of 30 days. The estimated working capital for this project is Rs.976.44 Lakhs. Seventy Five percent of this working capital will be raised as short term loans and the balance will be the margin money for the working capital. The estimated working capital margin for this project is Rs.244.11 Lakhs and this is capitalized. Table 14.7 gives the workings for the working capital requirements.

13.6.5 Cost of Arranging for the Finance:

It is assumed that the expenses towards the arranging and processing of the term loan will be One (1) percent of the term loan value. In this computation SDF loan is not considered. This also includes the legal fees and the stamp duty etc

13.7 Total Installed Project Cost

The total works cost for the proposed Distillery project is Rs. 9286.40 Lakhs. The total installed project cost inclusive of the pre-operative expenses, contingency and working capital margin is estimated to be Rs. 10738.11 Lakhs.
<table>
<thead>
<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>RATE (Rs)</th>
<th>Rs. In Lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CIVIL WORKS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Land</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Land Development, grading &amp; Leveling</td>
<td></td>
<td></td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TG Building</td>
<td></td>
<td></td>
<td>225.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Plant Buildings for the Fermentation Control Room, Electrical rooms, WTP Alcohol Issue area</td>
<td></td>
<td></td>
<td>200.00</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Foundation for the complete distillery &amp; power plant &amp; Tanks</td>
<td></td>
<td></td>
<td>550.00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Raw Water Tank</td>
<td></td>
<td></td>
<td>70.00</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Conveyor Foundations</td>
<td></td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Road and Drain Work - Land &amp; Site</td>
<td></td>
<td></td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Pipe Rack Support &amp; Cable Rack</td>
<td></td>
<td></td>
<td>68.40</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Concrete Chimney</td>
<td></td>
<td></td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL FOR CIVIL WORKS</td>
<td></td>
<td></td>
<td></td>
<td>1463.40</td>
</tr>
<tr>
<td>B. MECHANICAL WORKS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Complete distillery plant (fermentation distillation, evaporation) including Interconnecting piping, structural supports etc.</td>
<td>No.</td>
<td>1</td>
<td>3000.00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20 TPH spent wash incineration steam generator including fabric filter, fans pumps, valves and specialties, piping PRDS and other Auxiliaries</td>
<td>No.</td>
<td>1</td>
<td>1450.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 x 2.2 MW back pressure turbogenerator unit, including all auxiliaries, piping, governor turbovisory, controls and Instrumentation and electicals as per scope.</td>
<td>No.</td>
<td>1</td>
<td>350</td>
<td></td>
</tr>
</tbody>
</table>
## Detailed Project Report

**Gobind Sugar Mills Limited**

**Molasses Based 60 KLPD Distillery with Spent Wash Incineration**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate (Rs)</th>
<th>Rs. In Lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Bagasse handling system with all its accessories</td>
<td>LS</td>
<td></td>
<td>150.00</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Ash handling system for the boiler consisting of submerged scraper conveyars, for wet ash and dense phase handing system for fly ash</td>
<td>LS</td>
<td></td>
<td>120.00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Induced draft cooling tower (RCC work included in civil scope)</td>
<td>LS</td>
<td></td>
<td>60.00</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Centrifugal Pumps with base frames and electric motor drives for the cogeneration power plant</td>
<td>LS</td>
<td></td>
<td>60.00</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Steam, Water piping and valves &amp; supports from the power plant. Tanks for Molasses, DM &amp; Process water.</td>
<td>LS</td>
<td></td>
<td>325.00</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Reverse Osmosis based water Treatment Plant</td>
<td>LS</td>
<td></td>
<td>220.00</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Day receiver and Bulk Storage Tanks for the products</td>
<td>LS</td>
<td></td>
<td>400.00</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Power House EOT Crane</td>
<td>LS</td>
<td></td>
<td>30.00</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Air Conditioning system &amp; Ventilation system for the TG building, MCC room &amp; control rooms in process plant &amp; cogen. Plant</td>
<td>LS</td>
<td></td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Air Compressors for both Process and cogeneration plant</td>
<td>LS</td>
<td></td>
<td>65.00</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Fire Protection Systems for the process and cogeneration plant</td>
<td>LS</td>
<td></td>
<td>180.00</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Laboratory</td>
<td>LS</td>
<td></td>
<td>28.00</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Weigh Bridge</td>
<td>LS</td>
<td></td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Condensate &amp; Spent lees treatment and Polishing</td>
<td>LS</td>
<td></td>
<td>275.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL FOR MECHANICAL WORKS</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>6818.00</strong></td>
</tr>
</tbody>
</table>
## C. INSTRUMENTATION WORKS

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>RATE (Rs)</th>
<th>Rs. In Lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distributed Control system &amp; Misc Instrumentation other than those covered by other packages and UPS</td>
<td>LS</td>
<td></td>
<td>225.00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Balance of Plant Instrumentation</td>
<td>LS</td>
<td></td>
<td>125.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL FOR INSTRUMENTATION WORKS</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>350.00</strong></td>
</tr>
</tbody>
</table>

## D. ELECTRICAL WORKS

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>RATE (Rs)</th>
<th>Rs. In Lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Generator and all generator accessories including relay metering and control panels, AVR, Synchronising panel, NGR &amp; LAVT and Switchboard</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Plant Electrical Package including Transformers, cables, LT Panels, VFD Panels, contract package etc.</td>
<td>LS</td>
<td></td>
<td>500.00</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>DG Set Package</td>
<td>Nos.</td>
<td>2</td>
<td>-</td>
<td>110.00</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL FOR ELECTRICAL WORKS</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>610.00</strong></td>
</tr>
</tbody>
</table>

## E. MISCELLANEOUS FIXED ASSETS

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>RATE (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Furnitures for Office, WTP building office including computers, EPABX etc.</td>
<td>15.00</td>
</tr>
<tr>
<td>2</td>
<td>Furnitures for process control rooms and office</td>
<td>10.00</td>
</tr>
<tr>
<td>3</td>
<td>Plant Vehicles</td>
<td>15.00</td>
</tr>
<tr>
<td>4</td>
<td>Office Air Conditioning &amp; Ventilation Equipment, Lighting, s etc.</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL FOR MISC. FIXED ASSETS</strong></td>
<td><strong>45.00</strong></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL WORKS COST</strong></td>
<td><strong>9286.40</strong></td>
</tr>
</tbody>
</table>

**Notes:**
1. This works cost is inclusive of all taxes and duties.
**GOBIND SUGAR MILLS LIMITED**  
**MOLASSES BASED 60 KLPD DISTILLERY WITH SPENT WASH INCINERATION**

### TABLE 13.2

<table>
<thead>
<tr>
<th>Sh. 1 Of 2</th>
<th>Rs. In Lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 SUMMARY OF PROJECT COST ESTIMATE (Rs. In Lakhs)</strong></td>
<td></td>
</tr>
<tr>
<td>1.1 Land</td>
<td>0.00</td>
</tr>
<tr>
<td>1.2 Buildings And Civil Works</td>
<td>605.00</td>
</tr>
<tr>
<td>1.3 Plant And Machinery and Misc. Fixed Assets including foundations</td>
<td>8681.40</td>
</tr>
<tr>
<td>1.4 Preliminary expenses. *</td>
<td>320.00</td>
</tr>
<tr>
<td>1.5 Technical Knowhow Fees</td>
<td>150.00</td>
</tr>
<tr>
<td>1.6 Contingencies (~3%)</td>
<td>293.00</td>
</tr>
<tr>
<td>1.7 Front end Fee to the FI (@ 1 % of the Loan Amount)</td>
<td>53.69</td>
</tr>
<tr>
<td>1.8 Working Capital Margin</td>
<td>244.11</td>
</tr>
<tr>
<td>1.9 Total Cost Including contingency &amp; WCM But Excluding IDC</td>
<td>10347.20</td>
</tr>
</tbody>
</table>

**2.0 CALCULATION OF INTEREST DURING CONSTRUCTION**

| 2.1 Construction Period (Months) | 16 |
| 2.2 Rate Of Interest for Term Loan | 12.50 |
| 2.3 Rate of Interest for SDF Loan | 6.50 |
| 2.4 Rate of Interest for Bridge Loan ** | 13.00 |
| 2.5 Debt Equity Ratio (SDF Loan is also considered as Equity) | 1.00 |
| 2.6 Total IDC | Rs. in Lakhs 390.91 |
| 3.0 Total Project Cost Including IDC & WCM | Rs. in Lakhs 10738.11 |
| 4.0 Equity | Rs. in Lakhs 1654.49 |
| 5.0 SDF Loan | Rs. in Lakhs 3714.56 |
| 6.0 Term Loan | Rs. in Lakhs 5369.05 |

---

* Preliminary expenses include the cost of feasibility study, project Management, travels, third party inspection, training, plant start up etc.

** Bridge loan will be a short term loan to make up for the shortfall in fund flow due to late receipt of Term loans and the SDF Loan disbursements.
### Table - 13.2 (Contd.)

#### 8.0 SPLIT UP OF THE PROJECT COST: (Rs. in Lakhs):

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (Rs. in Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1 Land</td>
<td>0.00</td>
</tr>
<tr>
<td>8.2 Buildings &amp; Civil Works</td>
<td>605.00</td>
</tr>
<tr>
<td>8.3 Plant &amp; Machinery Including Misc. Fixed Assets</td>
<td>8681.40</td>
</tr>
<tr>
<td>8.4 Pre-Operative Expenses (Including IDC &amp; Front end Fee)</td>
<td>914.60</td>
</tr>
<tr>
<td>8.5 Contingencies</td>
<td>293.00</td>
</tr>
<tr>
<td>8.6 Working Capital Margin</td>
<td>244.11</td>
</tr>
</tbody>
</table>

#### 8.7 TOTAL INSTALLED PROJECT COST:

<table>
<thead>
<tr>
<th>Cost (Rs. in Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10738.11</td>
</tr>
</tbody>
</table>

#### 9.0 Project Cost Without WCM

<table>
<thead>
<tr>
<th>Cost (Rs. in Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10494.00</td>
</tr>
</tbody>
</table>

---

Date: 4/27/2015

**
### Table 13.3

**Phasing of Capital Expenditure and IDC Calculations**

I. Phasing Of Capital Expenditure (Tentative): (RS.IN Lakhs):

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Capital Expenditure</th>
<th>Equity Portion</th>
<th>SDF Loan</th>
<th>Term Loan Portion</th>
<th>Bridge Loan outstanding at the end of the Quarter</th>
<th>Interest on SDF Loan till the completion of construction (IDC)</th>
<th>Interest on Term Loan till the completion of construction (IDC)</th>
<th>Int. on the Outstanding Bridge Loan for the Quarter</th>
<th>Term Loan + IDC</th>
<th>Total Capital Spent (Equity + Loan)</th>
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<td>1</td>
<td>1000.00</td>
<td>661.80</td>
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<td>0.00</td>
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<td>0.00</td>
<td>0.00</td>
<td>21.81</td>
<td>27.30</td>
<td>523.65</td>
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<td>496.35</td>
<td>928.64</td>
<td>1244.54</td>
<td>672.33</td>
<td>42.76</td>
<td>110.19</td>
<td>10.93</td>
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<td>0.00</td>
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<td>1244.54</td>
<td>999.15</td>
<td>27.67</td>
<td>71.30</td>
<td>16.24</td>
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<td>1244.54</td>
<td>1325.98</td>
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<td>32.41</td>
<td>21.55</td>
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<td>0.00</td>
<td>928.64</td>
<td>1244.54</td>
<td>0.00</td>
<td>5.03</td>
<td>12.96</td>
<td>0.00</td>
<td>1262.53</td>
<td>2191.17</td>
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<td><strong>Total</strong></td>
<td><strong>10347.20</strong></td>
<td><strong>1654.49</strong></td>
<td><strong>3714.56</strong></td>
<td><strong>4978.15</strong></td>
<td><strong>88.03</strong></td>
<td><strong>226.87</strong></td>
<td><strong>76.01</strong></td>
<td><strong>5369.05</strong></td>
<td><strong>10738.11</strong></td>
<td><strong>10738.11</strong></td>
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</tbody>
</table>

II. Total Project Cost Including IDC & WCM

Rs. in Lakhs 10738.11

III. Equity

Rs. in Lakhs 1654.49

IV. SDF Loan

Rs. in Lakhs 3714.56

V. Term Loan

Rs. in Lakhs 5369.05

VI. Total IDC

Rs. in Lakhs 390.91

VII. Actual Debt Equity Ratio

1.00
14.0 FINANCIAL ANALYSIS

14.1 General

This section of the report gives the financial viability analysis of the proposed 60 KLPD molasses based distillery project with spent wash incineration plant at Gobind Sugar Mills Limited (GSML) located in Aira Estate in Lakhimpur Kheri District of Uttar Pradesh. The financial analysis based on the cost estimates given in the earlier section on the 'Project Cost Estimate' and on the technical data on the input and output and the operating costs discussed in the various sections of the report. The financial analysis gives the details of the operation and profitability, cash flow for a period of fifteen (15) years from the date of commissioning of the project facilities. The analysis also gives the Internal Rate of Return (IRR) for the project, Debt Service Coverage Ratio (DSCR) and payback period.

The Financial viability of the project is worked out based on certain assumptions. The Table-14.1 give the Basis for the Financial Analysis for the proposed distillery project.

14.2 Mode of Financing

The total project cost with the interest during construction and working capital margin is estimated to be Rs.10738.11 Lakhs as given in Table-13.2 of the section on 'Project Cost Estimate'. GSML has said that they will go for funding from Sugar Development Fund and a reputed financing Institution and has suggested that the financial analysis of the project is made with a debt equity ratio of 1:1. The funding from the SDF shall be treated as quasi equity. For the modernization and expansion of crushing capacity with simultaneous implementation of Cogeneration, SDF fund will be available to the extent of 40% of the cost of the plant and machinery and the civil works. The total project cost of Rs.10738.11 Lakhs will be funded
with, an equity of Rs.1654.49 Lakhs SDF loan of Rs.3714.56 Lakhs and a term loan of Rs.5369.05 Lakhs.

Based on the information provided by GSML, it is assumed that the term loan from the Financial Institution will be available at an interest rate of 12.5% and the repayment will be quarterly over a period of six (6) years with a moratorium of 2 years. The SDF loan will be available with an interest rate of 6.5% and with a moratorium period equal to the term loan repayment period. Thereafter the SDF loan will be repaid in 5 years in half yearly instalments. As seen in the earlier section of this report, it is assumed that the SDF loan and the term loan will be available only in the third quarter of the project construction period, due to the processing time. Till such time, the project fund flow requirements will be met by the equity and short term bridge loans.

14.3 Plant Operation

The proposed plant will be a multi product distillery capable manufacturing Rectified Spirit (RS), Extra Neutral Alcohol (ENA) and Anhydrous Alcohol (AA). The capacity of the plant in terms of total spirit production is 60 KLPD. Under 100% RS manufacturing mode the plant will produce 57000 Litres per day of RS. Under the ENA and AA mode of operation, the plant respectively can produce 56320 litres per day and 56000 Litres per day of ENA and AA. Under all modes of operation, the plant will also produce as by products, 3000 Litres per day of Technical alcohol and 60 Litres per day of Fusel Oil. Even though the plant is capable of operation in any mode, a product mix of 70% ENA and 30% AA is assumed for the study of the viability of the project.

The raw material for the production of alcohol is molasses. As the distillery plant will be located near the complex of the sugar mill, the entire molasses produced from the sugar operations will be made available to the distillery. The sugar mill crushing Thirteen Lakhs and Fifty Thousand (13.5 Lakhs) MT of cane per annum will produce about
60750 MT of molasses per annum. With the daily requirement of about 270 MT of molasses for the full production in the distillery and with 90% capacity utilization, the total molasses produced in the sugar mill enable the distillery to operate for a period of 250 days. However with the spent wash incineration system installed, the distillery should be operated for a longer period in a year. GSML has indicated that they could procure about 15,000 MT of molasses per annum from nearby sugar mills, apart from their own production of molasses. Considering this maximum of 15,000 MT of molasses available in addition to the 60750 MT of molasses produced by GSML in their sugar mill, the 60 KLPD distillery could be operated for a period of 310 days. The fermentable sugar in the in-house molasses is 36.8% and the level of fermentable sugar in the bought out molasses is also expected to be same.

With 310 days of operation of the distillery, the total annual molasses requirement will be 75,337.53 MT, with 90% capacity utilization of the distillery. Out of this 60,750 MT of molasses will be bought from the sugar mill and the balance of 14,587.53 MT will be procured from nearby sugar mills.

Molasses price varies round the year. It is taken that the average basic price of molasses in the plant area will be Rs.4000 per MT. It is assumed that even the in-house molasses from the sugar mill will be bought at this price of Rs.4000 per MT, to study the viability of the distillery unit as a standalone entity. There will an excise duty payment of Rs.750 per MT, both for the in-house and bought out molasses. Apart from the above there will be a cess of Rs.22.5 per MT of molasses and a molasses development fee of Rs.110 per MT of molasses. So the cost of both the in-house molasses and the bought out molasses work out to Rs.4882.50 per MT. For the bought out molasses an average transportation cost of Rs.300 per MT is also considered and hence the landed cost of in-house molasses and the bought out molasses will be respectively Rs.4882.50 and Rs.5182.50 per MT. This cost is not escalated in the viability analysis.
The distillery will generate the necessary steam and power in house. There will be no external steam or power supply for the distillery operations. As the plant is designed for zero effluent discharge, the spent wash generated in the distillery will be used as a fuel in the boiler to generate steam. The spent wash will be concentrated to approximately 60% solids (w/w) and fired in a boiler along with bagasse, procured from the sugar mill, to generate the required quantity of steam. The viability of the project is studied with this bought out bagasse as the supporting fuel for the boiler. The estimated bagasse consumption in the plant will be 5 MT per hour and the bagasse cost is assumed to Rs.1000 per MT. The high pressure steam generated in the boiler will be used in a back pressure turbine to generate the required quantum of power for the operation of the distillery. As there will be a surplus power of an average of 300 kW, and also for the purpose of providing operational flexibility, the turbogenerator in the distillery will be operated in parallel with the 30 MW Cogeneration TG in the sugar mill. In case the 30 MW Cogeneration plant is not exporting to the grid, the 300 kW of power could be used in the sugar mill for off-season maintenance or for meeting the requirements of the colony, thereby reducing the drawl from the grid or generation in the sugar plant’s DG sets.

14.4 Alcohol Production and Sales

With proposed product mix of 70% ENA and 30% AA, the plant will produce 109.99 Lakhs litres of ENA and 46.87 Lakh Litres of AA respectively per annum. In addition the plant will also produce 8.37 Lakh Litres of Technical alcohol and 0.17 Lakhs litres of Fusel oil respectively. The prevailing sale price of RS, ENA and AA are respectively Rs. 39 Rs.43 and Rs.40.5 per litre. The price of TA and FO is expected to be Rs.20 per Litre. The exportable power is assumed to be sold at Rs.5.50 per kWhr. In the viability analysis, no escalation is considered on the above indicated sale prices.
14.5 Other Input Costs:

The distillery plant uses a lot of chemicals and utilities for its operation. The chemicals are used for various applications from being a nutrient to yeast, for pH correction, cleaning, preventing scaling etc. The major chemicals are urea, Di-ammonium phosphate, sulphuric acid, anti foaming oil, nitric acid, phosphoric acid, caustic soda etc. The consumption and the cost of the chemicals are given in Table 14.1.

Apart from the various chemicals, the plant also uses a lot of raw water, Demineralised water and soft water for the process as well as for the boiler make up. The estimated consumption of the raw water is 1000 Cu.m/day. The DM plant is part of the distillery and the cost of the DM plant and its operation costs are already included in the project cost and other operating costs. Even though the raw water is going to be pumped from the bore wells, to cover the cost of pumping and any possible charges to the government a cost of Rs.2 per Cu.m is considered for the raw water.

Other Utilities Cost:

A provision of Rs.10 Lakhs per Annum is made towards the Cost of Balance of the Utilities, Other Chemicals & Yeast Culturing. This also includes the cost of chemicals and other consumables used in the plant occasionally or in small quantities.

14.6 Operation and Maintenance Cost

The repairs and maintenance cost for this project is assumed as 2.0% of the total works cost which comes to Rs.155.56 Lakhs per annum. In reality this cost will not be incurred in full for the first year of operation as the plant will be under warranty. Still this cost is considered for all the operating years. The salaries and wages of the operation and maintenance personnel of the plant and the administrative expenses are respectively considered as Rs.220
Lakhs and Rs.10 Lakhs per annum. No escalation is considered on all the costs for the viability analysis.

14.7 Insurance

The cost of insurance, for the distillery and the spent wash incineration cogeneration plant equipment has been taken to be 0.2% of the cost of the plant and machinery and the civil works. This cost works out to Rs.18.57 Lakhs per annum.

14.8 Escalation Provision for Various Costs and Expenses

The financial analysis does not consider any escalation on both the input costs and the output prices.

14.9 Depreciation

A straight line depreciation rate of 3.34% for the buildings and civil works and 6.33% for the plant and machinery is considered in the financial analysis. Table-14.3 gives the details. For Income-tax calculation purposes, 10% depreciation for buildings and civil works and 15% depreciation for the sugar plant’s plant and machinery, on the Written Down Value (WDV) is considered. Table 14.9 gives the details.

14.10 Estimates of Cost of production

The Table-14.4 gives the estimates of cost of production for the ethanol distillery and the spent wash incineration Cogeneration plant for fifteen (15) years operation from plant commissioning.

14.11 Sales and Profitability Statement

Table-14.5 gives the estimates of sales for the ethanol distillery plant operations. The saleable products are the ENA, AA, Technical Alcohol, the Fuseil oil and the surplus electrical energy generated in
the 2.2 MW Cogeneration plant. Table-14.6 gives the working results (Gross Profit) for the plant operations. Table-14.8 gives the calculation of the Net Profit for the plant operation. Table 14.7 gives the computation of the working capital requirements, as given in the earlier section on the "Project Cost Estimate". The interest for the working capital loan is taken as 14%. An amount of about 25% of the total working capital requirement is considered as margin money and the balance is considered as loan from banks.

Provision is made for Income Tax in the analysis of the profitability. A tax rate of 30% with 5% surcharge and 3% Cess is considered for the taxable portion of the profit. Minimum Alternate Tax rate of 18.5% with 5% surcharge and 3% Cess is taken to compute the MAT obligations. Table-14.10 gives the work out for Income-tax liability for the Distillery operations.

14.12 Cash Flow

The detail of the estimated cash flow generated by the project operations over a period of fifteen (15) years is given in Table-14.11.

14.13 IRR, DSCR and Payback

Table-14.12 gives the working of the Project Internal Rate of Return (IRR) and The Debt Service Coverage Ratio (DSCR). The project post tax IRR works out to 16.22% and the DSCR values are given for the operating years in the table. The minimum value of DSCR is 1.24 and the maximum value is 4.1 with the average of 1.84. While computing the IRR the terminal value of the equipment in the fifteenth year is taken into the calculations. Considering technological obsolescence and the fact that the plant would have served a substantial part of its useful life, it is assumed that the dismantling and selling will fetch about 50% of its original value. It is assumed that the income tax is payable on the disposal value of the equipment and the currently applicable rate of tax is used in the computations.
The Table 14.12 also gives the **Net Present Value (NPV)** considering a Weighted Average Cost of Capital (WACC) of 11.3%. The calculated NPV for this project is **Rs.3039.74 Lakhs**. The equity, SDF loan and the Institution Term loan works out to 15%, 35% and 50% of the total capital employed. The cost of equity is calculated to be 18% with a risk free return on capital of 8%, a risk premium of 9% and a Beta value of 1.11 for the industry. With the cost of Equity, SDF loan and the institution term loan at 18%, 6.5% and 12.5% respectively, the WACC is calculated to be 11.3%.

The return on Equity is calculated to be 35.51% based on the fifteen years of operation. The calculated simple payback period is 5.2 years.

### 14.14 Conclusion

GSML is an operating sugar plant with the present crushing capacity of 7200 TCD. Considering the excellent cane potential in the command area, the company is increasing the crushing capacity to 10,000 TCD. With the view of value addition to the sugar produced, GSML is planning to implement a 500 TPD sugar refinery. These sugar plant modifications and upgradation will be completed in the present off-season and the plant will start crushing at the new enhanced crushing capacity from the 2015-2016 season. The 30 MW Cogeneration plant implemented and ready for commissioning will also start operating from the ensuing season.

With the addition of the proposed ethanol distillery, one of the other valuable by product of the sugar mill, which is the molasses, will be put to better use. With the proposed distillery capable of producing both ENA and Anhydrous alcohol, the opportunities are enormous. With ethanol being touted as the future fuel of this planet, utilizing the molasses to produce ethanol will make good business sense. Even if there is a sluggish off-take of Anhydrous Alcohol for gasoline blending, the ENA will have an ever expanding
market with the ENA consumption in India posting an average annual growth of 4 to 5%. With the advent of the spent wash concentration and incineration technology, the disposal of spent wash, one of the worst nightmares of the distillery industry has been made easy. In fact the dreaded effluent is now used as a fuel for powering the distillery.

The financial analysis discussed in this section of the report indicate that the proposed distillery unit is immensely viable.
### TABLE 14 | BIAS FOR THE FINANCIAL ANALYSIS - DISTILLERY OPERATIONS

<table>
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<tr>
<td>Number of Days Distillery operation per Annnum</td>
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<tr>
<td>Operation under RS mode (100% RS from Wash)</td>
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<td>BSE (LPD)</td>
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<td>Technical Alcohol (LPD)</td>
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<td>Operation under ENA mode (100% ENA from Wash)</td>
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<td>ENA (LPD)</td>
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<tr>
<td>Technical Alcohol (LA) (LPD)</td>
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<td>Operation under AA mode (100% AA from Wash)</td>
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<td>AA (LPD)</td>
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<tr>
<td>Technical Alcohol (BA) (LPD)</td>
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<td>Fired Oil (BS) (LPD)</td>
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<tr>
<td>Rectified Spirit (RS) as % of Annual Production (%)</td>
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### TABLE 141 BIAS FOR THE FINANCIAL ANALYSIS - DISTILLERY OPERATIONS (Contd.)

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### TABLE 14.1 BASIS FOR THE FINANCIAL ANALYSIS - DISTILLERY OPERATIONS (Contd.)

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**Note:** All costs are in Indian Rupees (Rs).
### TABLE 14.1 BASIS FOR THE FINANCIAL ANALYSIS - DISTILLERY OPERATIONS (Contd.)

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<td>(Taken as 0.20% of Equipment &amp; Civil Cost)</td>
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### Table 14.1 Basis for the Financial Analysis - Distillery Operations (Contd.)

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### Table 14.2: Term Loan Repayment and Interest Schedule

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<th>Outstanding at the End of Qtr.</th>
<th>Interest For the Qtr.</th>
<th>Interest Paid for the Year for the Year</th>
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**Note:** The Interest During Construction is Capitalized.
# TABLE 14.2 - SDF LOAN REPAYMENT AND INTEREST SCHEDULE

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<th>Interest For the Half Year</th>
<th>Interest Paid Repayment for the Year for the Year</th>
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The Interest During Construction is Capitalized.
### Asset Valuation and Depreciation for the Distillery Plant

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<tr>
<th>S.No</th>
<th>Particulars</th>
<th>Basic Cost</th>
<th>Share of Preliminary Expenses</th>
<th>Share of Contingencies</th>
<th>Total Cost</th>
<th>Rate of Depreciation (%)</th>
<th>Amount of Depreciation</th>
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<td>Plant &amp; Machinery</td>
<td>806.4</td>
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<td>4</td>
<td>Misc assets</td>
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<td><strong>Total</strong></td>
<td><strong>9266.4</strong></td>
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The Prel. & Pre-Op expenses to be capitalised proportionately (Rs. Lakhs): 914.60
The Contingencies to be Capitalised proportionately (Rs. Lakhs): 293.00

Asset Value For Depreciation (Rs. In Lakhs): 10494.0

**Table 14.3 - Asset Valuation and Depreciation for the Distillery Plant**
### Table 14.4 - Estimates of Cost of Production for Distillery Operations

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<tr>
<th>Particulars</th>
<th>Operating Years</th>
<th>Raw Materials, Chemicals, Components &amp; Consumable Stores</th>
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<td>2030-2031</td>
<td>2031-2032</td>
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<td>Molasses from Sugar Mill</td>
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<td>Molasses Bought Out from Nearby Mills</td>
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<td>C. Total Labour</td>
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TABLE 14.5 - ESTIMATES OF PRODUCTION AND SALES FOR DISTILLERY OPERATIONS

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<td>6. Sale Price of RS (Rs./Litres)</td>
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<td>9. Sale Price of TA &amp; PG (Rs./Litres)</td>
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<td>12. Annual Revenue from ENA (Rs. In Lakhs)</td>
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<td>13. Annual Revenue from AA (Rs. In Lakhs)</td>
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## DETAILED PROJECT REPORT

**GOBIND SUGAR MILLS LIMITED**

**MOLASSES BASED 60 KLPD DISTILLERY WITH SPENT WASH INCINERATION**

### TABLE 14.6: ESTIMATES OF WORKING RESULTS FOR DISTILLERY OPERATIONS (PBDIT)

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### Table 14.7: Working Capital Requirements for Distillery Operations

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<td>8. Increase in Working Capital Loan</td>
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### Table 14.8 - Estimates of Working Results for Distillery Operations (Net Profit)

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### Table 14.9: Depreciation Schedule for Income Tax Purposes for Distillery Operations

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### Table 14.10 - Computation of Income Tax Liability for Distillery Operations

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### Table 14.11 - Projected Cash Flow Statement

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### TABLE 14.11 - PROJECTED CASH FLOW STATEMENT (Contd.)

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TABLE 14.12 - IRR, DSCR & PAYBACK PERIOD

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Note: ** - The Terminal Value of the Equipment is taken as 50% of the Installed Plant and Machinery cost less the Income Tax Payable.
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TABLE 14.13 - Projected Balance Sheet

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GOREN SUGAR MILLS LIMITED
MOLASSES BASED 60 KLPD DISTILLERY WITH SPENT WASH INCINERATION

DETAILED PROJECT REPORT

14.31

AVANT-GARDE
## 15.0 DRAWING LIST

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<td>Process flow diagram for distillation section</td>
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<td>Process flow diagram for Effluent Treatment Plant</td>
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<td>Power Balance</td>
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GOBIND SUGAR MILLS LIMITED
MOLASSES BASED 60 KLPD DISTILLERY WITH SPENT WASH INCINERATION

DISTILLERY
1. TRUBBED COLUMN LEVEL CONTROL
2. SUPERHEATED WASH FLOW CONTROL LOOP
3. FIREBOX COLUMN STEAM FLOW CONTROL
4. STEAM ROSE CONTROL FOR FCL
5. REHEAT HEATER TANK LEVEL CONTROL
6. MASH COLUMN IN AN ICE FLOW CONTROL
7. RICE OR BRAN TANK LEVEL CONTROL
8. ALL ELECTRICAL SERVICE INTERRUPTERS

BOILER
1. WATER LEVEL & GJDECONTROL
2. COMBUSTION CONTROL
3. MAIN STEAM EMBLO
4. DEOXYDATION PRESSURE CONTROL
5. DEOXYDATION LEVEL CONTROL
6. FURNACE DRAFT CONTROL
7. SODIUM SAFETY & PROTECTION INTERLOCK

DISTRIBUTED CONTROL SYSTEM
AT CENTRAL CONTROL ROOM
(DISTILLERY PLANT)

TURBO GENERATOR
1. LUBE OIL SYSTEM
2. COOLING OIL SYSTEM
3. FINAL COOLING SYSTEM
4. TURBINE PROTECTION & SAFETY INTERLOCKS
5. MAINTENANCE OF POWER GENERATION SYSTEM AND START-UP ALARMS

ELECTRICAL
1. SWITCH RELAY SYSTEM
2. BREAKER CIRCUITS
3. POWER JUNCTIONAL BOX
4. CONTROL PANELS
5. WEC

NOTE:
--- SIGNAL/CONTROL CABLES
--- COMMUNICATION CABLES

AVANT-GARDE
ENGINEERING & CONSULTANTS (P) LTD.
CHENNAI 600 116, INDIA.

CUSTOMER: GOBIND SUGAR MILLS LIMITED
PROJECT: MOLASSES BASED 60 KLPD DISTILLERY WITH SPENT WASH INCINERATION
OVERVIEW OF THE CONTROL SYSTEM