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6.10.3 Material Balance

Material Balance RDF & Power Plant GWMCL-ME-SCH-003 is enclosed in Annexure -I

6.10.4 Water balance

Water Balance Diagram GWMCL-ME-SCH-002 is enclosed in Annexure -I

Basic information for Design and RDF analysis are given in Annexure-II, Table – 2

6.10.5 Water Availability and Analysis

The water requirement for the plant is to be utilized from the Ground water. The consumptive water requirement for the project is 105 m^3/hr apart from the potable and service water requirement The plant potable requirement of about 20 m^3/day (Volume to be checked) will also be met from Ground water. The requirement of service water for toilets, floor washing, cleaning of trucks tyres will be about 20 m^3/day and this water shall be taken from the Ground water.

6.10.6 Power Plant Technical Details

A. Process details

RDF and Biomass are fired in a boiler, which generates steam. The steam generated from the boiler is expanded in a steam turbine generator to generate electricity. The steam turbine will exhaust steam to a condenser where it is condensed to water. The cooling water required to condense the steam in the condenser is supplied from a cooling tower using cooling water pumps. The condensed water is supplied to the Deaerator via condensate extraction pumps. In the Deaerator the oxygen present in the "feed water to the boiler" is removed and also the feed water is heated. The steam for heating the feed

water is supplied from the steam turbine extraction. The heated feed water is pumped into the boiler-using boiler feed pump.

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B. RDF / Biomass fired Boiler

The Boiler will be capable of firing fluff of RDF and Biomass at the indicated flow rates available. The RDF will be non-uniform in size, properties may vary from season to season and calorific value may vary over a wide range. RDF on combustion will have components, which may cause corrosion and erosion of heating surface. Some compartments may cause agglomeration and fouling of heating surface. Presence of SO2 / NOx will cause acid dew point corrosion. Some components may lower the ash fusion temperature creating clinker formation on the grate. All these aspects will be taken into account while designing boiler for firing RDF. The critical components of the boiler is indicated below:

Generally RDF is fired in traveling grate type boiler, however the boiler manufacturer will be given the freedom to select his design for firing RDF, provided the technology is proven for firing RDF produced out of MSW generated in Indian cities/ towns. The grate will be multi louvered type with grate bars arranged across the direction of travel. Grate bars can be designed to swivel individually at right angles to the direction of travel. This will enable the grate to be self-cleaning type so that the fines will not block the holes in the grate bars and choke the supply of primary air. Grate bars will be of corrosion resistant and heat resistant cast alloy steel. Grate speed can be varied.

The RDF fluff generated from the RDF plant will be stored in a covered area adjacent to the boiler. The Boiler is located to the east of the RDF fluff storage area. The Fluff is transferred from this storage to a Belt feeder by a grab crane, which turn feed the boiler Receiving Hopper through a belt conveyor. The hopper will be sized for 10 minutes of RDF fluff usage. This chute supplies the RDF to a drag chain conveyor which in-turn distributes the fuel to feeding chutes of the boiler. Rotary type drum feeder, located below each feeding chute, controls the feed flow. High-pressure air will be used to spread the RDF uniformly across the grate.

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The furnace will be water wall type. When firing RDF, the environment at the bottom of the furnace constantly changes between oxidizing atmosphere (excess oxygen than required for combustion) and reducing atmosphere (deficient oxygen than required for combustion). This will accelerate the corrosion of the membrane wall. Hence to reduce the corrosion the furnace bottom shall either be refractory lined internally with silicon carbide refractory or water wall coated with eutectic coating. Designing the furnace at with 2 sec retention and temperature of 850 Deg C after secondary air injection will ensure destruction of any Dioxin formed.

The Boiler will have a Gas recirculation system to recirculate the flue gas thus enabling the reduction in unburnt carbon, reduction in the excess air required. Thus provision of a gas recirculation system will increase the Boiler efficiency.

Combustion air is admitted in two stages. In the Primary stage the air is admitted below the grate / through sides. The secondary air is located above the grate to ensure better air penetration and turbulent mixing to for complete combustion. The admission of the secondary air will reduce the temperature of the combustion products thus lowering the formation of NO_x. The correct proportion of primary and secondary air will reduce CO formation.

Super heater will be located either in the convective zone or provided in the radiant zone with baffle protection arrangement to avoid erosion of tubes.

Steam drum may be single drum of bidrum type. The single drum is preferred over the bidrum since maintenance and replacement of Boiler bank tubes may be difficult.

All other pressure parts like evaporator, economizer, etc will be designed similar to conventional boilers. Soot removal can be either by steam soot blowing or by continuous rapping and hammering of Superheaters, economizers, evaporators etc. Steam soot blowing is cheaper from investment point of view but the coils near the soot blower will have to be replaced frequently due to erosion by high-pressure steam.

The boiler is designed to fire RDF and biomass. Separate burners for biomass are provided on the furnace walls.

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Other features of the boiler shall be similar to any other conventional boilers

C-1. Design considerations

The following design considerations will be taken care

i) Considering low ash IDT and fusion temperatures, the gas temperature and thus the heat transfer metal temperatures will be maintained sufficiently low (Furnace heat release rates will be low, higher furnace size for same rating.)

ii) The grate where RDF would be fired need to designed specially for firing RDF to avoid clinker formation and will have heat resistant, wear resistant properties and longer life. The grate bars will be of cast alloy steel.

iii) The combustion will be to avoid formation of NOx, CO and Dioxin.

iv) Number of passes in the boiler may be decided keeping in view of the erosion properties of the ash in flue gas.

v) The pressure parts will be so designed that corrosion and erosion are avoided by avoiding high flue gas velocities and sharp changes in direction of flow. Maximum velocity will not exceed 5 m/sec.

vi) Superheater tubes will only be of Stainless steel and seamless. No Carbon steel Superheater tube will be used.

vii) Corrosion prevention in furnace walls is an issue and hence protective coating, high tube wall thickness or refractory lining for furnace walls will be provided. But the design will be to make it maintenance free.

viii) In view of the extensive dust deposits expected on tubes, the boiler will have an adequate cleaning system in place to remove combustion dust settled on boiler surface impairing heat transfer, which ultimately affects the steam generation. Steam operated soot blowers or mechanical cleaning devices in adequate numbers may be provided so that effective removal of dust is ensured.

ix) The minimum temperature of exit flue gas temperature may be limited to 150 °C considering sulphur content in the fuel

x) It is important to keep SPM in flue gas as limited to 75 mg/Nm^3 which is much below the CPCB requirement. Number of fields in ESP will have one spare field, so that even in case of one field down condition SPM levels are maintained at 75 mg/Nm^3.

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xi) Suitable sealing arrangement will be provided in the fuel feeding system and the stoker/traveling grate for preventing cold air ingress into the furnace

xii) A Chimney of height 60 m will be provided according to the CPCB requirements

xiii) The fluff will be stored near the boiler. The fluff will be transported to the Boiler receiving hopper through belt conveyors. The receiving bin will be sized for 10 minutes requirement of fluff. From the receiving hopper the fluff will be fed to the boiler-traveling grate through boiler chutes, rotary feeders and high pressure air for spreading.

C-2. List of systems and equipment included in Boiler is indicated below:

1) Boilers drum with internals.
2) Boiler water circulation system considering of evaporator, water walls, screens
3) Complete circulating system, connecting pipes and headers.
4) Super heater system, including pipes and headers
5) Economizer systems connecting pipes and headers
6) Superheat temperature attemperating system.
7) Boiler integral piping, valves and fittings including the drain and vent piping, safety valves with silencers, exhaust piping, sampling lines and sample coolers and drain piping.
8) Fuel feeding system
9) Traveling Grate
10) Fluegas and Cinder re-injection system
11) Forced draft fan with motor - 1 X 100% capacity
12) Secondary air fan with motor - 1 X 100 % capacity
13) Induced draft fan with motor - 1 X 100% capacity
14) Complete boiler roof covering, supporting structural steel works, platforms and walkways, handrails and complete foundation bolts & anchor channels for equipment and columns.
15) Complete buck-stays and tie-bars for pressure parts system
16) Outer casing for boiler auxiliary equipment, ducting
17) Complete air and gas ductwork with necessary expansion joints, dampers, support and access door.

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18) Complete boiler refractory and insulation materials with all cladding fixing materials and reinforcements.
19) Boiler mountings including safety valves, access doors, inspection doors and peep holes.
20) Steam soot blowing system complete with all controls and instrumentation
21) Electrostatic precipitator and flue gas treatment system to meet international standards.
22) Blow-down tanks
23) Deaerator / storage tank
24) LP dosing system
25) HP chemical dosing system
26) Boiler feed water system
27) Ash handling system for dry collection of bottom ash separately, fly ash separately
28) Steel chimney comply with PCB norms and height will not be less than 60 m.
29) Complete electrical system including MCC, local push button station, power cables, earthing.
30) LT motors
31) Electrical actuators
32) Local gauges for pressure and temperature measurements
33) Boiler drum level indicators/ controllers and Alarms
34) Direct acting switches and thermocouples for remote monitoring and control
35) Process transmitters for remote monitoring and control
36) Flow elements for measuring feed water, spray water and main steam flows
37) Impulse lines along with fittings
38) GI lines for instrument air.
39) PLC based control system for the boiler operation with provision for integration with power plant DCS
40) Instrument cables
41) Local junction boxes
42) Pneumatic actuators

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C-3. Design Data for Boiler

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The main fuels will be RDF and Biogas

Design steam generation		28 TPH
Normal steam generation		27.76 TPH (for 6 MW power generation)
Pressure		46 bar (a)
Temperature		435 + 5 °C
Feed water temperature		
Entering economizer		105 °C
SH outlet steam temp		
Control range		60% to 100% MCR load of boiler,
RDF Fuel available		180 TPD
Biomass quantity	:	50 TPD

D. **Turbo Generator System**

The steam turbine will be horizontal, single uncontrolled extraction (bleed off) condensing type. The turbine is designed for main steam parameters of 45 bar (a) at 430 °C to generate 6 MW at Generator terminals.

All casings and stator blade carriers will be horizontally split and the design will 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 will be such as to permit free thermal expansion in all directions. The casing will also permit the inspection of the bearings without dismantling of the casing. The extraction branches will be located on the lower half of the casing.

The casing towards the lower pressure region will have a bottom exhaust arrangement configuration and the exhaust casing will be suitable for connection to the condenser without air leakage and hence suitable for maintaining the condenser vacuum. The turbine exhaust hood will be provided with exhaust water spray system (if required) to protect the turbine against excessive temperature at no load and low load conditions. The spray system will be provided with complete spray nozzles, automatic spray control valve, interconnecting piping, all necessary controls, instrumentation and fittings. The turbine

will have solidly forged and machined rotor with integral disks. The rotor after fully machined and bladed will be dynamic balanced accurately in the shop and will be given an over-speed test under vacuum. None of the critical speeds of the rotor will fall within the range of 20% above and 20% below the normal running speed of the rotor. The rotor will be designed to withstand the maximum shock loading that may occur during any power system disturbance.

The turbine will be provided with liberally rated hydrodynamic radial and thrust bearings. The radial bearings will be split for ease of assembly and of the sleeve or pad type, with steel shell backed, babbitted replaceable pads. These bearings will be equipped with anti rotation pins and will be positively secured in the axial direction. A liberal flow of lube oil under pressure will be supplied to all the bearings for lubrication and cooling.

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

The glands will preferably be of labyrinth type and sealed with steam. The gland packing will be of 13% chromium stainless steel. The labyrinths will 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 gland sealing system design will permit the examination and any replacement, if necessary of the glands without lifting the upper half of the turbine casing. During the normal operation of the turbine the source of sealing steam will be from the turbine. During the start up of the turbine, steam will be supplied externally for effecting the sealing. Required gland steam condenser with 2 x 100% capacity ejectors / AC motor driven exhausters will be provided. Suction fans will have one operating fan and one standby fan. All piping and components of shaft seal system will be sized for 150 percent of the calculated clearance leakages.

A pressurized lubrication and control oil system will be provided 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 will supply oil to the turbine generator under all the load conditions, including the turning gear operation. The oil system of the

turbo generator will 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 turbo generator.

The turbine governing system will be designed for high accuracy, speed and sensitivity of response. The governor will ensure controlled acceleration of the turbo generator and will prevent over speed without tripping the unit under any operating condition or in the event of maximum load rejection. The governor will have linear droop characteristics with a suitable range for stable operation and will have provision for adjusting the droop in fine steps.

The governing system will have the following important functions:

i) Speed control
ii) Overspeed control
iii) Load control
iv) Inlet steam pressure control

The governor will be configured to incorporate the following controls while operating in parallel with the grid.

Load set point will remain unaffected for variation of frequency between 47.5 Hz and 52.5 Hz.

The turbine inlet steam pressure will be maintained at the set value by controlling the power export to the grid.

Condensate system will consist of shell and tube, horizontal surface condenser with connection for turbine exhaust along with complete supporting arrangement and integral hotwell with level control, recirculation and control valve stations, thermal relief valves and cathodic protection.

The air ejector system is used to extract the non-condensable gases from the condenser and thereby creating vacuum in the system. It consists of one hogging ejector and two

main ejectors. Each main ejector consists of first stage and second stage ejector inter and after condenser. To create vacuum during starting condition hogging ejector is used to extract the non-condensable gases from the system. When the vacuum in the condenser reaches a predetermined level main ejector is taken into operation and after stabilization of main ejector, hogging ejector is switched off. Out of the two main ejectors, one is for normal operation, while the other one serves as stand by.

2 x 100% (one working + one standby) pit mounted horizontal pump directly coupled to 415V AC 3 phase motor will be provided.

D-1 Steam turbine generator will consist of the following:

1) Horizontal split casing extraction cum condensing steam turbine with double helical speed reduction gearbox, digital type governor, common structural base frame for turbine etc.
2) Turbine inlet emergency control cum stop valve with integral steam strainer.
3) Quick closing non-return valves, relief valves and isolation valves in extraction line
4) Coupling and Coupling guard between turbine and gear box & between gear box and alternator.
5) AC driven turning device with automatic engagement and disengagement and hand barring device.
6) Throttle valves and governor valves
7) Lube and hydraulic oil system with adequate redundancy and emergency provisions, common for turbine, gear box and alternator.
8) One Lube oil reservoir complete with strainers, drains, maintenance openings, vents, connections to oil inlet, outlet and to oil purifier unit, oil level indicators, level switches and oil vapor extractors.
9) Two Nos. (1W+1S) oil coolers with change over device for oil coolers, with necessary vent and drain valves on water and oil side.
10) Two Nos. (1W+1S) oil filters each for both lube oil and control oil.
11) One main oil pump driven by turbine shaft or a motor, 1X100% AC operated auxiliary oil pump and one emergency oil pump driven by DC motor.
12) One centrifugal type oil purifier

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13) Emergency gravity lube oil system with overhead tank, piping, valves and instrumentation

14) One (1) shell and tube, horizontal surface condenser with connection for turbine exhaust along with complete supporting arrangement Integral hotwell with level control, recirculation and control valve stations, thermal relief valves and cathodic protection

15) 2X100% capacity AC motor driven condensate extraction pumps. The pump will have a minimum margin of 15% margin over the maximum flow and output pressure requirements.

16) Steam jet air ejector (2 x 100%) with steam strainers

17) One Hogging Ejector with Silencer

18) Gland sealing steam system with steam pressure regulators, gland steam condenser etc.

19) Flash tank for receiving all high pressure drains from piping and turbine, steam and condensate lines from flash tank to condenser.

20) All interconnecting HP/ LP and Integral piping connecting all equipment in the scope of supply

21) Steam line from Bleed off to the Deaerator inlet

22) Steam line from the main steam line to Aux steam header

23) Steam line from Aux steam header to SJAE and Deaerator pegging steam

24) Condensate line from CEP discharge to Deaerator inlet through SJAE condenser and Gland steam condenser

25) Complete Gland sealing system piping

26) Complete piping for SJAE

27) PRDS (Pressure reducing and De-superheating stations)

28) Removable blanket type insulation for steam turbine proper and insulated pipe section with cladding for piping.

29) Painting and surface protection.

30) Shims, anchoring systems, wedges, foundation bolts

31) Flushing oil and initial fill of lubricants.

32) Generator with excitation system

33) Generator air coolers

34) MCC for TG auxiliaries.

35) Power and control cabling with cable tray supports within battery limit

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36) AVR panel and excitation panel

37) Generator relay, metering control cum synchronization panel

38) NGR cubicle

39) Earthing

40) Lightning arrestor and surge protection cubicle

41) Starters and Push button stations within the battery limits

42) Woodward governing system

43) Turbine control Panel & instrumentation system consisting of vibration probe and monitor and axial displacement monitor with protective alarms and trips as required, electronic tachometer with remote indicator, local instrumentation for inlet and outlet steam temperatures and pressures; lubricating oil temperature and pressure, temperature sensors for thrust and journal bearings, safety devices including over speed trip with audio-visual alarm, low lube oil trip with visual alarm, remote operated manual trip, low oil pressure and high oil temperature alarm, high back pressure trip etc.

E. Design operating parameters and Specified Datasheet

Steam Turbine Inlet Pressure, Bar	45 bar a
Steam Turbine inlet temperature	430 ± 5 Deg. C
Steam quantity at turbine inlet (After considering the steam for SJAE)	About 27.49 TPH
Deaerator pressure and temperature	1.21 bar a and 105°C
First extraction steam pressure	3 bar (a) or to suit the Deaerator pressure
First extraction steam quantity	2.36 TPH
Condenser operating pressure	0.10 bar
Condenser Cooling water inlet temperature	32 °C
Condenser cooling water outlet temperature	40 °C
Power Generation required	6 MW
At Generator terminal normal operating conditions	
Power factor (lagging)	0.8

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363

Generation Voltage (kV)	11 kV ± 5%
System frequency	50 Hz ± 5%, ± 3%
Ambient temperature for electrical equipment design	45 Deg.C
Parallel operation with grid	Required

6.11.1 Cooling water system

The cooling water system will cater to the cooling water requirements of Condenser, Generator Air cooler, TG Lube Oil cooler, Compressor etc. The cooling water system will be designed for circulating cooling water flow of 2100 m^3/hr, including 10% margin.

The cooling water system will consist of the following major items of equipment.

Three (3) electrically driven horizontal centrifugal cooling water pumps, each of 920 m^3/hr capacity (two working and one standby) with associated drive motors for TG condenser cooling.

Two (2) electrically driven horizontal centrifugal auxiliary cooling water pumps each of 220 m^3/hr capacity (one working and one standby) with associated drive motors.

Induced draft cooling tower will be designed for a total circulating water flow of 2100 m^3/hr. The tower will be of RCC construction with two cells (both working). The cooling range will be 8 Deg C based on a WBT of 28 Deg C and approach of 4 Deg. The Cooling water inlet temperature will be 40 Deg C. There will be two cells with capacity of 1050 cum/hr (both working)

The induced draft cooling tower will be complete with basin, associated supporting structures, foundation, casing with internals such as fills, drift eliminators, hot water distribution system, instrumentation, fans, recovery cone, isolating valves. The basin will be partitioned suitably to facilitate isolation and maintenance and will be complete with draining facilities, cold-water outlet channel, with screens and stop logs. Suitable

handlings system for handling fans, associated motors, and screens, slop logs will be provided.

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Cold water from the cooling tower basin will be pumped by the cooling water pumps to the TG condenser and other auxiliary consumers in the power plant. The hot water return from the consumers will return to the cooling towers for cooling and recirculation

About 94.59 m^3/hr of make up water will be added in the cooling tower basin to compensate the evaporation, drift and blow down losses.

The cooling water system will include all associated electricals and instrumentation.

6.12 Other plant auxiliaries

6.12.1 MSW Handling Facilities

After inspecting various Dhalaos and different type of MSW, MSW handling system will have following positive features. Incoming MSW will be properly disinfected by spray All odd objects will be manually removed from the system. Most of the objectionable material like PVC rubber leather etc will be separated. MSW will be dried before refinement.

6.12.2 Compressed Air System

A suitable air compressor system with two compressors (1W + 1S) will be provided for meeting the instrument and service air requirements of power plant and RDF plant. The air compressor will be oil free screw type. The compressed air requirement of the power plant (apart from the conveying air of dense phase ash handling system) is about 200 Nm^3/hr at a pressure of 8 bar (g). This quantity caters to the requirement of service and instrument air for the plant. For this purpose two (2) compressors will be provided. The plant air will be directly stored in the Service Air receiver. The instrument air will be made to pass through an Air drying plant and then stored in the instrument air receiver. The compressors will be of reciprocating, non-lubricated type and providing moisture free and oil free air.

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The compressed air system will be complete with

a) 2 x 100% capacity air compressors

b) Two air receivers

c) 2 x 100% desiccant type air drying plant for instrument air requirement to achieve atmospheric dew point of -40 Deg. C

The compressed air system will included all associated electricals and instrumentation.

6.12.3 Cranes & Hoists

TG Building will be provided with an EOT Crane with pendant operation, for erection & maintenance requirements of turbo generator. Hoists and monorails will be provided wherever handling of heavy equipment is required. The tentative capacity of crane will be 15 Tons / 5 Tons.

An electrically operated overhead traveling crane will be provided in the RDF fluff Boiler storage area, with a grab bucket. Long travel and cross travel will be electrically operated. Grab will be controlled Hydraulically.

All cranes will include all associated electricals and instrumentation.

6.12.4 Ventilation system

TG Building operating floor will be provided with air washer units for evaporative cooling. Each air washer unit will consist of centrifugal fans, centrifugal pumps with all filters, ducts and other accessories as required. In addition to this, roof extractors will be provided for the TG building, to ensure at least ten (10) numbers of air changes.

Dry forced ventilation will be provided for the Switchgear and MCC rooms. Wall mounted axial flow supply / exhaust fan will be provided for rooms of other building other than TG building.

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366

6.12.5 Air Conditioning System

Split air conditioning will be provided for main control room

6.12.6 HP/LP Piping

The piping for the plant will consist of HP piping and LP piping. The HP piping consists of power cycle piping like main steam, condensate, extraction steam, feed water are classified under HP piping. The major LP piping consists of piping for Cooling water, RO/DM water, plant service air and instrument air, raw water, filtered water, drinking water, dense phase ash handling, fuel oil piping etc

6.12.7 Fluff handling system

The RDF fluff generated from the RDF plant will be stored in a covered area adjacent to the boiler. The Boiler is located to the east of the RDF fluff storage area. The Fluff / is transferred from this storage to a Belt feeder by a grab crane, which turn feed the boiler Receiving Hopper through a belt conveyor.

6.12.8 Ash Handling system

Ash generated during the operation in the power plant will be suitably collected and disposed. A detailed ash disposal plan will be worked out for disposal of ash. The bottom ash will be collected at the bottom of the boiler furnace and will be removed manually. The fly ash handling will be by means of dense phase handling system. The fly ash will be collected from various hoppers of the boiler including Economiser hopper and ESP hoppers and conveyed to an ash silo. Ash quantities will be as below:

Total ash generated	:	1.604 TPH
Bottom ash	:	1.04 TPH
Fly ash	:	0.52 TPH

6.12.9 Workshop Equipment

1) Heavy duty portable grinder (wolf) 180 mm) 1 No.

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2)	Heavy duty portable grinder (1 ... mm	1 No
3)	Angle hand grinder	1 No
4)	Flexible Grinder	1 No
5)	Bench Grinder (1.5 Hp, double ended)	1 No.
6)	Portable drill machine	1 No.
7)	Radial drill machine - 25 mm 2 m Ht with 1 hp motor	1 No.
8)	Portable drill machine	1 No.
9)	Welding transformer (Indore type 300 st, 1 phase)	1 No.
10)	Gas cutter set complete in all respects	1 set
11)	Grease pump (50 kg pneumatic)	1 No.
12)	Grease pump (manual 20 kgs)	1 No.
13)	Hand grease guns	6 Nos.
14)	Air compressor 175 psi	1 set
15)	Electronic weighing scale (0 - 100 Kgs)	1 No.
16)	Sheaving machine	1 No.
17)	Indef - N super gear hand hoist 1 Ton	1 No.
18)	Indef - N super gear hand hoist 2 Ton	1 No.
19)	Indef - N super gear hand hoist 5 Ton	1 No.
20)	Centre lathe H- 26	1 No.
21)	Shaper with stroke 800 mm	1 No.
22)	Hydraulic Jack 50 Ton	1 No.
23)	Hydraulic Jack 100 Ton	1 No.
24)	Micrometer outside/Inside (0 - 200 mm)	Complete set
25)	Vernier Calipers (0 - 150 MM)	2 No.
26)	Vernier Calipers (0 - 300 mm)	1 No.
27)	Workshop hand tools consisting of DE spare sets,	
28)	Ring spanner sets, Box spanner set, hand files,	
29)	Allen key set, Tap sets, Drill Bits, Hacksaw, Punch set,	
30)	Scales, Screw Driver, Pliers, etc.	2 sets
31)	Techno meter	1 No.
32)	Tong Tester	1 No.
33)	Multi Meter	1 No.
34)	Megger 0 - 500 v.	1 No.

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As per the revised proposal, the entire site of 11.72 Ha has been divided into two parts:

i. Part 1 of 7.05 Ha for development of compost plant and RDF plus Power Plant. This part is to be developed by raising the level of ground by filling upto 8m.

ii. Part 2 of 11.67 Ha for the development of sanitary landfill by construction of retaining wall around this area.

GMC would support the cost of site development to the extent Rs. 20 Crores for the entire complex.

B. Roads

All roads in the plant area will be well-designed bitumen roads. All main roads will be 4m wide with 1 m wide berm on either side. The crown of the road will be minimum 200mm above FGL. The final finished road will have a camber of 1in 60. Camber on top of water bound macadam surface will be 1 in 40.The existing ground level is NGL+0.00LVL and the formation level is FGL +1.00.

C. Drainage

Surface drainage will be designed based on the maximum rainfall intensity prevalent in the area over the last 50 years. Building will be provided with plinth protection all around, sloped towards side drains. The side drains will be connected to the main drains on either side of the roads.

For pipe drains, concrete pipe class NP2 conforming to IS: 458 will be used. However for road crossing, class NP3 pipe will be used. If sufficient clearance cannot be provided between the top of pipe and road top, the pipe will be encased in PCC / RCC. For the process drain, catch pits will be provided at the source location and they will be interconnected by buried RCC / CI pipelines and connected to waste water treatment plant.

369
391

The MSW storage areas will be provided with a slope to drain the water collected to a sump from where it will be pumped to effluent treatment plant

6.13.4 Boundary Wall

The boundary wall for the MSW-Energy complex will be provided to a height of 2.5 m from the finished ground level (FGL) with angle iron bars and barbed wire for an additional height of 1 m.

6.13.5 Civil Works for RDF Plant

The civil works for RDF plant will include a Paved Yard of about 3000 sq.m, MSW Dumping Pit (P2) of size 20 m x 14 m x 9 m and the factory shed/ Building of a total area of 1800 sqm and other civil works. The area required for Factory shed/ Building is as follows:

a) Factory Shed / Building	
b) Primary Shredder area fully covered from sides	700 sq.m.
c) Dryer Area open from sides	600 sq.m.
d) Other cover area	500 sq.m.
e) Other Civil Works	
f) Rest house canteen etc.	
g) Sanitation, wash area & water showers	
h) Equipment foundations	
i) Administrative Building	

6.14 Electrical Power distribution

The plant electrical single line diagram GWMCL-EE-SLD-001 is enclosed in Annexure-I. The following are the description of the electrical equipment for Integrated Plant

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6.14.1 Generator

The generator will have the following salient features

a)	Type	Synchronous generator
b)	Rating at MCR condition	6000 kW
c)	Rated power factor	0.8 lag

6.14.2 11kV Switchgear

The switchgear will be indoor, metal clad, 11 kV , 3 phase, 3 wire system and will be fully draw out type. The switchgear assembly, Circuit breakers, CTs, VTs, bus bars etc., will be suitable for the following system parameters.

	Description	11kV
a)	Highest system voltage	12 kV
b)	Fault level	25 kA
c)	Degree of protection	IP-54
d)	Type of circuit breaker	SF6/ VACUUM

6.14.3 Motor Control Center and Power Control Center

Motor Control Centre (MCC) and Power Control Centre (PCC) will be of sheet steel vertical section, compartmentalized with draw out type modules for PCC & fixed type for MCCs for individual feeders having aluminium alloy buses designed to withstand LT fault current for 1 sec. Each cubicle will house the necessary equipment required for control, such as fuse, contactors, relays, push buttons and indicating lamps in the case of MCCs and air circuit breakers and switch fuse units in the case of PCCs.

The buses will be of aluminium alloy and will be designed to withstand, without damage, a fault current of 45 kA (RMS) at 415 V for one (1) second duration.

The 415 V breakers of the PCC will be of airbreak, trip free and draw-out type capable of safe breaking of the full load current in connected feeders. The operating mechanism will

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be spring charged, stored energy type. The breaker rupturing capacity is selected as 45 kA at 415 V considering the fault level on the LT bus.

Fuses will be of HRC type with minimum rupturing capacity of 45 kA at 415V. Rating of the fuses will be as per requirement of individual feeders

6.14.4 Grounding & Lightning Protection

The earth mat of the station will be designed as per the requirements of IEEE-80 and 142 and IS: 3043 such that the total ground impedance does not exceed 1.0 ohm. The lightning protection will be as per IS: 2309. The chimney will be provided with adequate lightning protecting system and aviation warning lights.

6.14.5 Protection

The major electrical equipment will be provided with the protections as listed herein under:

A. Generator Protection

Differential protection – generator winding
Back up impedance protection
Over voltage protection
Under voltage protection
Voltage restrained over current protection
Stator earth fault protection
Low forward power protection
Reverse power protection
Negative phase sequence protection
Field failure protection
Rotor earth fault protection
Generator overload alarm
Generator under-frequency protection
VT fuse failure supervision
Generator out of step protection

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B. LT Transformer

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Over current (IDMTL & Instantaneous) protection

Earth fault protection

C. Outgoing Feeder

Over current (IDMTL & Instantaneous) protection

Sensitive Earth fault protection

6.14.6 Power and Control Cables

11kV cables will be of heavy duty XLPE insulated, each core is screened on stranded aluminium conductor as well as on insulation, colour coded, extruded PVC inner sheathed, single round galvanized steel strip armoured (for multicore cables only) and overall PVC sheathed with FRLS (Fire Retardant Low Smoke) protection feature. The cables will be suitable for unearthed system.

LT power cables will be 1100V grade with stranded aluminium conductor PVC insulated, extruded PVC inner sheathed, single galvanized steel strip armoured (for multicore cables only) and overall PVC sheathed with FRLS feature

Control cables will be multicore 1100V, PVC insulated inner sheathed, single round galvanized steel strip armoured and overall PVC sheathed with FRLS feature with 2.5 sqmm stranded copper conductors.

6.14.7 Station DC System

The station DC power system will comprise:

110V Battery

Battery charger (float and boost charger)

DC distribution boards.

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6.14.8 **Battery**

Battery will be maintenance free lead acid tubular type and will be sized for one-hour duty to cater to the emergency loads. The battery set will be of suitable voltage rating of 110V.

6.14.9 **Battery Charger**

The float charger will be capable of floating the battery and supplying the DC load.

The boost charger will be capable of quick charging the battery to 2.75 volts per cell. The charger will have sufficient capacity to restore a fully discharge battery to a state of full charge in 10 hrs.

6.14.10 **DC distribution boards**

One (1) no. main DC distribution board will be provided for the entire plant DC system. The main DC distribution board will have one incomer and outgoing switchfuse units.

6.14.11 **Uninterrupted Power Supply System**

One (1) no. 10 kVA UPS unit will be provided common for the whole plant sized to feed the following loads:

DCS

Turbine supervisory instruments

RO/ DM Plant

6.14.12 **Plant lighting system:**

Lighting for the plant areas, buildings and structures will be provided as per industrial norms. The plant lighting system will include the normal lighting of the plant as well as emergency lighting to selected areas of the plant during plant emergency conditions. The lighting distribution system of the plant will consist of:

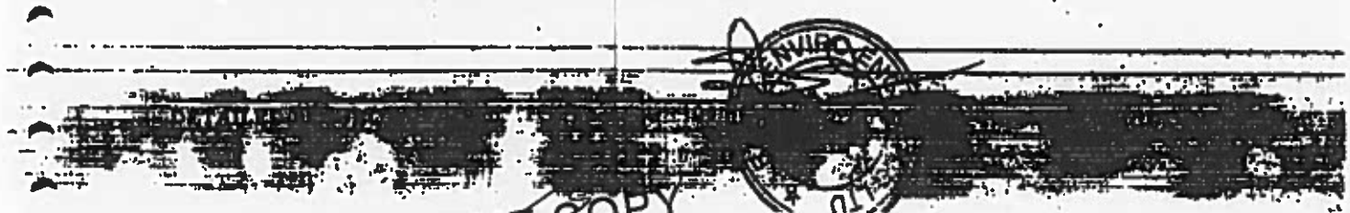
Normal AC lighting

Emergency DC lighting

Road lighting

Illumination levels will be based on the Indian Standards Code of practice.

In addition sufficient number of receptacles with individual switches will be provided in various areas for routine maintenance and inspection.



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6.14.13 Normal AC lighting of the Plant

For general illumination, fluorescent fixtures are taken into consideration. However in some places where fluorescent fixtures are not suitable, high intensity discharge (mercury/sodium vapour) and incandescent lighting fixture of suitable design are considered. This lighting will be energized from the normal AC supply of three phase, 4-wire, 415V available from the main lighting boards. All lighting fixtures connected will be 'ON' as long as the 415 V AC supply is healthy.

Plant emergency DC lighting will be fed from the emergency lighting panels and will be supplied from the plant DC distribution system. Normally, these lights will remain energized from A.C source. On total failure of A.C supply, these will be supplied from DC battery.

6.14.14 DG Set

A 415 V / 250 kVA DG set will be provided to cater to emergency loads of the power plant in case of loss of power supply. The DG set will primarily feed the battery charger, AC lube oil pump, control and protection requirement.

6.14.15 Miscellaneous

Cables trays and weather-proof junction/ terminals boxes will be provided.

6.14.16 Electrical System of RDF Plant

The Salient features of Electrical System of RDF Plant is as follows:

a) All the drives are LT drives
b) Only single supply arrangement has been planned.

Double independent earthing network has been planned. One earthing grid will be from substation and second will be at each motor control center.

A. Major Installations (RDF Plant)

i)- One 1000 KVA 11kv/415 volt transformer will be installed at 0.0 level in ADS area.

ii) Motor control center for AD's will also be installed in the same premises.

iii) Motor control center for primary shredding and screening will be installed at 0.0 level near primary shredder.

iv) Motor control center for dryer will be installed at + 4 meter level at feeding end of the dryer.

B. Controls (RDF plant)

i) Independent starting from local and remote location

ii) MCB protection for drive below 20 HP and MCCB for drive above 20 HP

iii) All the drives to have independent power isolation

iv) Common control supply will be separate from power for all the drives.

v) Positive lockable control switch is to be used for short mechanical shutdown.

vi) Long mechanical shutdown and electrical shutdown are to be given by disconnecting power supply.

vii) Sequential starting will be from logical control panel.

viii) All drives will be monitored at central control panel

ix) All MCC will indicate the drive ON OFF positions.

C. Electrical Requirements (RDF Plant)

i) All drives up to 20 HP will be DOL and will have copper cables.

ii) Normal drives above 20 HP will be star-Delta starter

iii) All the high torque drives will have soft starter.

iv) Power factor will be manually controlled at all MCC's

v) PDB will be under control of electrician

vi) All MCC's will be under control of operator however shut down will be given by electrician

vii) Fire fighting equipment will be installed near all the MCC's and PDB's

viii) Safety Board and other requirements will be properly displayed.

6.15 Plant Control & Instrumentation

6.15.1 Power Plant

i) The instrumentation and Control (C & I) system will be designed for safe, reliable, efficient and easy operation of Boiler having capacity of 27 T/Hr, 6 MW

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Turbine. Water treatment plant including RO and DM plant Cooling water system and other associated auxiliaries.

ii) The C& I system will be designed to have fully automated and capable for operating remotely from unit control room DCS through Remote I/ O's for boiler, TG and Water Treatment Plant.

iii) The CCR shall house control desks/ panels with workstations based operator consoles and other peripherals like printers etc. The CCR shall also house has the control and relay panels of the Boiler, Steam turbine and generator, switch gear, station transformer, Water Treatment Plant including auto/manual stations, indicators/ recorders, DC equipment, Fire alarm panel etc.

iv) The complete hardware and software along with Man Machine Interface (MMI) capable of operating together as an integrated system along with panels, cables, and unit control desk, cabinets, field instruments and erection hardware, control elements and devices to perform the various functions will be provided as specified. The system supplied will be upgradeable, both hardware and software of the latest version.

v) The instrumentation and control system envisaged for Boiler, Turbine, Water Treatment Plant and other auxiliary system includes the following.

a) Open/Close loop control system.
b) Control Desk.
c) Sequence of Events Recording (SER) and annunciation system.
d) Power supply system
e) Cables (Instrument and control cables) System cabinets, marshalling unit etc.

vi) Sequence control will be provided to start and stop and safe emergency shutdown the "functional systems" or 'sub-systems" and associated equipment & auxiliaries.

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vii) Interlocking and protection requirements will be met for various equipments/system as applicable

viii) All drives of DCS & CLCS are controlled via Input/ Output modules. The controllers, and other binary/Analog input/output modules are housed through Remote Processing Units "RPU" and reside on the data highway, which serves as a transport medium for signals between various RPUs and the upstream-connected Man-Machine Interface and Plant Information system (MMIPIS).

ix) The DCS system will have the following:

a) Operator Stations/Associated hardware

b) Operator Station with 21" LCD Flat Monitor

c) Servers/Engineering station with common LCD Monitor

d) Dot Matrix Printers

e) Color deskjet Printer & B &W Laser printer (A4)

f) Consoles

g) Ethernet Cable and Terminal servers.

h) Controller Subsystem consists of Control Processor, Power supply system etc.

i) I/O Sub-system consists of modules having the following Input/Output requirements:

Analog Input	4-20 mA	... 125 Nos
Analog Output	4-20 mA	... 90 Nos.
RTD /Thermocouple		... 120 Nos
Digital Input Process		950 Nos
Digital Input –SOE		... 650 Nos
Digital Output		... 500 Nos.

x) All required field instruments for Boiler, Turbine Generator, Water/Steam system and Analyser will be included to make the power plant control system operable from central control room.

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6.16 Fire fighting facilities

a) Fire protection system will be provided as per LPA (Loss Prevention Association) norms. The total number of hydrants for the power plant will be a minimum of 38 nos. The fire protection system will be provided with a main one electric driven pump, one standby diesel engine operated pump, o 273 cum/hr and 88 m head and one jockey pump.

b) The fire protection for the power plant will include Hydrants covering TG building, boiler areas, fuel-handling plant, pump houses, miscellaneous building etc. The system will be complete with piping, valves, instrumentation and nozzles.

c) Hydrant system for RDF plant and Biomethanation plant should include portable and mobile fire extinguishers at strategic locations throughout the plant and especially in the control room.

d) Fire alarm and detection system will be provided for control room and electrical room.

e) The requirement of fire fighting equipment for RDF plant is as given in Annexure-II, Table-3 These are in addition to the water hydrant being planned in the yard by Power Plant. The RDF main storage building and Boiler fluff storage building will be provided with automatic high velocity water spray system throughout. The storage building shall be divided into 4-5 zones A pipe network fitted with quartzoid bulb detectors (heat detectors) shall be provided throughout the building. The pipe network will be kept pressurized by water trapped from the upstream side of deluge valve. Each zone will be provided with one deluge valve. The water supply for the high velocity spray system deluge valve is connected to the fire hydrant main. The downstream of the deluge valve is kept dry and shall be connected to a pipe network having spray nozzles. The spray nozzles shall be suitable for operation up to 150 °C. In case of fire the quartzoid bulb will break and release the pressure in the detector network. This will open the deluge valve and allow water to be sprayed. The deluge valve can be operated manually and electrically. A local control panel will be provided for each deluge valve for location electrical actuation. The deluge valves will also be provide with pressure switches for remote annunciation in the fire alarm

panel located in the power plant control room. The exact details of water spray system including the protection area per spray nozzles (density) to cover the entire area of storage building and provision of spray nozzles at more than 2 levels will be decided during detailed engineering. The tentative cost for automatic spray system will be at least about Rs.25 Lakhs

g) 'No Smoking' and hazard / danger warning stickers will be put up at appropriate places. All personnel deployed for the construction, erection and operation of biogas plant will be given proper training for fire drill. Emergency numbers will also be put up at appropriate places. Empty fuel drums / tanks and other inflammable material will be removed from the premises as soon as possible. Storage yard for chemicals and fuel lubricants will also be provided with fire extinguishers and sand bucket racks.

6.17 Project Implementation Schedule

a) It is proposed that one EPC Contractor will be engaged for MSW processing facility and Power Plant installation and commissioning. Another Contractor will be engaged for Bio-, installation & commissioning.

b) The implementation of MSW processing plant And Power Plant will be taken up independently. The interface between MSW processing and RDF Plant will be engineered and construction sequence coordinated subject to final alignment before the erection of equipment at the interface point.

c) The civil works for all the three sections may preferably be carried out by one contractor even though the layout-wise foundations, buildings and structures are independent. The engineering of the buildings, foundations and structures will be carried out by individual plant engineering contractor and design will be handed over to the civil construction group for construction of foundations, buildings and structures.

d) The power distribution for pre-commissioning activities will be taken from the power plant. The power plant MV and LV Switchgear will be supplied and installed

sufficiently in advance, to cater to the power supply distribution for the RDF and compost plants. The power supply will be drawn from Cuncliem Sub-station for distribution to various auxiliaries for pre commissioning works.

e) Common facilities such as roads and drains, area lighting will be done by the power plant electrical contractor based on agreed layout

6.18 Operation & Maintenance aspects

A. Organization Chart (Operation and Maintenance)

The organization chart for Operation and Maintenance of the Integrated Municipal Waste complex is attached in Annexure-II The Plant General Manager will head the organization. The following personnel will report directly to the Plant General Manager:

1. Operation Manager for RDF processing plant,
2. Operation Manager for Power plant,
4. Maintenance Manager for the entire complex
5. Plant security Supervisor
6. MSW Collection
7. Sanitation and House Keeping (for entire Industrial Municipal Waste complex)

6.19.1 Maintenance aspects of Integrated Waste Complex

The maintenance of both RDF plant and the Power plant has to be planned during the monsoon season.

The maintenance functions of the integrated municipal waste complex will be under the responsibility of the Maintenance Manager. The following manpower will be required for Maintenance of the complex:

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Area	Maintenance Engineer	Maintenance Supervisor	Technicians Fitter/welder, Unskilled labour
RDF processing plant (mechanical)		3	6
Power plant (mechanical)	1	2	2
Electrical and C&I		3	6
Workshop		1	4
Total	1	9	18

The cost of the maintenance manpower for RDF processing plant, and Power plant are covered under the subsection for cost of operation of the RDF plant and power plant.

The cost for workshop manpower requirement will be Rs.3,60,000. The break-up is as follows:

Workshop supervisor (1 No.) : Salary (Rs. 10,000 per month)

Workshop Technicians (4 Nos.) : Salary (Rs. 5,000 per month)

6.19.2 Operation aspects of RDF plant

The operation staff for the RDF processing plant will be under the control of Operations Manager for RDF processing plant. Manpower is required for the following areas of RDF plant

a) Receipt of MSW/Dispatch of reject, spreading of material and mobile equipment
b) Feeding area of Municipal Solid Waste
c) Primary Screening and Shredding.
d) Rotary dryer and intermediate yard.
e) Ballistic separator and Fluff management

A. **Operation Manpower Requirement Estimation (RDF processing plant)**

	Operation				
	Receipt and Feeding	Pre-Shredding	Dryer and BAG	Ballistic Separator and rejects	Total
Supervisor	2	1	2	2	7
Operator/ Mechanic	6	–	6	3	11
Semi-Skilled	6	2	3	3	14
Khallasi	6	2	3	3	14
Sub-Total	**20**	**7**	**11**	**11**	**49**

B. Summary of Operation and Maintenance Cost

The detailed break up of the yearly operation and maintenance cost is as below:

Sr. No.	Description	Amount – Rs. in Lacs
1	Cost of transportation of raw material	00.00/-
2	Lubricants	3,00,000/-
3	Chemicals	6,00,000/-
4	Spares	3,00,000/-
5	Mechanical / electrical maintenance	2,00,000/-
6	Salary	18,20,000/-
7	Office expenses	1,20,000/-
	Total	34,00,000/- (Rounding off)

6.19.3 Operation and Maintenance aspects-Power Plant

The Operation and Maintenance cost consist of:

- Operation Manpower Cost
- Consumables Cost
- Spares Cost

A. Operation Manpower Cost

The manpower requirement for operation of Power plant is as indicated in the Organisation chart in Annexure II

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The manpower comprises of the following

Power plant Engineer	1 (General Shift)
Shift-in-charge	3
Boiler operator	4
TG operator	4
Balance of Plant operators	4
Electrical and C&I operators	4
Skilled Technicians	4
Total Number persons	24

The salaries and perks for these personnel work out to Rs. 54 Lakhs per annum. This amount is for operation and maintenance of the power plant.

B. Consumables Cost

Consumables consist of chemicals required for Water Treatment Plant/ RO and Mixed Bed DM Plant, dosing chemicals for boiler circulating water, lube oil make up, if required and general maintenance material like grease etc.

The estimated cost per year for the consumables is Rs. 9 Lakhs.

C. Spares Cost

Spares have been estimated as an average of 15 years as 0.75% of capital cost, which is Rs. 20 Lakhs

Total Operation and maintenance cost works out to Rs. 82 Lakhs per year (it works out to 3.1% of the project cost without spares and contingency).

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6.19.4 MSW Collection

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There will be 13 ward supervisors, each representing 4-5 wards from where the garbage for the integrated waste complex will be collected and who will be reporting to the RDF Plant Manager. The ward supervisors will be responsible for logistics reporting and coordination between the MSW supplying agencies and the RDF processing plant. The gross monthly salaries of each of the ward supervisors will be Rs. 8,000. This will amount to Rs. 9,36,000 per annum.

6.19.5 Sanitation and Housekeeping

The following manpower provision is considered for sanitation and housekeeping:

Sanitary supervisor	:	1 No	: Salary Rs. 6,000 per month
Sanitary labours	:	5 No	: Salary Rs. 2,000 /labour/ month

Hence the annual salary will be Rs. 1, 92, 000 per annum.

6.19.6 Manpower for Security

The manpower requirement for security will consist of the following:

Plant security supervisor	:	1 No. (Salary Rs.10,000 per month)
Watch and Ward	:	6 Nos. (Salary Rs. 4,000 per month each)

Hence the annual salary will be Rs. 4, 08, 000 per annum.

6.20 Operation scenarios for Interface aspects of Integrated Plant

6.20.1 Low Load Operation of the power plant

During low load operation the following will be initiated:

A. Keep utilizing the entire biogas available (which contributes to only 4% of total heat load).

B. Reduce the RDF feed by controlling the speed of drag chain feeder and control the stoker speed.

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C. Maintain an air rich atmosphere by supplying sufficient quantity of air to prevent furnace explosions due to accumulation of unburnt fuel in the furnace due to incomplete combustion.

D. Super-heater steam temperature control is not possible in the boiler below 60% load, boiler pressure remaining the same. However turbine can operate up to as low as 30% load.

E. The RDF plant will continue to generate 180 TPD of fluff, which gets accumulated in the storage areas.

6.20.2 RDF Plant shutdown

A. During the RDF plant shut down, the available fuel stored * in the main storage area and the boiler fluff storage building will be utilized along with the available quantity of biomass. This procedure can be continued to the extent of about 30% of plant load.

B. Below the load of 30%, initiate and shut down the Power Plant in safe mode. #

6.20.3 Conveyor from Main storage area to Boiler fluff storage building fails

A. When the conveyor from Main storage area to Boiler fluff storage building fails, the available fuel stored * in the boiler fluff storage building will be utilized along with the available quantity of biomass. This procedure can be continued to the extent of about 30% of plant load.

B. Below the load of 30%, initiate and shut down the Power Plant in safe mode. #

6.20.4 Conveyor from Boiler fluff storage building to Boiler receiving bin(chute) fails

A. When the conveyor from Boiler fluff storage building to Boiler receiving bin (chute) fails, the available fuel stored * in the boiler receiving chute (sized for 10 minutes fuel requirement of boiler) will be utilized along with the available quantity of biomass.

B. Shut down the Power Plant in emergency mode #.

Notes:

1 BRIEF OVERVIEW OF FLUFF HANDLING SYSTEM

The fluff generated in the RDF plant is stored in a main storage building (40M X 20 M X 10M). From the main storage building the "conveying arrangement" will carry the fuel to the boiler RDF storage building (20 M X 14M X 10M). From the boiler RDF storage

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building. the fuel is transported by belt conveyor to the RDF receiving chute which is sized for 10 m of boiler fuel requirement of the boiler. From the RDF receiving chute the drag chain feeder transports the fuel to the air swept spout and then to a pneumatic distributor, which spreads the fuel onto the grate.

- During low load operation of the power plant, RDF will get stored in the storage areas. Also during normal operation of the plant excess quantity of RDF generated over and above the requirement of the boiler, will also be stored in the RDF storage areas.

All the shutdowns will be initiated on auto-controls

6.21 Integrated Project cost with Power Plant

The integrated project cost summary:

RDF Plant	:	**Rs. 1,193.40 Lakhs**
Power Plant	:	**Rs. 3,049.00 Lakhs**
Total	:	**Rs. 4,242.40 Lakhs**

The break up of cost for RDF Plant & Power Plant project cost are given below.

6.21.1 RDF processing plant

The cost break up for RDF Plant, including cost of Machinery & Assumptions is given in Financial Analysis at Annexure II Table 1.

6.21.3 Power Plant

The Project Cost for the Power Plant equipment and systems is arrived at after estimating cost for each item separately for Taxes and Duties, Erection, Testing and Commissioning, Packing and Forwarding, Freight and Insurance. The equipment cost has been arrived at based on recently placed orders and from cost data bank.

A. The basic cost of all equipment systems works to Rs. 2,587.50 Lakhs.

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B. The cost of all equipment with Taxes and Duties, Packing & Forwarding, Freight & Insurance charges including Erection, Testing and Commissioning and Spares works out to Rs. 5049.0 Lakhs

C. The cost of land has not been taken into account in the project cost estimate

D. The break up of the project cost estimate is as given in Financial Analysis at Annexure II, Table 1

6.22 Integrated Operating cost with Power Plant

6.22.1 Operating Cost:

The operating cost consist of manpower cost, consumables, spares & maintenance, miscellaneous cost such as fuel cost for mobile equipment such as front end loader, tractors etc. The individual plant operating costs are listed below.

Operating Cost	(Rs. In lakhs)	
	RDF	Power Plant
Manpower cost	101	-
Consumables	82	-
Spares & maintenance cost	28	-
Misc. & Fuel cost	27	-
Total	238	78

Total operating cost works out to Rs. 316 lakhs per year.

The above cost does not include cost for energy used in RDF plant as this energy is being supplied from the power plant only.

6.22.2 The estimate of saleable energy from the power plant

A. The power plant is expected to generate 6 MW while firing 180 TPD of RDF and 57 TPD of biomass. Depending upon the RDF availability, biomass availability and grid

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conditions. it is expected that the power plant will be operated at PLF of 70% over the year. Based on this, the calculated energy generated will be 37MU

B. The requirement of energy for auxiliaries of power plant is expected to be 3.36 MU per year.

C. The estimated energy consumption of the RDF plant over the year is 4 to 5%. Accordingly, the saleable energy to the power off taker is calculated as 29.48 MU per year, based on 70% PLF of the power plant

D. The RDF fuel requirement for generation of 37 MU is calculated as 69,424 tons/year. The generation of RDF fuel & biomass is calculated as 78,210 per annum, which will meet the power plant requirement plus keeping some additional storage. The above will also meet the peak requirement of energy over and above 6 MW as per the system demand.

6.23 List of Equipment suppliers.

The list of Equipment suppliers for RDF processing plant and Power plant is indicated in Table-4 of Annexure II.

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7.0 ENVIRONMENT MANAGEMENT PLAN

The purpose of the Environment Management Plan (EMP) is to mitigate potential emissions from various activities associated with the integrated facility. It is noted that a rapid EIA report is being prepared and a detailed EMP would form part of that study. This includes understanding and incorporating of mitigation measures by the designers and the contractors to ensure that the emissions at site boundary are within the required CPCB and DPCC Limits.

The Environment Management Plan will adhere to the "MSW (Handling & Management)-Rules 2000" of Ministry of Environment & Forest, Govt. of India and also the applicable norms stipulated by CPCB and DPCC.

A study area of 10 Kms radius has been considered, as impact area Within this area there are no ecologically sensitive areas or places of archaeological, religious or tourist importance. The acquired site includes no forest area or prime agricultural land. Around the periphery of the plant area, wherever possible tall trees will be planted in order to maintain a better environment.

This chapter highlights the major sources of emissions from the proposed activities, while the environmental impact report would address (in detail) the emissions from each source and their mitigations.

7.1 MSW Handling & Processing

Air Emissions

The unloading as well as processing of the waste would generate dust and odours. Since these activities are carried out under covered areas which are under negative pressure as well fugitive air emissions will be collected through extraction systems and treated.

Leachate

The municipal waste arriving at the site will be unloaded in to a deep pit, which is covered. The small quantities of leachate generated will be collected in the sump adjacent to the pit.

Odour, Fly Vectors & Rodents

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As MSW processing facilities are all covered no vector and rodents menace is expected. After unloading the MSW herbal pesticides or effective microorganisms will be sprayed to control further decomposition and thereby preventing problems related to odour, flies, vectors and rodents in the receiving pits.

7.2 **RDF Plant**

Air Emissions

The Rotary dryer will have a Hot Air Generator in which bulk combustible MSW will be combusted to generate hot air. The following pollution control equipment will be installed:

a. The emissions from dryer will be collected by dust settling chamber, cyclones, and final cleaning of hot gases through bag filters. The air from Ballistic separators will be extracted and treated through the dust filtration system.

b. Secondary shredder discharge will be enclosed and provided with suction connected to bag filters before air is let out to atmosphere.

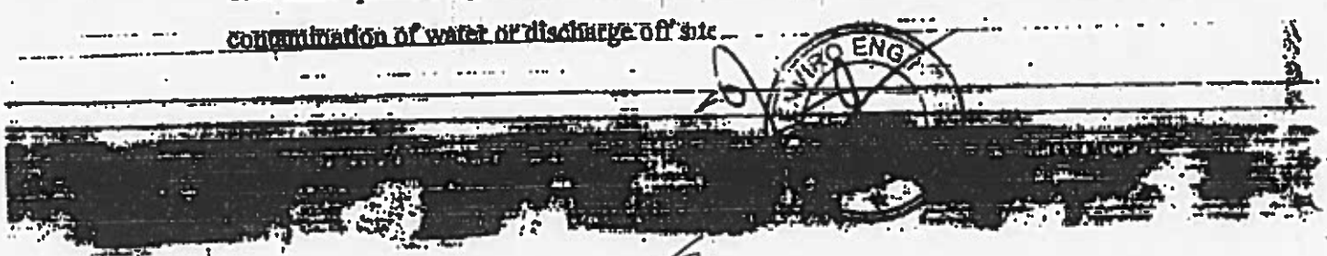
The dust extraction system will consist of the following extraction points:

- Rotary Trommels
- Dryer solids Discharge chute
- Discharge chute of Rotary Trommel (Secondary)
- Coarse fluff discharge chutes
- Secondary cyclone discharge duct
- All material transfer points

Air from these points will be directed to cyclone for primary collection and air bag filters.

Water Pollution

The RDF processing does not require water and therefore there would be no contamination of water or discharge off site.



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Solid Rejects

The solid rejects from the processing would consist of stone, sand, earth, ceramic etc which will be segregated and managed appropriately. Ash generated from the IIAG unit will be used for beneficial purposes.

Noise Pollution

There are a number of sources of noise pollution such as truck traffic, blowers, shredders. Where necessary, enclosures would be provided to ensure that noise levels do not exceed the prescribed standards (85 dBA at 1 m distance from the equipment). For the workers' safety earplugs would be provided and equipments would be maintained to ensure optimum working conditions.

RDF Storage

The proposed facility will have Seven (7) days storage for RDF fluff. To mitigate potential fire problems, adequate measures such as water hydrants with adequate pressure or dry powder type will be provided.

7.3 Power Plant

The 6 MW Power Plant consisting of RDF fired Boilers and Turbo Generator set with associated water system will have effluents in the form of gas, liquid and solid. In this section, the method of disposal of gaseous, liquid and solid effluents is described. During the operation of power plant air pollutant emissions, waste water and solid wastes, such as boiler ash are generated. The release of pollutants, if unchecked, can lead to negative impact on the environment. Therefore the system would be designed to minimize the adverse impacts to an acceptable level.

As a part of the Environmental Management Plan (EMP) to be implemented for the Power Plant as a whole, monitoring of air and water quality both at source and at the plant site will be done regularly as per Central Pollution Control Board (CPCB) guidelines after the plant is commissioned. For this purpose, necessary equipment and

instruments will be procured along with necessary chemicals consumables and glassware.

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Air Emissions

Successful control of air emissions involves a combination of two processes: firstly combustion control to limit conventional and trace contaminant emissions, and secondly, post-combustion control to reduce the amount of material leaving the stack.

MSW / RDF is a heterogeneous material, constituting of a mix of paper, plastics, other organic materials and non-combustibles. Each component has its inherent energy content and this must be matched with sufficient oxygen to ensure proper combustion. The combustion control systems sense the rate of heat release in the furnace and adjust the supply of combustion air to compensate for especially high or low heat-release rates.

The use of RDF provides the ultimate control for fuel variability when compared with mass burn system.. The nature of RDF provides the ultimate control for fuel to be more uniform; the non-combustibles have been removed; and, in the process the materials are thoroughly mixed. These characteristics make the control of the furnace less critical than it is in other combustion processes, such as the mass burn system described, and therefore lead to a better control of trace organic compounds emission.

If excessive air is present in the furnace, the combustion temperature and the concentration of hydroxyl radicals are reduced. In turn, the organics react with the OH radicals and the CO oxidation does not occur. Conversely, insufficient air can lead to pockets of fuel rich that lacks sufficient oxygen to oxidize the CO. It is possible to establish an appropriate range for the concentration of oxygen in any system. This will illustrate the limited extent of the appropriate or "good" operating region. Operation in this zone minimizes the release of CO and thus also minimizes trace organic releases.

The establishment of this range is most important because, once determined for a system, it can be used for the purpose of ensuring that the system is operating at its most efficient level. To ensure this is achieved, the RDF combustion device proposed

for this project will operate with Oxygen level of about 8% to achieve the optimum condition

The conditions that lead to a reduction in organic emissions also can cause an increase in the generation of NOx. The formation of NOx is attributed to two mechanisms; the oxidation of the fuel nitrogen to NOx and the combination of nitrogen and oxygen in combustion air at high temperatures. the thermal NOx reaction is strongly temperature dependent because it is formed by the combination of radicals of the two spices. It has been shown that the conversion of fuel Nitrogen can range from 5% to 50% controlled largely by the extent of mixing of Oxygen present.

Pollution Control Systems

Municipal waste being a pollutant, the RDF process aims at disposal of the waste in an environment friendly manner and at the same time extract the dormant energy present in it in the form of electricity, besides retrieving Re-cyclables and Re-usables.

Pollutants are present in the waste. Pollutants are generated in the combustion process and some pollutants form even after combustion. Pollution control needs to be effected in three phases–pre-combustion phase, combustion phase and post combustion phase.

The RDF process operates in a low temperature ambience. There is no generation of pollutants in the RDF process itself. PVC, containing organic chlorine is removed in the process and eliminates the possibility of dioxin formation during combustion. The possibility of volatilization of heavy metals is eliminated as the drying temperature in the dryers is kept at around 160°C. This temperature is sufficient to kill pathogens and render the waste bio-inertised. This confirms that the RDF plant in operation will not add any pollutants to the environment.

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Pre-Combustion Phase

PVC being an organic Chlorine component gives rise to formation of Dioxin during combustion. In the RDF process PVC items are removed in the air classification system. Mercury, Cadmium and certain other heavy metals are present in batteries and electronic items. These are also removed in the air classification system. Certain Toxins produced by bio-activity in the waste are removed in the screening process along with decomposed garbage. In high moisture waste some dissolved pollutants come out in the leachate which is treated for removal of pollutants. Some pollutants generated by microbial activity are neutralized by spraying certain specific herbal enzymes which de-activate the polluting microbes.

Combustion Phase

Effective control of combustion ensures minimal generation of pollutants in the combustion process.

RDF will be combusted in a furnace equipped with a pusher grate stoker. The fuel will be spread uniformly over the grate and remain undisturbed till the combustion process is over. This will enable good combustion control.

The fuel as fired will be in the form of discrete pieces of odd shapes of about 150 mm size considered to a density of 400 kg/m^3 with a limited percentage of loose waste generated during mechanical handling of fuel from storage up to the point of delivery to the stoker.

The grate is designed for a lower specific that release per sq ft of grate area as compared with other solid fuels. This will enable maintaining a thinner bed thickness and make it possible to deliver the primary air to the grate at a lower pressure, thus minimizing the fly over of loose waste lying on the grate.

The combustion process is designed to occur in the following manner. In the first part of the grate release of volatiles is achieved. In the second part as the fuel moves on, solid components of the fuel burns and supplies heat for volatilization and maintain-a

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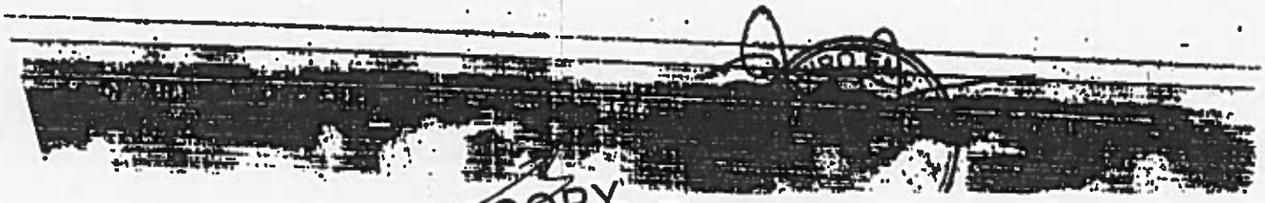
low temperature profile in this zone to minimize NO_x formation. Primary air is supplied at about 90°C to facilitate faster release of volatiles. Sub-stoichiometric air is supplied to maintain a reducing zone. As the bed moves along, combustion of solids is completed and ash gets sintered before it drops in to the water seal.

Addition of specific reagents to the fuel to combine with ingredients producing acidic fumes and form inorganic compounds that will go with the ash stream. Thus certain acid fume generation during combustion will be minimized.

As the volatiles move up in the furnace secondary air is supplied across its patch at higher velocity and temperature of about 160°C and creates a turbulence to effect thorough mixing. Air supplied here will be in the super-stoichiometric mode to maintain appropriate level of excess air to achieve complete combustion and achieve the desired temperature. Although efforts have been taken to remove organic Chlorine compounds from the waste during RDF process, any such remnants in the fuel is prone to generate Dioxin in this zone. Steps have been taken to minimize this possibility first by minimizing the fly-over of solid loose waste into this zone along with volatiles and supply solid carbon particles, which when not completely combusted form the base for dioxin formation. Secondly, the three 'T's (time, temperature and turbulence) essential for efficient combustion are maintained in the following manner to affect complete combustion and prevent presence of un-burnt carbon particles which form the base for dioxin formation.

Effective Turbulence is created by impinging the flow of volatiles with cross current jet of secondary air and ensures thorough mixing. Desired Temperature is achieved by high temperature of secondary air and thorough mixing with volatiles to ensure efficient combustion. For effecting complete combustion the Time needed is provided in the following manner. In the combustion zone if combustion is incomplete and un-burnt carbon is carried in the flue gas, furnace design provides for a two seconds residence time before the flue gas reaches the first convection heating surface whence the flue gas temperature gradient starts. Till such time the gas temperature is maintained at >850°C. This give ample Time for un-burnt carbon particles to burn out thus preventing formation of dioxin.



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Besides dioxin, there is chance of formation of acidic gases in the combustion zone especially HCl and SO_2. These will be removed in the post combustion phase of pollution control

Any remnant heavy metals like mercury and cadmium in the fuel will volatilize in the primary zone itself and the vapours will pass through the combustion zone and remain in the flue gas. These will be removed in the post combustion phase of pollution control.

Post–Combustion Phase

The flue gas treatment proposed for the project consists of dry flue gas cleaning system with a bag filter located before the ID fan. Ammonia / Urea injection is proposed in the furnace to reduce Nitrogen Oxide emission reduction. A low pressure mechanical dust collector preempts the possible resynthesis of Dioxin at lower temperature with excess air and chance present of unburnt carbon particles in the flue gas.

Lime injection before the reactor and activated carbon injection before the bag house is proposed for capturing HCL, SO2, HF & heavy metals.

All the measures taken as mentioned above will ensure that the stack emission will be well within the prescribed limits.

The bottom ash has no pollutant presence. All the other ash is collected pneumatically and they are disposed off as land fill. The pollutants from the plant is expected to be within the limits as given below.

Parameter	Limit (mg/Nm³)
NOx	200
Particulate	50
TOC	10
SO_2	50
HCL	10
HF	1

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Parameters	Limit (mg/Nm^3)
Mercury	0.05
Cd + Tl	0.05
Sb+As+Cr+V+Co+Cu+Mn+Ni+Pb	0.50
Dioxin/Furan	0.1ng-TEQ/Nm^3

Even with the acute shortage of air pollution control equipments/manufacturers in India that are capable to meet the standards envisaged by the project, all efforts would be made to meet the specific standards, with the option of outsource or import of the technology/equipments. In any case, the project will strive to meet the limits specified in table given above.

According to the CPCB norms, the Chimney height shall be calculated using the formula Height = $14 \times Q^{1/3}$, where Q= Qty of Sulphur Dioxide in kg/hr. The stack height for the boiler will be 65 M (52 m) to assimilate any contaminants. However, should monitoring indicate any adverse impacts on the environment, appropriate pollution control equipments would be provided.

Water Pollution

The contaminated streams of water are:

- RO rejects
- MB unit regeneration wastes
- Boiler Blowdown
- Auxiliary Cooling tower blow down
- Filter back wash water
- Waste water from floor washing
- Wastewater from domestic usage
- Clarifier waste

Out of the above, RO rejects, MB unit regeneration wastes and Boiler Blowdown will be neutralized before discharge to the Drain. Suspended particles from the filter backwash water and Cooling Tower blow-down will be removed for disposal after settling in the common monitoring basin. This plant is going to use air cooled condenser for condensing steam from the TG exhaust. The cooling water requirement

is basically for the auxiliary cooling only. Hence the blow down quantity will also be very much less.

In the common monitoring basin, the water will be checked for the proper pH values and TDS values to be as per the Pollution Control Board (PCB) Norms. If it is not as per the PCB Norms, adequate treatment will be done to bring in to the levels prescribed by the PCB Norms. Part of the water will be used for the green belt to be put up around the plant. Balance treated water will be pumped back to the public sewage system

Solid Waste

The solid waste generated (Sand and Silt) from the Common Monitoring Basin would be disposed off at a landfill site. The ash generated from the boiler (bottom ash and fly ash) is proposed to be disposed of to agencies, which utilize them for manufacturing building materials or as land fills.

Noise Pollution

The plant and equipment will be so specified and designed to minimize noise pollution. Major noise producing equipment such as turbo generator, compressors will be provided with suitable noise abatement enclosures. Equipment will be statically and dynamically balanced to eliminate any vibration that can lead to noise generation. Blow off valves, discharge pipes, relief valves and other noise producing static equipment will be equipped with silencers Pipelines will be suitably sized to avoid excess velocities that can lead to noise generation. Wherever necessary, insulation will be provided for reducing heat loss and noise pollution. The above abatement measures will ensure that noise levels are kept below standards from the rotating equipment. Employees in high noise areas will be provided with ear protection devices.

Bird Menace

Providing ultrasonic hooters will mitigate bird menace in the Integrated waste complex.

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8.0 OCCUPATIONAL HEALTH HAZARDS

8.1 RDF Plant

With the limited experience of processing Municipal solid waste in India, the following mentioned occurrences could lead to hazardous situations

Fire

Prolonged period of storage of MSW in its wet form can lead to spontaneous onset of fire due to biological decomposition and production of Methane. To mitigate the situation, provision has been made in the processing plant not to store raw MSW for more than 24 hours. So the fire hazard possibility has been eliminated.

Leachates

The raw MSW is stored in pits under enclosed conditions with no possibility of rainwater getting into MSW. Hence no leachates are expected. Moreover, these pits are cleaned periodically and the washings are pumped to the adjoining STP plant. These pits have proper floor slopes and sumps to pump the effluents to STP plants.

Moving Equipment

There are a large number of moving equipment in the RDF Plant and accidental occurrences can take place in few of the equipment, as mentioned below.

a) **Primary Shredder:** - During operation, the hammers may get broken and come out with high velocity. These can cause accidents. To avoid these, safety features will be built in the equipment design.

b) **Rotary Screens:** - All rotary screens are covered to ward off the dangerous occurrences.

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c) **Dryer:** - Rotary Dryer is not prone to accident of any type.

d) **Conveyors:** - Although conveyors operate at low speed but can cause some accidents due to negligence of the operating personnel. For this suitable training will be imparted to all concerned. Safety switches will be installed in all conveyor.

e) **Drives:** All moving parts like V belts, tail end and head end pulleys sprockets, etc. will be covered using appropriate safety guards to make sure that no material especially textiles come in contact.

8.2 Power plant and overall fire safety of the plant

The main occupational hazard likely can be fire and noise.

Fire protection system will be provided as per LPA (loss prevention association) norms. The total number of hydrants for the power plant will be a minimum of 30 Nos including the hydrants for Power Plant and RDF plant. The fire protection system will be provided with a main one electric driven pump, one standby diesel engine operated pump of 273 cum/hr and 88 m head and one jockey pump.

The plant and the equipment will be designed and specified with a view to minimize noise pollution to levels of 85 dBA at a distance of 1 m from the equipment. Employees will be provided with ear protection devices.

In addition, the proper Mechanical/ Electrical Shutdown procedures will be adopted by ensuring a Permit card system (to be placed and issued from the Control Room). Positive isolation of drives from the Circuit Breaker will be ensured during Electrical shutdown and Earthing of out going will also be done as and when necessary.

Worker will be trained to adapt to environmentally benign practices. "No Smoking" and hazard /-danger warning stickers will be put up at appropriate places. Emergency numbers will also be put up at appropriate places. Empty fuel drums / tanks and other inflammable material will be removed from the premises as soon as possible. Storage

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