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BOILERS FOR PALM OIL MILLS
RECENT TRENDS – SELECTION & FEATURES

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AT

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THERMODYNE TECHNOLOGIES

PALM OIL MILLS

STEAM – FUEL – POWER BALANCE

PROCESS STEAM DEMAND

- 350 kg-500 kg of steam per tonne of FFB.
- For boiler selection 450 kg-600 kg boiler capacity per tonne of FFB. This includes steam for deaerator

WASTE FUEL GENERATED

- 130 kg of Mesocarp Fibre at 39% moisture and a higher healing value (HHV) of 2800 kcal/kg (13% of FFB).
- 60 kg of cascara shell at 14% moisture and a HHV of 4390 kcal/kg (6% of FFB).
- 230 kg of EFB at 70- 75% moisture and a HHV of 1225 kcal/kg (~23% of FFB) (needs shredding & dewatering for use as a boiler fuel)
    - OTHER FUEL GENERATED
        - Biogas from ETP
        - Palm Kernel shell de oiled cake from solvent extraction plant

POWER DEMAND

- ~21 kWe per tonne of FFB for crude palm oil plant.
- Extra for kernel oil plant and refinery plant

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BOILERS FOR PALM OIL MILLS

- Self sustaining power generation met with saturated (or slightly superheated) steam at 21bar(g) pressure and to achieve fuel disposal (100% palm fibre), boiler efficiencies are typically 63% on HHV and gas outlet temperatures are around 300^{o}C.
- Any higher efficiency results in fuel saving.
- If all the generated waste fuels are burnt in a high efficiency boiler then 1TPH of steam can be generated for 1 TPH of FFB. Extra steam (0.5TPH) can be used for power generation.
- **Steam Parameters adopted in a modern palm oil mill**
  - 21 bar(g) / low SH / Low efficiency — Fuel steam power balance
  - 31 bar(g) / SH / high Efficiency
  - 41 bar(g) / SH / high efficiency

  } Results in saving of fuel and higher generation of power for use either in integrated refinery or export of power as desired by end user

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FUEL STEAM AND POWER BALANCE

Sl. No.	Plant processing capacity (FFB)	TPH	10	20	30	40	60	90	120
1	**Waste fuel generated**								
2	Palm fibre - 13% of FFB	TPH	1.3	2.6	3.9	5.2	7.8	11.7	15.6
3	Palm shell - 6% of FFB	TPH	0.6	1.2	1.8	2.4	3.6	5.4	7.2
4	EFB at 50% moisture - 12% of FFB	TPH	1.2	2.4	3.6	4.8	7.2	10.8	14.4
5	Process steam requirement	TPH	5	10	15	20	30	45	60
6	Power generation potential (kWe) for process steam requirement	Refer Note 1							
7	at 21 bar(g) / 250 ^{o}C	kWe	130	270	400	580	900	1400	2000
8	at 31 bar(g) / 330 ^{o}C	kWe	Not Viable	600	900	1250	1900	3000	5000
9	at 45 bar(g) / 410 ^{o}C	kWe	Not Viable	Not Viable	1350	1900	2900	4500	6250
10									
11	Steam generation potential from utilisation of all the waste fuels generated	TPH	9.8	19.6	29	39	59	88	117
12	Max power generationfor above conditions	Refer Note 2							
	Note 1: The power generation values are indicative considering multi stage turbines and may vary depending on the turbine manufacturer. **Note 2 : Power Generation will be 2 to 3 times that indicated at 7,8,9 depending on the fuel and steam utilisation and matching COGEN cycle(extraction or extraction condensing turbine)**								

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BOILERS SIZING & SELECTION

- DESIGN INPUT
- DESIGN CONSIDERATIONS
- BOILER CONTROLS
- INDUSTRY SPECIFIC REQUIREMENTS

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DESIGN INPUTS (FOR BOILER SIZING)…

- **FUEL CHARACTERISTICS**
- **BOILER PARAMETERS**

  Capacity, Steam outlet Pressure, Temperature, Feed water temperature.
- **BOILER EFFICIENCY**
- **AMBIENT CONDITIONS**
- **OTHER STATUTORY AND AUXILIARY STIPULATIONS**

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Fuel Characteristics …

INFLUENCING FACTORS …

- PROXIMATE ANALYSIS & ULTIMATE ANALYSIS
- ASH CHARACTERISTICS
- PHYSICAL CHARACTERISTICS
- FUEL SIZING

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Fuel Characteristics …

- **PROXIMATE ANALYSIS**
  - Fixed carbon
  - Volatile Matter
  - Total moisture
  - Ash

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Typical Bio Mass Fuel Analysis - Proximate

		Palm Fibre	Palm shell	Empty Fruit Bunch	Saw dust (partial dry)
Fixed Carbon	% wt.	11- 12	17.50	8.53	12 - 13
Volatile Matter	% wt	44 – 45	65.40	37.83	60 - 64
Total Moisture	% wt	38 - 39	14.30	50.00	18 – 20
Ash	% wt	5 - 6	2.80	3.64	1 – 1.5
Higher Heating Value	Kcal/kg	2920	4400	2460	4000 - 4500

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Ash Characteristics

- Quantum
- Alkali Compounds
- Chlorine (as Chlorides)
- Fusibility temperatures

Ash Analysis – Fusibility Temperatures

		Palm Fibre	Palm shell	Empty Fruit Bunch
Initial Deformation Temperature	**ºC**	**1120**	**1070**	**930**
Softening temperature	**ºC**	**1180**	**1130**	**990**
Fluid temperature	**ºC**	**1280**	**1290**	**1210**

Typical Requirement Of Fuel Sizing

- **Shredded biomass**

  Grate Firing (Spreader)

  - 100% < 100 mm long
  - 95 % < 50 mm long
  - 50 % < 15 mm long

- **Semi Prepared Biomass**

  Grate Firing (Gravity Feed)

  - Semi Prepared / Under Prepared

BOILER EFFICIENCY

- **CONSIDERATIONS**
  - ➢ INITIAL COST Vs. RUNNING FUEL COST
  - ➢ ENERGY CONSERVATION
  - ➢ WASTE FUEL UTILISATION
  - – **GOVERINING FACTORS**
  - ➢ Excess air
  - ➢ Flue gas Outlet Temperature
  - ➢ Moisture and Hydrogen content in Fuel
  - ➢ Ambient Temperature and Moisture in Air (Humidity)
  - ➢ Completeness of Combustion
  - ➢ Effectiveness of Insulation

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BOILER PARAMETERS

CAPACITY	- Either at 0.5 TPH per tonne of FFB or higher to generate more power (for Power export/other utilisation)
PRESSURE	- 21/31/41/65 bar(g) depending on fuel and power balance
STEAM TEMPERATURE	- 300 to 410^{o}C (higher steam temperature not advised due to chlorine presence)
FEED WATER TEMPERATURE	- 105 to 120^{o}C (120^{o}C is better suited to tackle sulphur corrosion issues)

Pressure and steam temperature are the basic design considerations for a palm oil mill boiler.

DESIGN CONSIDERATIONS

Management of combustion and alkali fouling issues of palm waste fuels with following distinctive features…

- Large furnace with conservative volumetric loading
- Low furnace outlet gas temperature to reduce ash deposition
- Strategic location and apportioning of secondary air for better combustion
- Judicious transverse pitch of super heater to reduce ash fouling
- Special spacers for super heater assemblies (For large transverse pitch)
- Judicious transverse pitch of bank tubes to reduce ash fouling

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Design Considerations … Membrane Wall Design

- Membrane wall design is characterized by:
  - Gas tight chamber
  - Effective utilisation of furnace radiant surface
  - Significant elimination of refractory and reduction of refractory maintenance
  - Less cycle time for installation
  - Excellent response to boiler load changes

Design Considerations …

Boiler Quality Material -Typically Used

CARBON STEEL – ASTM

- DRUMS - SA 516 Grade 70
- WATERWALLS - SA 210 Grade A1 (Seamless) / SA 178 GR A (ERW)
- BOILER BANK - SA 210 Grade A1 (Seamless) / SA 178 GR A (ERW)
- ECONOMIER - SA 210 Grade A1 (Seamless) / SA 192 (Seamless) / SA 178 Grade A (ERW)
- SUPER HEATER - SA 210 Grade A1 (SEAMLESS) (up to steam temperature 400°C)

ALLOY STEEL – ASTM

- SUPER HEATERS SA 213 Grade T11 UPTO 460°C (steam temperature)
  SA 213 Grade T22 UPTO 510°C (steam temperature)

SEAM LESS VS ERW

ERW successfully used up to 67 barg pressure in INDIA for furnace, boiler bank and economiser

Beyond 67 bar seamless tubes used

ERW – proven reliability over 30 years

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Design Considerations … Gas Emissions (Typical)

SUSPENDED PARTICULATE MATTER (SPM)

- **UNCONTROLLED** - 8 to 9 g/Nm^3 at inlet of SPM abatement device

SPM CONTROL DEVICES

- **Multicyclone** - upto 400 mg /Nm^3 at 10% O_2 Typical gas side draft loss of about 80 mm wc
- **Wet scrubber** - upto 100 mg / Nm^3 at 10% O_2 Typical gas side draft loss between 80 to 150 mm wc venturi type scrubbers are with higher gas side pressure drop.
- **ESP** - upto 50 mg / Nm^3 at 10% O_2 Generally with pre-collector. Typical gas side pressure drop of 25 mm wc. ESP consumes power for particulate capture. Typically 25% of the installed ESP connected power.
- **Bag Filter** - upto 50 mg / Nm^3 at 10% O_2 Typical gas side draft loss 150mm to 200 mm wc

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Design Considerations …
Gas Emissions (Typical)

- **Wet scrubber**
  Low initial cost, but still can meet SPM levels of 100 mg/Nm3.
  Slurry handling to be addressed.

- **ESP with Pre-collector**
  Low gas side pressure drop. Acid condensation during low load and startup conditions can be managed with automated temperature sensing bypass dampers to protect ESP.
  Pre collector is installed to address issues of ESP fires / extreme puffs
  High initial cost , especially in lower sizes (less than 30 T, Mill)

- **Bag Filter**
  High gas side pressure drop with associated high power consumption.
  Medium level initial cost, especially in lower sizes. Offers lowest SPM levels.

- Both ESP and bag filter are options available for dry ash collection and low SPM levels.

THERMODYNE TECHNOLOGIES

Design Considerations … Gas Emissions (Typical)

- **Other Gaseous Emissions**

  - **NOx (Oxides of Nitrogen)**

    Generally uncontrolled and typically between 400 – 500ppm for palm Waste for lower levels external mechanisms are employed for Abatement

  - **SOx (Sulphur Di Oxide)**

    Depends on fuel bound sulphur. Generally low with palm waste fuels and additionally alkali in fuel Inhibits dew point corrosion temperature rise and acid attack. Typically about 300ppm if fuel sulphur is 0.2% by Weight.

NOx and SOx - generally within permissible level in many countries, Does not warrant any additional control device.

Where applicable, low NOx can be met with in-furnace capture /External abatement device

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SOOT BLOWERS

- **STEAM SOOT BLOWERS**
  - Typical operating pressure 11 bar to 21 bar
  - **Long Retract Steam Soot Blower (LRSB)**
    - For High level cleaning requirement
    - Location can be at high gas temperature zones
    - Maximum cleaning on-line device
  - **Rotary Soot Blower (RSB)**
    - For low level cleaning requirement
    - Can be located only at gas zones with less than 550° C
- **SONIC SOOT BLOWERS**
  - Operates on sound signals of low fundamental frequency and high intensity . Pneumatically operated using compressed air (Plant air at 5-7 $kg/cm^2(g)$)
  - Typically operating time of 10-12 sec at intervals varying between 30 min to 90 min
  - Can cover high , medium , and low gas temperature zones
  - Used when ash is friable and low adhering
  - Can complement in combination with steam soot blowers for sticky and adhering ash

BIO GAS UTILISATION

- **Bio gas from effluent treatment plant can be used in two ways**
  - Directly in biogas engine, producing electrical power
  - As auxiliary fuel in boiler

- **Typical analysis**

Methane, CH_4	60% by volume
Carbon-Di-oxide, CO_2	39 % by volume
Air and hydrogen sulphide	balance
Higher heating value	5700 kcal /NM^3

- **When used in boiler**
  - Bio gas pressure at boiler inlet 2500-3000 mm wc
  - Recommended to always co-fire with main fuel for safe and sustained combustion

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EMPTY FRUIT BUNCH (EFB)

- EFB is characterised by…
  - high alkali(potash,K_20) content in ash,
  - low fusibility temperature,
  - high moisture and low calorific value .
  - presence of chlorine

- 100 % EFB can be fired in specially designed boiler. Proper fuel preparation is essential

- EFB preparation (As fired)
  - Recommended sizing (linear)
    100% < 100 mm
    95% < 50 mm
    50% < 12 mm
  - Moisture < 50 %
  - High Heating Value > 2200 Kcal/kg

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EMPTY FRUIT BUNCH (EFB)…

- Boiler Parameters :

Operating Pressure	45 bar(g)
Super heater outlet temperature	≯ 410° C

- Salient Design Features of the boiler
  - Air assisted gravity feeding
  - Special design fuel feeder
  - Reciprocating Grate
  - Tall furnace
  - Large transverse pitch for SH, with special design spacers
  - Large Pitch for bank tubes
  - For boiler capacities higher than 40 TPH , pneumatic spreading with travelling grate. (finer EFB preparation)

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BOILER CONTROLS

TYPICAL CONTROLS

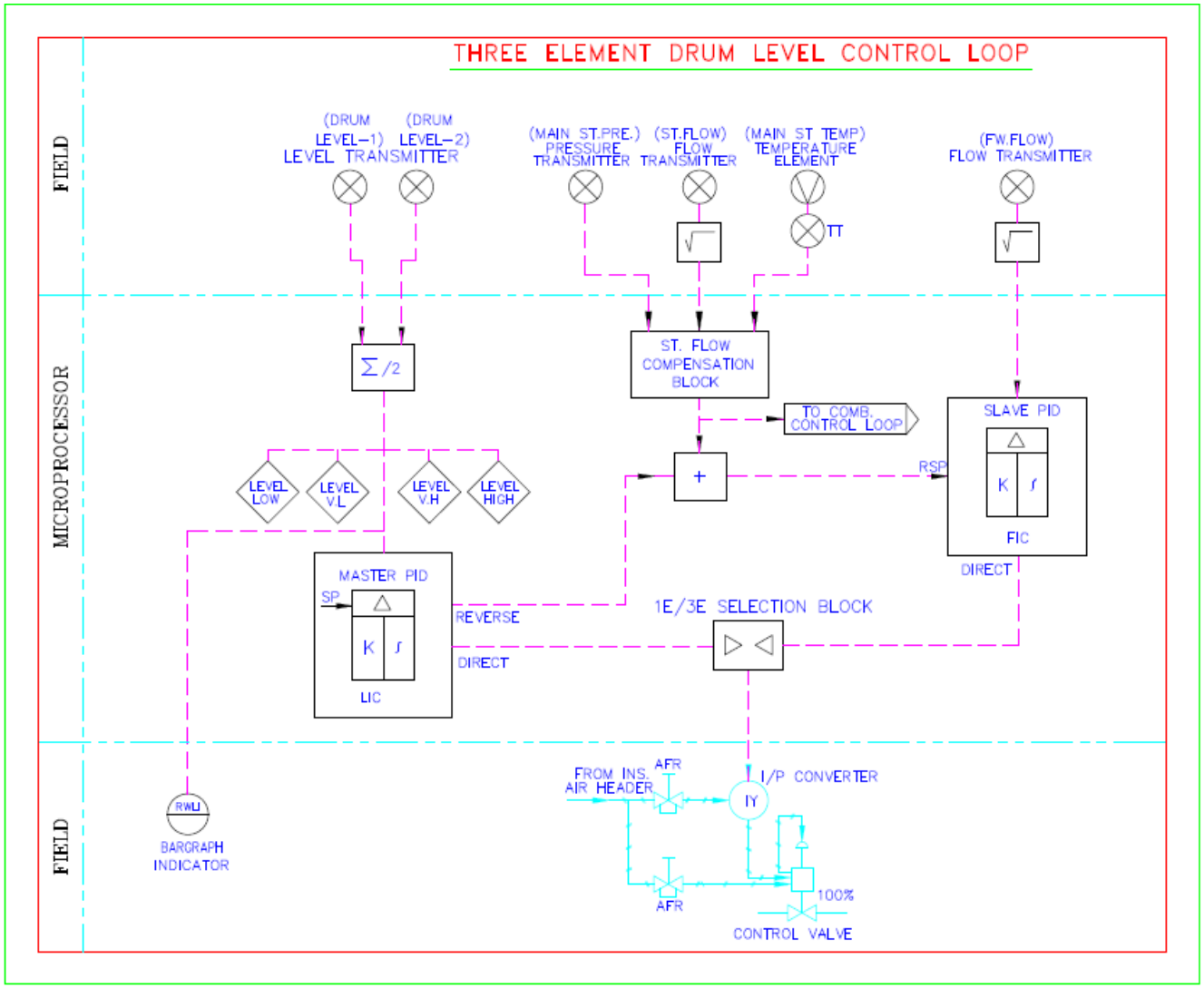
1) Drum water level control

- Single Element
- Three Element

Single element: input - drum water level for control valve operation. Does not provide fine control of water.

Three element takes signal of steam flow as well as feed water flow in addition to drum level signal

Boiler Controls …



Drum water level control

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Boiler Controls …

2) Furnace draft control

Maintains furnace pressure at near atmospheric pressure over various loads. This is done by adjusting the ID fan damper position (or speed if with VFD) after measurement of furnace pressure

Boiler Controls …

3) Combustion control

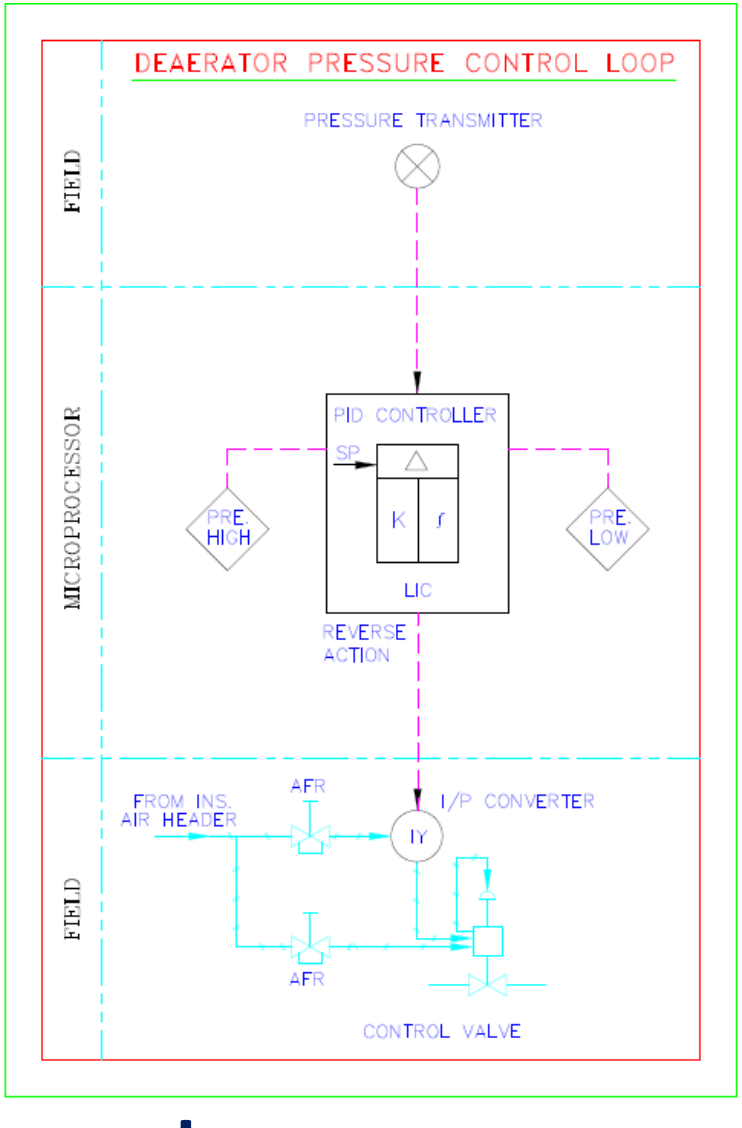
Maintains steam pressure at various boiler load Combustion air flow and fuel feeder speed is adjusted to suit load and maintain pressure

Boiler Controls …

4) **Steam temperature control**

Main steam temperature within a specified range to ensure nearly uniform temperature at turbine inlet within the control range Feed water sprayed in steam path is calculated quantities to control steam temperature. Feed water quality requirement to be as specified by boiler manufacturer.

Boiler Controls …



5. Deaerator pressure control

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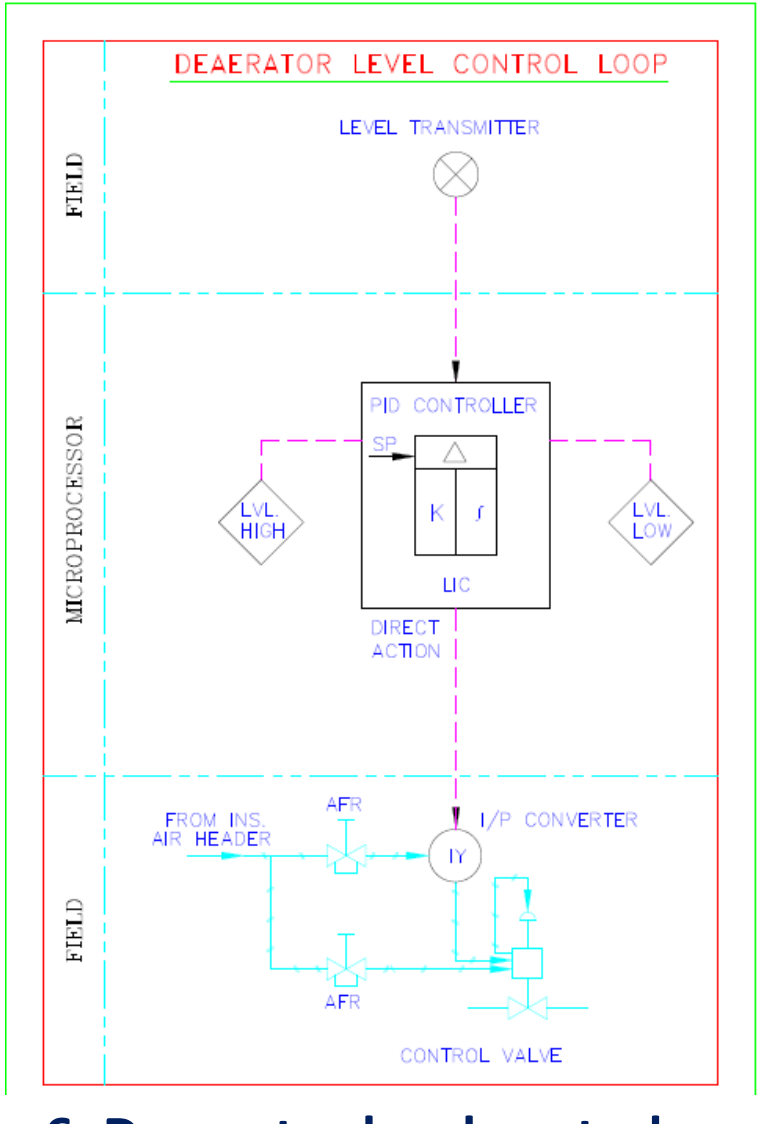
Boiler Controls …



6. Deaerator level control

Boiler Controls …

7) **Soot blower pressure control**

To limit steam pressure for soot blowing from available main steam employed only for high pressure boiler

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INDUSTRY SPECIFIC REQUIREMENTS

- POMs are a STOP & GO industry
- During peak season units are operated non stop
- During lean season – stopped up to even twice a week
- Also operated at very low loads

BOILERS FOR STOP AND GO OPERATIONS

- Low load operation / STOP & GO operation risks low gas flue temperature leading to dew point corrosion issues.
- Managed with either APH bypass or Economiser bypass or combination of both
- ECO/APH bypass protects downstream SPM control equipment
- Bypass mechanism can be Manual / Remote manual or automated

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Twin Travelling Grate

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Reciprocating Grate

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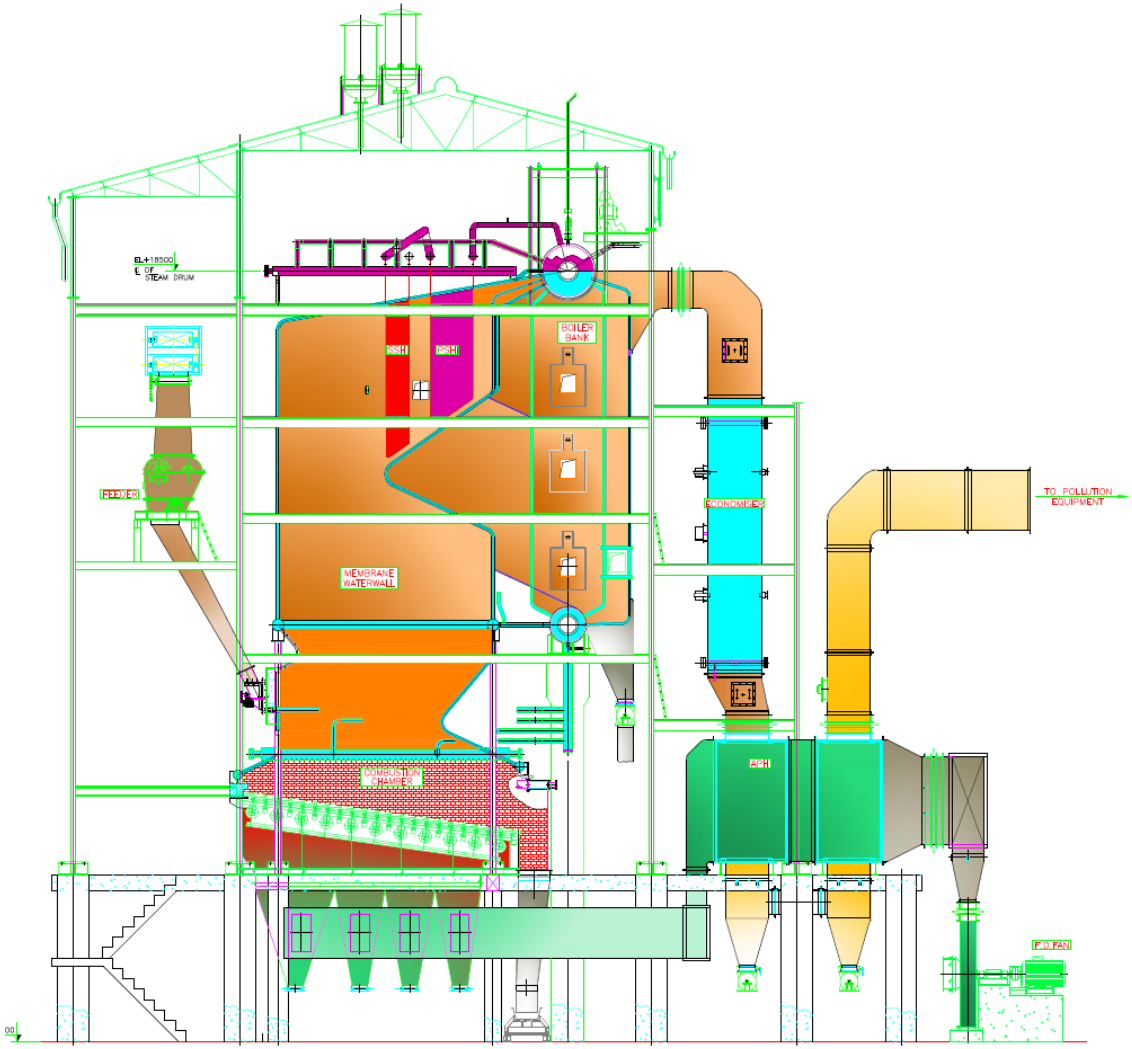
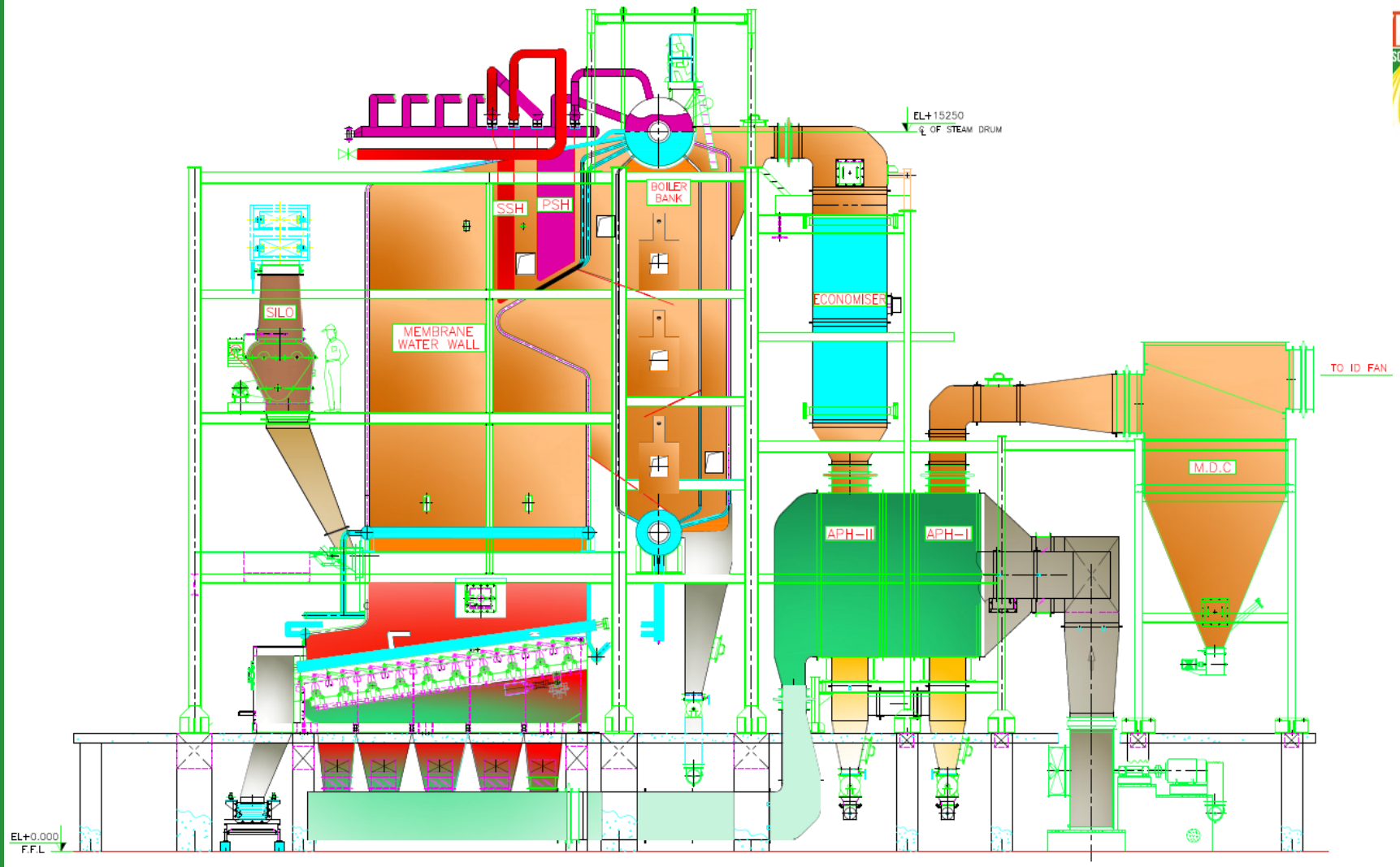


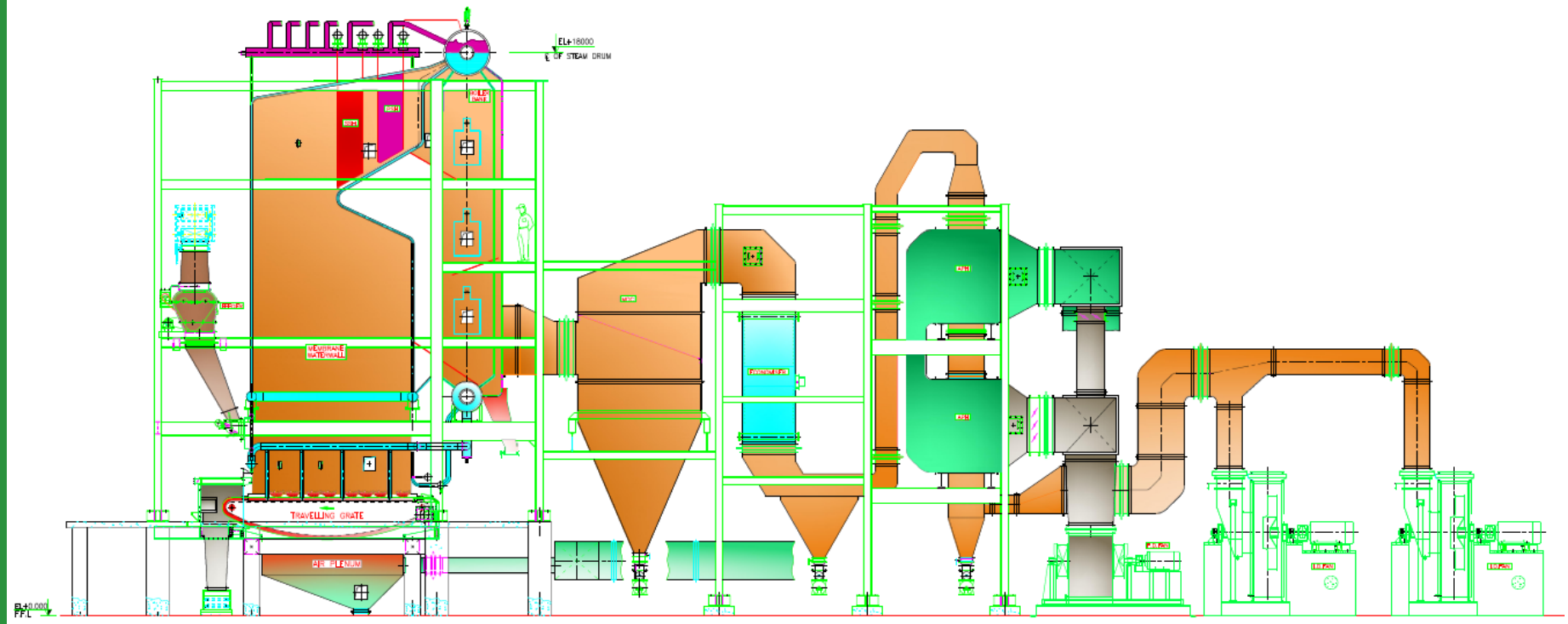
TYPE	: Bi-Drum Bottom Supported, Outdoor	CAPACITY	: 30 TPH
FUEL	: Palm Fibre /EFB/ PK Shell/Biogas	PRESSURE	: 45 bar(g)
FIRING SYSTEM	: Reciprocating grate	TEMPERATURE	: 440 ± 5 ° C
SOOT BLOWERS	: LRSB/RSB		

THERMODYNE TECHNOLOGIES



TYPE	: Bi-Drum Bottom Supported, Indoor	CAPACITY	: 35 TPH
FUEL	: Palm Fibre / PK shell	PRESSURE	: 31 bar(g)
FIRING SYSTEM	: Reciprocating grate	TEMPERATURE	: 400 ± 5 ° C
SOOT BLOWERS	: LRSB/RSB		

THERMODYNE TECHNOLOGIES



TYPE	: Bi-Drum Bottom Supported, Indoor
FUEL	: Palm Fibre / EFB
FIRING SYSTEM	: Spreader, Traveling grate
SOOT BLOWERS	: LRSB/RSB

CAPACITY	: 60 TPH
PRESSURE	: 31 bar(g)
TEMPERATURE	: 330 ± 5 ° C

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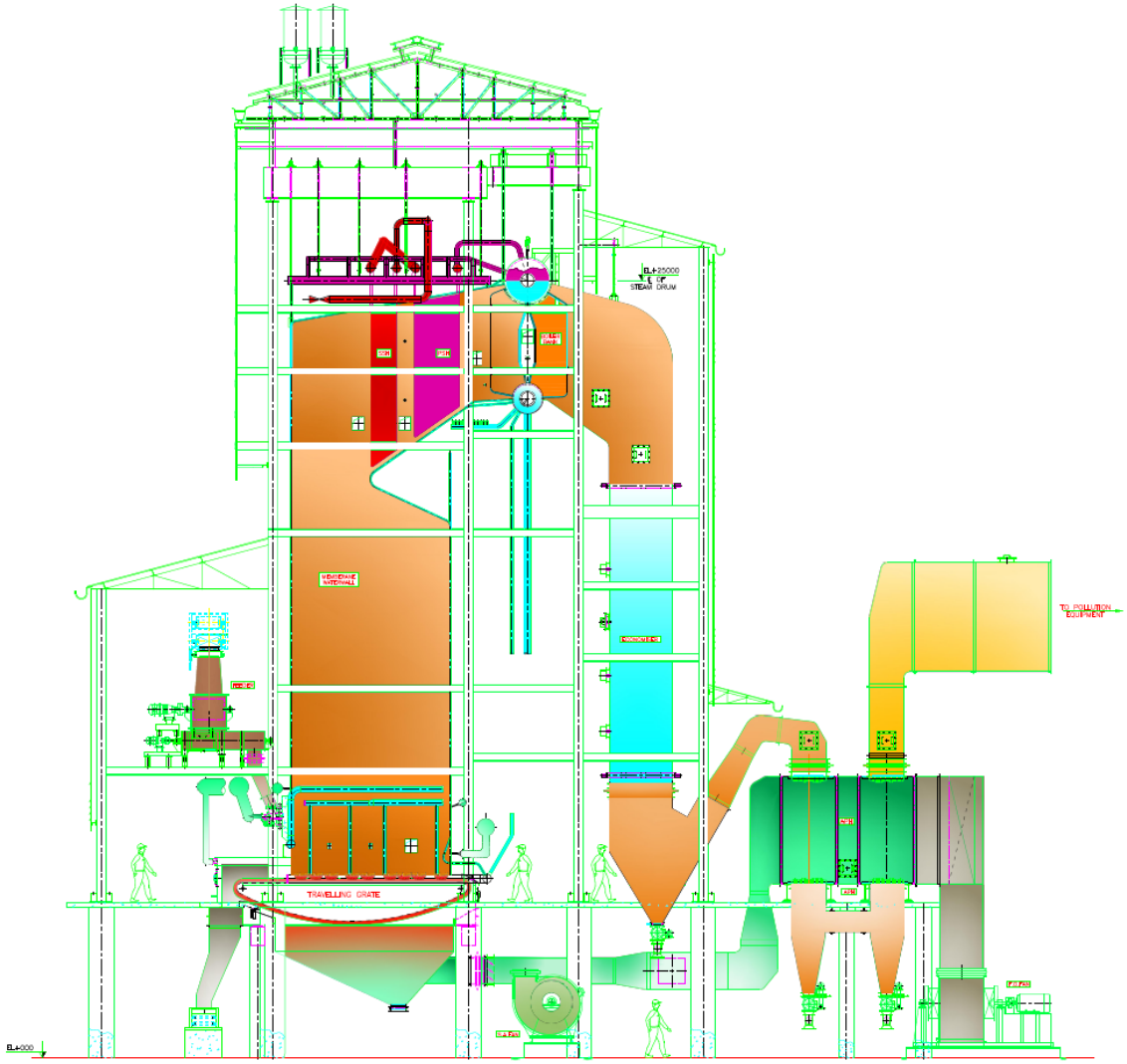
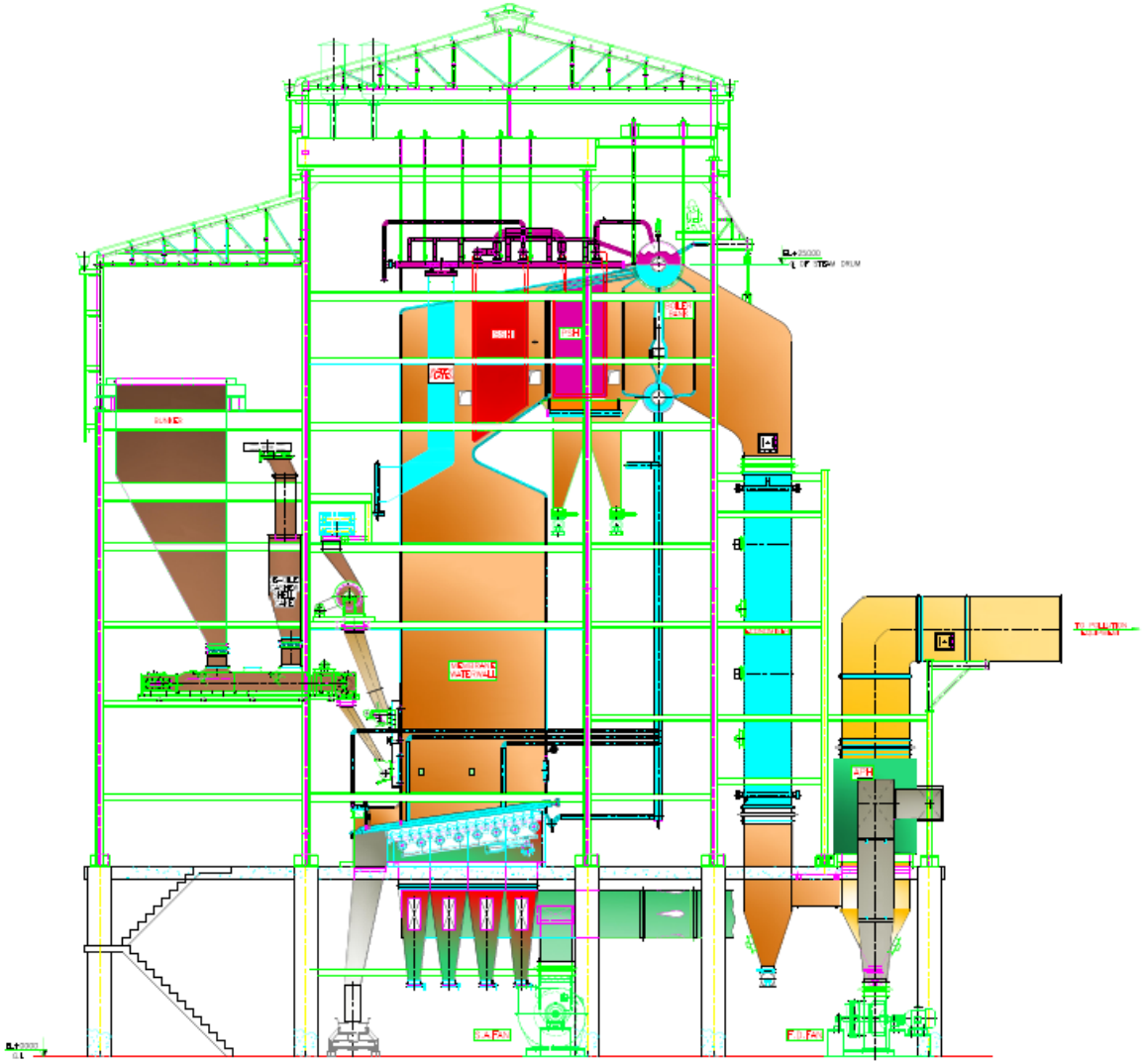


TYPE	: Bi-Drum Top Supported, Outdoor	CAPACITY	: 60TPH
FUEL	: Palm Fibre/ EFB/ PK Shell	PRESSURE	: 45 bar(g)
FIRING SYSTEM	: Spreader, Traveling grate	TEMPERATURE	: 440 ± 10 ° C
SOOT BLOWERS	: LRSB/RSB		

THERMODYNE TECHNOLOGIES



TYPE	: Bi-Drum Top Supported, Outdoor
FUEL	: Specialty Biomass
FIRING SYSTEM	: Reciprocating grate
SOOT BLOWERS	: LRSB/RSB

CAPACITY	: 34 TPH
PRESSURE	: 44 bar(g)
TEMPERATURE	: 420 ± 5 ° C

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THANK YOU

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