Appendix E2: Unit Design Data – Fluidized Bed Combustion

Note: The NERC Board of Trustees approved the GADS Task Force Report (dated July 20, 2011), which states that design data collection outside the required nine fields is solely voluntary. However, the GADS staff encourages that reporters report and update GADS design data frequently. This action can be completed by sending in this form to gads@nerc.net. GADS staff encourages using the software for design entry and updating.

Instructions
Use these forms to report design and installed equipment information for FLUIDIZED BED COMBUSTION (FBC) units. These units include atmospheric (circulating (CFB) and bubbling (BFB)) fluidized bed only.

Data reported on these forms should reflect the current condition and design of the unit (installed equipment, etc.). Do not report data for start-up equipment or for equipment that is not used to carry normal load unless specifically requested.

Some data fields are designated as M1 and M2. These indicate that the equipment being reported may have been supplied by more than one manufacturer. Use fields designated as M1 to report all the data associated with one manufacturer’s equipment and M2 for the other.

Unit Name
------------------

Location of Unit (State)
----------------------

Energy Information Administration (EIA) Number
---------------------------------------------

Regional Entity
-----------------

Subregion
----------

Date Reporter
--------------

Telephone Number
----------------

Date
---

GENERAL UNIT DATA

1. Identification
A series of codes uniquely identifies your utility and units. NERC assigned a unique code to identify your utility. You must assign the unique code that will identify the FBC unit being reported. This code may be any number from 650 to 699. Enter the unique utility and unit code and the full name of the unit below:

Utility Codes: ___________________________ Unit Codes: ___________________________

Name of Unit: ____________________________

2. **Date the Unit Entered Service**
The in-service date establishes the starting point for review of historical performance of each unit. Using the criteria described below, report the date the unit entered service:

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Day</th>
</tr>
</thead>
</table>

Criteria:

a. The date the unit was first declared available for dispatch at some level of its capability, OR
b. The date the unit first operated at 50% of its generator nameplate megawatt capability (product of the megavolt amperes (MVA) and the rated power factor as stamped on the generator nameplate(s)).

3. **Unit Loading Characteristics at Time of Unit’s Design**
Enter the number from the list below that best describes the mode of operation the unit *was originally designed for*:

1 – Base loaded with minor load following at night and on weekends
2 – Periodic startups with daily load-following and reduced load nightly
3 – Weekly startup with daily load-following and reduced load nightly
4 – Daily startup with daily load-following and taken off-line nightly
5 – Startup chiefly to meet daily peaks
6 – Other, describe ________________________________
7 – Seasonal Operation

4. **Design and Construction Contractors**
Identify both the architect/engineer and the general construction contractor responsible for the design and construction of the unit. If your utility was the principal designer or general constructor, enter “SELF.”

_____________________________ Architect/Engineer
_____________________________ Constructor

5. **Boiler – Manufacturer**
Enter the name of the manufacturer and the model or series name or number of the boiler:

_____________________________ Boiler manufacturer (original)
_____________________________ Boiler manufacturer (FBC portion) - retrofit
_____________________________ Manufacturers’ model, series name, or number (original)
_____________________________ Manufacturers’ model, series name, or number (retrofit)

6. **Boiler – Enclosure**
Is 50% or more of the boiler outdoors (not enclosed in building framing and siding)?

_____ 1 – Yes  2 – No
7. **Boiler – Nameplate Conditions**
Enter the following steam conditions for the MAIN STEAM LINES at the full-load, valves-wide-open design point:

- Steam flow rate (in lbs/hr)
- Design temperature (°F)
- Design pressure (psig)

8. **Boiler – Fuel Firing System**
Enter the type of fuel firing system found in the furnace:

1. **Circulating fluidized bed (CFB)** - an FBC with no clear region between the relatively dense bed and lean phase. A circulating bed usually has a superficial velocity greater than 13 ft./sec. and has a reinjection/recycle ratio greater than 5. Compared to a bubbling bed, a circulating bed has significantly higher solids concentration throughout the combustor.

2. **Bubbling fluidized bed (BFB)** - an FBC with a definite region between the relatively dense bed and lean phase. A bubbling bed usually has a superficial velocity of less than 13 ft./sec. and a reinjection/recycle ratio of less than 5. In addition, the fuel and sorbent are usually fed either over-bed or under-bed.

9. **Boiler – Method of Solid Feed to the Boiler**
Enter the method of feeding solid fuel, bed material and sorbent into the boiler.

- **For fuel:**
  1. **Over-bed feed (BFB)** – injection of solids above the fluidized bed into a slightly negative pressure environment where the solids then fall into the fluidized bed.
  2. **Under-bed feed (BFB)** – injection of solids through multiple points to the bottom of the fluidized bed into a positive pressure environment.
  3. **Both over-bed and under-bed feed (BFB)** - combination of the two above.
  4. **Within-bed feed (CFB)** - injection of solids through a few feed points to the fluidized bed into a positive pressure environment. (This refers to the method of fuel feed in a circulating bed.)

- **For sorbent:**
  1. **Over-bed feed (BFB)** – injection of solids above the fluidized bed into a slightly negative pressure environment where the solids then fall into the fluidized bed.
  2. **Under-bed feed (BFB)** – injection of solids through multiple points to the bottom of the fluidized bed into a positive pressure environment.
  3. **Both over-bed and under-bed feed (BFB)** - combination of the two above.
  4. **Within-bed feed (CFB)** - injection of solids through a few feed points to the fluidized bed into a positive pressure environment. (This refers to the method of fuel feed in a circulating bed.)

- **Feed with fuel:**
  1. Yes
  2. No
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For bed material

1 – *Over-bed feed (BFB)* – injection of solids above the fluidized bed into a slightly negative pressure environment where the solids then fall into the fluidized bed.

2 – *Under-bed feed (BFB)* – injection of solids through multiple points to the bottom of the fluidized bed into a positive pressure environment.

3 – *Both over-bed and under-bed feed (BFB) - combination of the two above.*

4 – *Within-bed feed (CFB)* - injection of solids through a few feed points to the fluidized bed into a positive pressure environment. (This refers to the method of fuel feed in a circulating bed.)

10. **Boiler – Type of Circulation**

Enter the type of circulation

1 – *Natural (thermal)* – water flows through furnace wall tubes unaided by circulating pumps (primarily used with subcritical units).

2 – *Controlled (forced or pump-assisted thermal)* – water flows through furnace wall and/or in-bed evaporator tubes aided by boiler recirculation pumps located in the down comers or lower headers of the boiler (used on some subcritical units).

3 – *Once through* – no recirculation of water through the furnace wall tubes and no steam drum (used on super and subcritical units).

4 – *Combination natural and controlled*

11. **Boiler – Circulation System**

Enter the following information on the pump(s) used to recirculate water through the boiler:

- Boiler recirculation pump(s) manufacturer(s)
- Number of boiler recirculation pumps per manufacturer; include installed spares
- TOTAL number of boiler recirculation pumps for the unit
- MINIMUM number of boiler recirculation pumps required to obtain maximum capacity from the unit

Enter the type of boiler recirculation pump(s) used

M1 M2

1 – *Injection (or injection seal)* – controlled-leakage boiler recirculation pumps mounted vertically with a rigid shaft designed to carry its own thrust.

2 – *Leak-less (canned, canned-motor or zero-leakage)* – leak-less pump and its motor designed as an integral pressurized sealed unit.

9 – *Other, describe*

12. **Boiler – Heat Exchange**

<table>
<thead>
<tr>
<th>In bed:</th>
<th>Reheat</th>
<th>Supht</th>
<th>Evap</th>
<th>Preheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of heat exchanger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube materials*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Total number of exchangers including spares</th>
<th>Minimum number of exchangers for full load operation</th>
<th>Location of exchangers (external/internal)</th>
<th>Square feet of surface</th>
</tr>
</thead>
</table>

**Convective:**

<table>
<thead>
<tr>
<th>Type of heat exchanger</th>
<th>Reheat</th>
<th>Supht</th>
<th>Evap</th>
<th>Preheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube materials*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of exchangers including spares</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum number of exchangers for full load operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location of exchangers (external/internal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square feet of surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Radiant**

<table>
<thead>
<tr>
<th>Type of heat exchanger</th>
<th>Reheat</th>
<th>Supht</th>
<th>Evap</th>
<th>Preheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube materials*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of exchangers including spares</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum number of exchangers for full load operation</td>
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<td></td>
</tr>
<tr>
<td>Location of exchangers (external/internal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square feet of surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*If more than one material is used, indicate each type with the predominant one mentioned first.

13. **Boiler – Char Reinjection System**

Char (unburned fuel, sorbent, and ash) is captured by the separator and transferred to disposal and/or reinjected into the fluidized bed. Enter the following information on the char reinjection system.

- Separator manufacturer(s)
- Number of separators including spares
- Minimum number of separators for full load operation
- Type of separator (cyclone, multi-clone, u-beam, horizontal)
- Separator recirculation temperature
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- Liner (refractory or water cooled)
- Type of pressure seal (lock hoppers, rotary valve, gravimetric pump, loop seal)
- Number of char reinjection systems including installed spares
- High pressure loop seal air fan(s)/blower(s) manufacturer(s)
- Manufacturer(s) of the motor(s) that drives the high pressure loop seal fan(s)/blower(s)
- Number of high pressure loop seal fans/blowers per manufacturer; include installed spares
- TOTAL number of high pressure loop seal fans/blowers for the unit
- MINIMUM number of high pressure loop seal fans/blowers required to obtain maximum capacity from the unit

Enter the type of high pressure loop seal fan(s)/blower(s) at the unit

M1  M2

1 – Injection (or injection seal) – controlled-leakage boiler recirculation pumps mounted vertically with a rigid shaft designed to carry its own thrust.

2 – Leak-less (canned, canned-motor or zero-leakage) – leak-less pump and its motor designed as an integral pressurized sealed unit.

9 – Other, describe

14. Boiler – Design Parameters

Percent SO<sub>2</sub> removal

Calcium-to-sulfur molar ratio – moles of calcium in the sorbent divided by the moles of sulfur in the fuel. (This is an indicator of the amount of sorbent required to reduce SO<sub>2</sub> to desired limit.)

Reinjection/recycle ratio – mass flow rate of char material that is reinjected to the combustor divided by the mass flow rate of fuel feed

Average superficial air velocity (ft/sec) – velocity of air through a fluidized bed. The superficial velocity is based on the cross sectional area of the bed and the total air flow rate. The density used to calculate superficial velocity is based on the average bed temperature and pressure.

Fuel feed rate

Sorbent feed rate

15. Boiler – Furnace (Surface) Release Rate

Enter the furnace (surface) release rate of the PRIMARY FUEL. This rate is specified in the boiler contract as the heat available per hour, in Btu per square foot of heat absorbing surface in the furnace. The absorbing surface includes all heat exchange surfaces (waterwall, super heater, external, etc.).

Furnace (surface) release rate at maximum continuous rating (in Btu’s/SqFt/Hr)
16. **Boiler – Furnace Volumetric Heat Release Rate**
Enter the furnace volumetric heat release rate of the PRIMARY FUEL. This rate is the total quantity of thermal energy released into the furnace by the fuel at its higher heating value (HHV). The volumetric heat release rate is expressed in Btu per cubic foot of total heat exchanger volume per hour. It does not include the heat added by preheated air or the heat unavailable due to evaporation of moisture in the fuel and combustion of hydrogen.

Furnace volumetric heat release rate at maximum continuous rating (in Btu/CuFt/Hr)

17. **Boiler – Primary and Secondary Design Fuel, Sorbents, and Non-sorbent**
The PRIMARY fuel is defined as that fuel primarily used to sustain load on the unit, (i.e., the first fuel of choice for either economic or control reasons) or that fuel contributing 50% or more of the load-carrying Btu. The SECONDARY fuel is that normally used to sustain load if the PRIMARY fuel is unavailable or uneconomical. Do NOT report ignition or warm-up fuel.

Sorbent is a material (usually a limestone or dolomite) that is fed into the combustor with the solid fuel (coal) thereby reducing the $\text{SO}_2$ that is released during the combustion process.

Non-sorbent is a material other than sorbent that is used to build the bed. All characteristics are based on an ultimate analysis of the as-received fuel using appropriate ASTM testing methods. Additional notes are provided where appropriate.

<table>
<thead>
<tr>
<th>Primary Fuel</th>
<th>Secondary Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Codes</td>
<td></td>
</tr>
<tr>
<td>BM</td>
<td>Biomass</td>
</tr>
<tr>
<td>CC</td>
<td>Coal</td>
</tr>
<tr>
<td>DI</td>
<td>Distillate Oil (No. 2)</td>
</tr>
<tr>
<td>GE</td>
<td>Geothermal</td>
</tr>
<tr>
<td>GG</td>
<td>Gas</td>
</tr>
<tr>
<td>JP</td>
<td>JP4 or JP5</td>
</tr>
<tr>
<td>KE</td>
<td>Kerosene</td>
</tr>
<tr>
<td>LI</td>
<td>Lignite</td>
</tr>
<tr>
<td>NU</td>
<td>Nuclear</td>
</tr>
<tr>
<td>OG</td>
<td>Other-Gas (Cu. Ft.)</td>
</tr>
<tr>
<td>OL</td>
<td>Other-Liquid (BBL)</td>
</tr>
<tr>
<td>OO</td>
<td>Oil</td>
</tr>
<tr>
<td>OS</td>
<td>Other-Solid (Tons)</td>
</tr>
<tr>
<td>PC</td>
<td>Petroleum Coke</td>
</tr>
<tr>
<td>PE</td>
<td>Peat</td>
</tr>
<tr>
<td>PR</td>
<td>Propane</td>
</tr>
<tr>
<td>SL</td>
<td>Sludge Gas</td>
</tr>
<tr>
<td>SO</td>
<td>Solar</td>
</tr>
<tr>
<td>WA</td>
<td>Water</td>
</tr>
<tr>
<td>WD</td>
<td>Wood</td>
</tr>
<tr>
<td>WH</td>
<td>Waste Heat</td>
</tr>
<tr>
<td>WM</td>
<td>Wind</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuel Characteristics</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Fuel</td>
<td>Secondary Fuel</td>
</tr>
<tr>
<td>Average Heat Content in Fuel (Btu/lb, Btu/bbl, Btu/CuFt)</td>
<td></td>
</tr>
<tr>
<td>% Ash Content (to one decimal place) (Btu/lb,Btu/bbl,Btu/CuF)</td>
<td></td>
</tr>
<tr>
<td>% Sulfur Content (to one decimal place) (Btu/lb,Btu/bbl,Btu/CuF)</td>
<td></td>
</tr>
<tr>
<td>% Moisture Content (to one decimal place) (Btu/lb,Btu/bbl,Btu/CuF)</td>
<td></td>
</tr>
<tr>
<td>Ash Softening Temp (°F) (in a reducing atmosphere)</td>
<td></td>
</tr>
</tbody>
</table>
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Grindability Hardgrove Index (ASTM STD D-1857, Part 26) (coal units only)

% Vanadium & Phosphorous (to one decimal place) (oil units only)

Fuel Top (largest particle) size

Grindability Hardgrove Index (ASTM STD D-409, Part 26) (coal units only)

% by Mass Magnesium Content (to one decimal place)

% by Mass Calcium Content (to one decimal place) (Btu/lb, Btu/bbl, Btu/Cuf)

% by Mass Carbon Dioxide Content (to one decimal place)

Sorbent top (largest particle size)

Non-Sorbent:

Initial Ash Fusion Temperature (°F)

Non-sorbent Top (largest particle size)

18. Boiler – Fuel Oil Forwarding System
The fuel oil forwarding system transfers oil from the main storage tanks to smaller tanks closer to the unit. (See Item 20 for pumps that feed oil directly to the burners.) Enter the following data for this system:

Fuel forwarding/transfer pump(s) manufacturer(s)

Manufacturer(s) of the motor(s) that drives the fuel forwarding/transfer pump(s)

Number of fuel forwarding/transfer pumps per manufacturer; include installed spares

TOTAL number of fuel forwarding/transfer pumps for the unit

MINIMUM number of pumps required to obtain maximum capacity from the unit

Enter the name of the manufacturers for the following burner management systems:

Manufacturer of the combustion control system that coordinates the feed water, air, and fuel subsystems for continuous unit operation.

Manufacturer of the burner management system that monitors only the fuel and air mixture during all phases of operation to prevent the formation of an explosive mixture.

20. Boiler – Fuel Oil Burner Supply System (In-plant)
These are secondary, high pressure pumps within the area of the boiler used to feed fuel oil directly to the burners.

Fuel oil burner supply pump(s) manufacturer(s)
Manufacturer(s) of the motor(s) that drives the fuel oil burner supply pump(s)

Number of fuel oil burner supply pumps per manufacturer; include installed spares

TOTAL number of fuel oil burner supply pumps for the unit

MINIMUM number of fuel oil burner supply pumps required to obtain maximum capacity from the unit

21. **Boiler – Burner Systems**

Enter the following information on the installed burner systems used for the preliminary heat up of the boiler:

**Duct burner:**

_________________________ Duct burner manufacturer

_________________________ Btu rating

Enter the type of duct burner fuel used:

A – Light (distillate) oil
B – Heavy oil
C – Gas
D – Coal
E – Oil and Gas
F – Propane
M – More than one

Enter the type of duct burner used:

1 – *Pilot torch lighter* – an oil or gas igniter that uses an electric spark to ignite the fuel
2 – *Carbon arc* – a carbon or graphite electrode that is energized and used to ignite the fuel
3 – *High energy arc* – a low voltage, high energy pulse arc that is used to ignite the fuel
4 – *Plasma arc* – a high dc voltage current used to ionize the air resulting in a high energy arc that ignites the fuel
5 – *Manual* – Ignition torch or lance inserted into boiler by operating personnel.
6 – *Combination* of any burner types above
9 – *Other, describe* ________________________________________________

**Warmup burner:**

_________________________ Warmup burner manufacturer

_________________________ Btu rating

Enter the type of warmup burner fuel used:

A – Light (distillate) oil
B – Heavy oil
C – Gas
D – Coal
E – Oil and Gas
F – Propane
M – More than one

_______ Enter the type of warmup burner used:

1 – *Pilot torch lighter* – an oil or gas igniter that uses an electric spark to ignite the fuel
2 – *Carbon arc* – a carbon or graphite electrode that is energized and used to ignite the fuel
3 – *High energy arc* – a low voltage, high energy pulse arc that is used to ignite the fuel
4 – *Plasma arc* – a high dc voltage current used to ionize the air resulting in a high energy arc that ignites the fuel
5 – *Manual* – Ignition torch or lance inserted into boiler by operating personnel.
6 – *Combination of any burner types above*
9 – *Other, describe* _______________________________________________________________________

**Lance injection burner:**

______________________________________________________________________________ Lance injection burner manufacturer
______________________________________________________________________________ Btu rating

_______ Enter the type of Lance injection burner fuel used:

A – Light (distillate) oil
B – Heavy oil
C – Gas
D – Coal
E – Oil and Gas
F – Propane
M – More than one

_______ Enter the type of duct burner used:

1 – *Pilot torch lighter* – an oil or gas igniter that uses an electric spark to ignite the fuel
2 – *Carbon arc* – a carbon or graphite electrode that is energized and used to ignite the fuel
3 – *High energy arc* – a low voltage, high energy pulse arc that is used to ignite the fuel
4 – *Plasma arc* – a high dc voltage current used to ionize the air resulting in a high energy arc that ignites the fuel
5 – *Manual* – Ignition torch or lance inserted into boiler by operating personnel.
6 – *Combination of any burner types above*
9 – *Other, describe* _______________________________________________________________________


Enter the following information on the equipment installed in the solid fuel yard:
23. **Boiler – Solid Fuel Crushers**
Enter the following information on the solid fuel crushing equipment used to supply solid fuel to the in-plant solid fuel-holding bunkers for burning in the boiler:

| Stacker/re-claimer system manufacturer | Number of critical path solid fuel conveyor systems available to the UNIT |

24. **Boiler – Solid Fuel Feed to Boiler**
Enter the following information on the solid fuel feed equipment used to supply solid fuel from the in-plant solid fuel-holding bunkers to the over-bed, under-bed, or within-bed entrance of the boiler:

<table>
<thead>
<tr>
<th>Crusher(s) manufacturer(s)</th>
<th>Manufacturer(s) of the motor(s) that drives the crusher(s)</th>
<th>Type of crusher(s)</th>
<th>TOTAL number of crushers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravimetric feeder manufacturer(s)</td>
<td>Manufacturer(s) of the motor(s) that drives the gravimetric feeder(s)</td>
<td>TOTAL number of gravimetric feeders</td>
<td></td>
</tr>
<tr>
<td>Volumetric feeder manufacturer(s)</td>
<td>Manufacturer(s) of the motor(s) that drives the volumetric feeder(s)</td>
<td>TOTAL number of volumetric feeders</td>
<td></td>
</tr>
<tr>
<td>Pneumatic feeder manufacturer(s)</td>
<td>Manufacturer(s) of the motor(s) that drives the pneumatic feeder(s)</td>
<td>TOTAL number of pneumatic feeders</td>
<td>Type of pressure seal (lock hoppers, rotary valve, gravimetric pump, loop seal)</td>
</tr>
</tbody>
</table>

25. **Boiler – Secondary Fuel Feed (other than coal)**

<table>
<thead>
<tr>
<th>Type of secondary boiler fuel feed system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – <em>Lance</em></td>
</tr>
<tr>
<td>2 – <em>Nozzle</em></td>
</tr>
<tr>
<td>9 – <em>Other, describe</em></td>
</tr>
</tbody>
</table>

| Percent (%) load carrying capability |

Enter the type of solid fuel feed(s):

| Gravimetric feeder manufacturer(s) |
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26. **Boiler – Sorbent Crusher or Pulverizer Capability**

Enter the following information on the capability of the installed crusher(s) or pulverizer(s):

- Sorbent crusher(s) or pulverizer(s) manufacturer(s)
- Manufacturers’ model number for the sorbent crusher(s) or pulverizer(s)
- Design sorbent flow rate in lb/hr PER sorbent crusher or pulverizer using design fuel specifications
- Number of sorbent crushers or pulverizers per manufacturer; include installed spares
- TOTAL number of sorbent crushers or pulverizers for the unit
- MINIMUM number of sorbent crushers or pulverizers required to obtain maximum capacity from the unit
- Sorbent stacker/reclaimer manufacturer

Enter the type of sorbent crusher(s) or pulverizer(s) at the unit:

- **M1**
- **M2**

1 – *Ball* – grinding elements are balls that operate freely in a race on a rotating grinding table

2 – *Roll race* – rotating grinding table that moves sorbent through a series of rollers or wheels supported within the pulverizer.

3 – *Ball tube (Hardinge)* – horizontal, rotating, grinding cylinder containing steel balls that move within the cylinder and grind or crush the sorbent.

4 – *Impact (Attrition)* – series of fixed or hinged hammers that rotate within a closed chamber impacting and crushing the sorbent.

9 – *Other, describe*

27. **Boiler – Sorbent Feed System to Boiler**

Enter the following information on the sorbent feeder equipment used to supply sorbent from the in-plant sorbent-holding bunkers to the boiler:

- Gravimetric feeder manufacturer(s)
- Manufacturer(s) of the motor(s) that drives the gravimetric feeder(s)
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28. **Boiler – Bed Material Injection Feed System**

Bed materials are the solids in the bed or dense phase of the combustor. Enter the following information on the bed material feed equipment used to supply bed material from the in-plant bed material-holding bunkers to the boiler:

- Gravimetric feeder manufacturer(s)
- Manufacturer(s) of the motor(s) that drives the gravimetric feeder(s)
- TOTAL number of gravimetric feeders
- Volumetric feeder manufacturer(s)
- Manufacturer(s) of the motor(s) that drives the volumetric feeder(s)
- TOTAL number of volumetric feeders
- Pneumatic feeder manufacturer(s)
- Manufacturer(s) of the motor(s) that drives the pneumatic feeder(s)
- TOTAL number of pneumatic feeders
- Type of pressure seal (lock hoppers, rotary valve, gravimetric pump, loop seal)
- Number of secondary solid fuel trains including installed spares

29. **Boiler – Balanced Draft or Pressurized Draft**

Enter the type of boiler draft:

1. **Balanced draft** – equipped with both induced draft and forced draft fans. The furnace operates at positive pressure at air entry and negative pressure at flue gas exit

2. **Pressurized draft** – equipped with forced draft fans only. The furnace and draft system operate at positive pressure

IF the unit was originally designed as a pressurized draft unit and converted to a balanced draft design, indicate the date the conversion was completed:

_Year_ _Month_ _Day_

30. **Boiler – Primary Air (Forced Draft) Fan System**
Appendix E2: Unit Design Data – Fluidized Bed Combustion

Primary air is used for combustion and/or fluidization processes. Enter the following information on the installed primary air (forced draft) fans:

- Primary air (forced draft) fan(s) manufacturer(s)
- Manufacturer(s) of the motor(s)/steam turbine(s) that drives the primary air (forced draft) fan(s)
- Number of primary air (forced draft) fans per manufacturer; include installed spares
- TOTAL number of primary air (forced draft) fans for the unit
- MINIMUM number of primary air (forced draft) fans required to obtain maximum capacity from the unit
- Horsepower of fan(s)

Enter the type of primary air (forced draft) fan(s) at the unit:

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Centrifugal – blades mounted on an impeller (or rotor) which rotates within a spiral or volute housing. Mark the type of blades used on this type of fan:

- 1 – Forward curved
- 2 – Straight (radial or radial tipped)
- 3 – Backward curved (air foil or flat)
- 4 – Axial (fixed or variable pitch) – blades attached to central hub parallel to air flow
- 9 – Other, describe

Enter the type of primary air (forced draft) fan drives(s) at the unit:

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 – Single speed motor
2 – Two speed motor
3 – Variable speed motor
4 – Steam turbine
5 – Fluid drive
9 – Other, describe

31. **Boiler – Induced Draft Fan System**

Enter the following information on the induced draft fans installed at the unit:

- Induced draft fan(s) manufacturer(s)
- Manufacturer(s) of the motor(s)/steam turbine(s) that drives the induced draft fan(s)
- Number of induced draft fans per manufacturer; include installed spares
- TOTAL number of induced draft fans for the unit
- MINIMUM number of induced draft fans required to obtain maximum capacity from the unit

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Horsepower of fan(s)

Enter the type of induced draft fan(s) at the unit:

M1 M2

Centrifugal – blades mounted on an impeller (or rotor) which rotates within a spiral or volute housing. Mark the type of blades used on this type of fan:
1 – Forward curved
2 – Straight (radial or radial tipped)
3 – Backward curved (air foil or flat)
4 – Axial (fixed or variable pitch) – blades attached to central hub parallel to air flow
9 – Other, describe

Enter the type of induced draft fan drives(s) at the unit:

M1 M2

1 – Single speed motor
2 – Two speed motor
3 – Variable speed motor
4 – Steam turbine
5 – Fluid drive
9 – Other, describe

32. Boiler – Secondary Air Fan System
Secondary air is used for purposes such as fuel transport. Enter the following information on the secondary air fans installed at the unit:

Secondary air fan(s) manufacturer(s)
Manufacturer(s) of the motor(s)/steam turbine(s) that drives the secondary air fan(s)
Number of secondary air fans per manufacturer; include installed spares
TOTAL number of secondary air fans for the unit
MINIMUM number of secondary air fans required to obtain maximum capacity from the unit

Horsepower of fan(s)

Enter the type of secondary air fan(s) at the unit:

M1 M2

Centrifugal – blades mounted on an impeller (or rotor) which rotates within a spiral or volute housing. Mark the type of blades used on this type of fan:
1 – Forward curved
2 – Straight (radial or radial tipped)
3 – Backward curved (air foil or flat)
Appendix E2: Unit Design Data – Fluidized Bed Combustion

4 – Axial (fixed or variable pitch) – blades attached to central hub parallel to air flow

9 – Other, describe

Enter the type of secondary air fan drives(s) at the unit:

M1  M2

1 – Single speed motor
2 – Two speed motor
3 – Variable speed motor
4 – Steam turbine
5 – Fluid drive
9 – Other, describe

33. Boiler – Primary Air Heating System

Enter the following information about the air heaters used to transfer the excess heat from the flue gases to the incoming primary air for the furnace:

Primary air heater(s) manufacturer(s)

TOTAL number of primary air heaters per manufacturer

Air heater outlet temperature

Enter the type of primary air heater(s) at the unit:

M1  M2

1 – Regenerative (Ljungstrom) – rotating heat exchanger that continuously rotates sections (baskets) composed of metal plates from the hot flue gas furnace exit plenum to the furnace intake air plenums thus heating the intake air.

2 – Tubular – hot flue gas from the furnace is channeled through tubes (vertical or horizontal) where the heat is transferred to the furnace intake air passing across the outside of the tubes.

3 – Steam Coil – similar to tubular except steam is used to preheat the intake air.

4 – Regenerative (Rothemule) – rotating heat exchanger similar to Regenerative (Ljungstrom) except sections (baskets) remain stationary while the housing rotates.

5 – Recuperative (plate-type) – air heater which uses thin, flat, parallel plates with alternate wide and narrow spacing to match the ratio of gas weight to air weight. Thus, flue gas is made to pass through the wider spaced passages (1" to ½") and the air through the narrower passages (3/4" to ¼") generally in counter flow relation.

6 – Heat pipe – this air heater allows the transfer of very substantial quantities of heat through small surface areas. Hollow pipes with wicking material covering the inside surface area used to transfer the heat in the following manner. A condensable fluid inside the pipes permeates the wicking material by capillary action. When heat is added by the flue gas at one end of the pipes (evaporator), liquid is vaporized in the wick and the vapor moves to the central core. At the air end of the pipes, heat is removed (the condenser) and the vapor condenses back into the wick. Liquid is replenished in the evaporator section by capillary action.

9 – Other, describe
34. **Boiler – Secondary Air Heating System**

Enter the following information about the secondary (or backup) air heaters used in the transfer of excess heat from the flue gases to the incoming primary air for the furnace:

- Secondary air heater(s) manufacturer(s)
- Total number of secondary air heaters per manufacturer
- Air heater outlet temperature

Enter the type of primary air heater(s) at the unit:

- **M1**
- **M2**

1 – *Regenerative (Ljungstrom)* – rotating heat exchanger that continuously rotates sections (baskets) composed of metal plates from the hot flue gas furnace exit plenum to the furnace intake air plenums thus heating the intake air.

2 – *Tubular* – hot flue gas from the furnace is channeled through tubes (vertical or horizontal) where the heat is transferred to the furnace intake air passing across the outside of the tubes.

3 – *Steam Coil* – similar to tubular except steam is used to preheat the intake air.

4 – *Regenerative (Rothemule)* – rotating heat exchanger similar to Regenerative (Ljungstrom) except sections (baskets) remain stationary while the housing rotates.

5 – *Recuperative (plate-type)* – air heater which uses thin, flat, parallel plates with alternate wide and narrow spacing to match the ratio of gas weight to air weight. Thus, flue gas is made to pass through the wider spaced passages (1” to ½”) and the air through the narrower passages (3/4” to ¼”) generally in counter flow relation

6 – *Heat pipe* – this air heater allows the transfer of very substantial quantities of heat through small surface areas. Hollow pipes with wicking material covering the inside surface area used to transfer the heat in the following manner. A condensable fluid inside the pipes permeates the wicking material by capillary action. When heat is added by the flue gas at one end of the pipes (evaporator), liquid is vaporized in the wick and the vapor moves to the central core. At the air end of the pipes, heat is removed (the condenser) and the vapor condenses back into the wick. Liquid is replenished in the evaporator section by capillary action.

9 – *Other, describe* ______________________________________________________________________

35. **Boiler – Soot blowers**

Enter the following information on the soot blower system installed on the furnace:

- Soot blower(s) manufacturer(s)
- Total number of soot blowers installed on the furnace per manufacturer.
- Air heater outlet temperature

Enter the type(s) of medium(s) used to blow the soot. If a variety of soot blowers are used at the unit, note the number of each.

- **M1**
- **M2**
- **M3**

1 – Steam

2 – Air
36. **Boiler – Bed Material Coolers**
Bed material coolers are heat exchangers used to cool the hot bed material as it is drained from the fluidized bed. Enter the following information on the bed material coolers:

- **Bed material cooler manufacturer**
- **TOTAL number of bed material coolers installed on the unit**
- **Bed material cooler tube materials used in the majority (50% or greater) of the tubes made by each manufacturer**
- **Bed material cooler type (screw, counter flow, fluid bed, other)**
- **Exit material temperature (°F)**

37. **Boiler – Bed Material Handling System**
Enter the following information on the bed material handling equipment:

- **Bed material handling system manufacturer**
- **Enter the type of bed material removal system used**

1. **Vacuum** – bed material conveying system operates at a vacuum relative to the bed material collection hoppers.
2. **Pressure** – bed material conveying system operates at a pressure greater than the pressure in the bed material collection hoppers.
3. **Vacuum pressure** – employs the best features of both the vacuum and pressure systems.
4. **Water (sluice)** – employs water to sluice the bed material away from the hoppers.
5. **Vacuum/water slurry** – bed material conveying system operates at a vacuum relative to the bed material collection hoppers.
6. **Mechanical** – refers to mechanical conveying systems such as conveyor belts, bucket elevators, and screw conveyors.
7. **Other, describe**

38. **Boiler – Char Disposal System**
Char (unburned fuel, sorbent, and ash) is captured by the separator and transferred to disposal and/or reinjected into the fluidized bed. Enter the following information on the char disposal handling equipment:

- **Char disposal handling system manufacturer**
- **Enter the type of bed material removal system used**

1. **Vacuum** – char disposal conveying system operates at a vacuum relative to the char disposal collection hoppers.
2. **Pressure** – char disposal conveying system operates at a pressure greater than the pressure in the char disposal collection hoppers.
Appendix E2: Unit Design Data – Fluidized Bed Combustion

3 – Vacuum pressure – employs the best features of both the vacuum and pressure systems.

4 – Water (sluice) – employs water to sluice the char disposal away from the hoppers

5 – Vacuum/water slurry – char disposal conveying system operates at a vacuum relative to char disposal collection hoppers

6 – Mechanical – refers to mechanical conveying systems such as conveyor belts, bucket elevators, and screw conveyors

9 – Other, describe

39. Boiler – Electrostatic Precipitator
Fly ash contained in the furnace exit flue gases can be removed by using an electrostatic precipitator. Enter the following information:

---------------------------------------- Electrostatic precipitator manufacturer
---------------------------------------- Number of fields
---------------------------------------- Surface collection area (SCA) (ft²/kacfm) at maximum continuous rating (MCR)

_____ Enter the location of the electrostatic precipitator with respect to the air

1 – Before air heaters
2 – After air heaters
3 – Both before and after, or between the air heaters

40. Boiler – Baghouse Fly Ash System
Fly ash contained in the furnace exit flue gas is removed using fabric or fabric bag fillers. Enter the following information:

---------------------------------------- Baghouse system manufacturer
---------------------------------------- Manufacturer(s) of the baghouse exhauster booster fan(s)
---------------------------------------- Manufacturer(s) of the motor(s) that drive the baghouse booster fan(s)
---------------------------------------- TOTAL number of baghouse booster fans installed on the unit
---------------------------------------- Air-to-cloth ratio, in ACFM/kft²
---------------------------------------- Bag material

_____ Sonic assist cleaning? 1 – Yes  2 – No

_____ Enter the type of baghouse at the unit:

1 – Reverse – clean flue gas is blown in a direction counter to normal operation to remove the fly ash from the bag.
2 – Pulse (or pulse set) – short bursts of compressed air are blown into the bag to cause a momentary expansion of the bag which dislodges the entrapped fly ash.
3 – Shaker – the bag is literally shaken to remove the fly ash collected on its surface.
4 – Combination (reverse/shaker)
9 – Other, describe
Enter the type of baghouse booster fan(s) at the unit:

*Centrifugal* – blades mounted on an impeller (or rotor) which rotates within a spiral or volute housing. Mark the type of blades used on this type of fan:

1 – Forward curved
2 – Straight (radial or radial tipped)
3 – Backward curved (air foil or flat)
4 – Axial (fixed or variable pitch) – blades attached to central hub parallel to air flow.

9 – Other, describe ___________________________________________________________________________________

41. **Boiler – Fly Ash Transport System**
Enter the following information:

______________ Fly ash removal system manufacturer

___________ Enter the type of fly ash removal system used:

1 – *Vacuum* – ash-conveying system operates at a vacuum relative to the fly ash collection hoppers. Ash is dry.
2 – *Pressure* – ash conveying system operates at a pressure greater than the pressure in the fly ash collection hoppers. Ash is dry.
3 – *Vacuum-pressure* – employs the best features of both the vacuum and pressure systems.
4 – *Water (sluice)* – employs water to sluice the ash away from the hoppers.
5 – Vacuum/water slurry – ash conveying system operates at a vacuum relative to the fly ash collection hoppers. Ash is wet.
6 – *Mechanical* – refers to mechanical conveying systems such as conveyor belts, bucket elevators, and screw conveyors.

9 – Other, describe ___________________________________________________________________________________

42. **Steam Turbine – Manufacturer**
Enter the name of the manufacturer of the steam turbine:

_________________________ Steam turbine manufacturer

43. **Steam Turbine – Enclosure**

Is 50% or more of the steam turbine outdoors (not enclosed in building framing and siding)?

_______ 1 – Yes  2 – No

44. **Steam Turbine – Nameplate Rating in MW**

“Nameplate” is the design capacity stamped on the steam turbine’s nameplate or published on the turbine guarantee flow diagram. In cases where the steam turbine’s nameplate rating cannot be determined, approximate the rating by multiplying the MVA (megavolt amperes) by the rated power factor found on the nameplate affixed to the unit’s generator (or nameplates in the case of cross compound units).

_________________________ Steam turbine’s nameplate rating (MW)
45. **Steam Turbine – Type of Steam Turbine**
Identify the steam turbine’s casing or shaft arrangement.

Enter the type of steam turbine at the unit:

1. **Single casing** – single (simple) turbine having one pressure casing (cylinder).
2. **Tandem compound** – two or more casings coupled together in line.
3. **Cross compound** – two cross-connected single casing or tandem compound turbine sets where the shafts are not in line.
4. **Triple compound** – three cross-connected single casing or tandem compound turbine sets.
5. **Other, describe**

46. **Steam Turbine – Manufacturer’s Building Block or Design Codes**
Steam turbine building blocks or manufacturer’s design codes are assigned by the manufacturer to designate a series of turbine designs (LM5000 or W501 for example). Enter the following information:

Manufacturer’s code, first shaft
Manufacturer’s code, second shaft (cross or triple compound Turbine configuration and number of exhaust flows (e.g. tandem compound, four flow)

47. **Steam Turbine – Steam Conditions**
Enter the following information on the Main, First Reheat, and Second Reheat Steam design conditions:

<table>
<thead>
<tr>
<th>Temperature (ºF)</th>
<th>Main Stream</th>
<th>First Reheat</th>
<th>Second Reheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (psig)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

48. **Steam Turbine – High, Intermediate, and Low Pressure Sections**
Enter the following information describing the various sections of the steam turbine:

**High Pressure Casings**
TOTAL number of high pressure casings, cylinders or shells
Back pressure of the high pressure condenser (if applicable) to the nearest one-tenth inch of mercury at the nameplate capacity and design water temperature.

**Combined High Pressure/Intermediate Pressure Casings**
TOTAL number of high/intermediate pressure casings, cylinders, or shells.

**Intermediate Pressure Casings**
TOTAL number of intermediate pressure casings, cylinders, or shells.
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Combined Intermediate/Low Pressure Casings

TOTAL number of intermediate/low pressure casings, cylinders, or shells.

Low Pressure Casings

TOTAL number of low pressure casings, cylinders or shells.

Back pressure of the low pressure condenser to the nearest one-tenth inch of mercury at nameplate capacity and design water temperature.

The last stage blade length (inches) of the low pressure turbine, measured from hub to end of top of blade.

49. Steam Turbine – Governing System

Enter the following information for the steam turbine governing system:

Enter the type of governing system used at the unit:

1 – Partial arc – main steam flow is restricted to one sector of the turbine’s first stage at startup.
2 – Full arc – main steam is admitted to all sectors of the turbine’s first stage at startup.
3 – Either – capable of admitting steam using either partial or full arc techniques.
9 – Other, describe

Enter the type of turbine governing system used at the unit:

1 – Mechanical hydraulic control (MHC) – turbine speed monitored and adjusted through mechanical and hydraulic linkages.
2 – Analog electro-hydraulic control (EHC) – analog signals control electro-hydraulic linkages to monitor and adjust turbine speed.
3 – Digital electro-hydraulic control (DHC) – same as EHC except signals are digital rather than analog.
9 – Other, describe

50. Steam Turbine – Lube Oil System

Enter the following information for the steam turbine main lube oil system:

Main lube oil system manufacturer.

Main lube oil pump(s) manufacturer(s).

Manufacturer(s) of the motor(s)/steam turbine(s) that drives the main lube oil pump(s).

TOTAL number of steam turbine main lube oil pumps; include installed spares.

Enter the type of driver on the main lube oil pump:

1 – Motor
2 – Shaft
3 – Steam Turbine
4 – More than one
9 – Other, describe

51. **Generator – Manufacturer**
Enter the name of the manufacturer of the electric generator:

____________________________________

Generator manufacturer

52. **Generator – Enclosure**
Is 50% or more of the generator outdoors (not enclosed in building framing and siding)?

_______ 1 – Yes  2 – No

53. **Generator – Ratings and Power Factor**
Enter the following information about the generator:

<table>
<thead>
<tr>
<th>Design (Nameplate) Item</th>
<th>Main Generator</th>
<th>Second* Shaft</th>
<th>Third* Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage to nearest one-tenth kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Megavolt amperes (MVA) Capability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Factor (enter as %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Cross compound units</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

54. **Generator – Cooling System**
Two types of cooling methods are typically used. First is the “inner cooled” method, where the cooling medium is in direct contact with the conductor copper or is separated by materials having little thermal resistance. The other is the “conventional” cooling method where the heat generated within the windings must flow through the major ground insulation before reaching the cooling medium.

_______ Enter the type of cooling method used by the generator:

1 – Stator inner cooled and rotor inner cooled.
2 – Stator conventionally cooled and rotor conventionally cooled.
3 – Stator inner cooled and rotor conventionally cooled.
9 – Other, describe

_______ ____
Enter the mediums used to cool the generator’s stator and rotor:

<table>
<thead>
<tr>
<th>Stator</th>
<th>Rotor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A –</td>
<td>Air</td>
</tr>
<tr>
<td>H –</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>O –</td>
<td>Oil</td>
</tr>
<tr>
<td>W –</td>
<td>Water</td>
</tr>
<tr>
<td>M –</td>
<td>More than one</td>
</tr>
</tbody>
</table>
55. **Generator – Hydrogen Pressure**

Enter the generator hydrogen pressure IN PSIG at nameplate MVA.

56. **Exciter – Configuration**

Enter the following information about the main exciter:

- **Exciter manufacturer**
- **TOTAL number of exciters; include installed spares.**
- **MINIMUM number of exciters required to obtain maximum capacity from the unit.**

Enter the type of main exciters used at the unit:

1 – *Static* – static excitation where D.C. is obtained by rectifying A.C. from generator terminals and D.C. is fed into rotor by collector rings.

2 – *Rotating D.C. generator* – exciter supplies D.C. from a commutator into the main rotor by means of collector rings.

3 – *Brushless* – an A.C. exciter (rotating armature type) whose output is rectified by a semiconductor device to provide excitation to an electric machine. The semiconductor device would be mounted on and rotate with the A.C. exciter armature.

4 – *Alternator rectifier*

9 – *Other, describe*

Enter the type(s) of exciter drive(s) used by the main exciter IF it is rotating:

1 – Shaft direct

2 – Shaft gear

3 – Motor

9 – *Other, describe*

57. **Auxiliary Systems – Main Condenser**

Enter the following information for the main condenser and its auxiliaries:

- **Main condenser manufacturer**
- **TOTAL number of passes made by the circulating water as it passes through the condenser.**
- **TOTAL number of condenser shells.**
- **Condenser tube materials used in the majority (50% or more) of the condenser tubes.**
- **Air ejector or vacuum pump manufacturer.**

Enter the type of air removal equipment used on the condenser:

1 – Vacuum pump

2 – Steam jet air ejector

3 – Both
9 – Other, describe

Enter the type of cooling water used in the condenser:

1 – Fresh – salinity values less than 0.50 parts per thousand.
2 – Brackish – salinity value ranging from approximately 0.50 to 17 parts per thousand.
3 – Salt – salinity values greater than 17 parts per thousand.
9 – Other, describe

Enter the origin of the circulating water used in the condenser:

1 – River
2 – Lake
3 – Ocean or Bay
4 – Cooling Tower
5 – Fresh water wells
9 – Other, describe

58. Auxiliary Systems – Condenser Cleaning System

Enter the following information about the ON-LINE main condenser cleaning system at the unit (leave blank if cleaning is manual):

On-line main condenser cleaning system manufacturer.

Enter the type of on-line main condenser cleaning system used at the unit:

1 – Ball sponge rubber
2 – Brushes
3 – Chlorination
4 – On-line backwash
9 – Other, describe

59. Auxiliary Systems – Condensate Polishing System

A “condensate polisher” is an in-line demineralizer located in the condensate water system to treat water coming from the condenser to the boiler. It is not the demineralizer that prepares raw or untreated water for eventual use in the steam production process.

Enter the following information about the condensate polishing system at the unit:

Condensate polishing system manufacturer

Enter the % treated of the condensate flow at maximum unit capacity that can be treated:

%% Treated
Appendix E2: Unit Design Data – Fluidized Bed Combustion

60. **Auxiliary Systems – Condensate Pumps**
Enter the following information for the main condensate pumps (those at the discharge of the condenser):

<table>
<thead>
<tr>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate pump(s) manufacturer(s).</td>
</tr>
<tr>
<td>Manufacturer(s) of the motor(s) that drives the condensate pump(s).</td>
</tr>
<tr>
<td>Number of condensate pumps per manufacturer; include installed spares.</td>
</tr>
<tr>
<td>TOTAL number of condensate pumps for the unit.</td>
</tr>
<tr>
<td>MINIMUM number of condensate pumps required to obtain maximum capacity from the unit.</td>
</tr>
</tbody>
</table>

61. **Auxiliary Systems – Condensate Booster Pumps**
Condensate booster pumps increase the pressure of the condensate water between the low pressure and the intermediate or high pressure feedwater heaters. Enter the following information for the condensate booster pumps:

<table>
<thead>
<tr>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate booster pump(s) manufacturer(s)</td>
</tr>
<tr>
<td>Manufacturer(s) of the motor(s) that drives the condensate booster pump(s).</td>
</tr>
<tr>
<td>Number of condensate booster pumps per manufacturer; include installed spares.</td>
</tr>
<tr>
<td>TOTAL number of condensate booster pumps for the unit.</td>
</tr>
<tr>
<td>MINIMUM number of condensate booster pumps required for maximum capacity from the unit.</td>
</tr>
</tbody>
</table>

62. **Auxiliary Systems – Feedwater (Boiler Feed) Pumps**
The feedwater (boiler feed) pumps move the feedwater through the feedwater system into the boiler. Enter the following information on the feedwater pumps installed at the unit:

<table>
<thead>
<tr>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedwater (boiler feed) pump(s) manufacturer(s).</td>
</tr>
<tr>
<td>Operating speed (RPM) of the feedwater pump(s) at full load.</td>
</tr>
<tr>
<td>Number of feedwater pumps per manufacturer; include installed spares.</td>
</tr>
<tr>
<td>TOTAL number of feedwater pumps for the unit.</td>
</tr>
<tr>
<td>MINIMUM number of feedwater pumps required to obtain maximum capacity from the unit.</td>
</tr>
<tr>
<td>PERCENT (%) of the unit’s maximum capacity that can be achieved with a single feedwater pump.</td>
</tr>
</tbody>
</table>

63. **Auxiliary Systems – Feedwater (Boiler Feed) Pump Drives**
Enter the following information for the feedwater (boiler feed) pump drives:

<table>
<thead>
<tr>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer(s) of motor(s) or steam turbine(s) that drives the feedwater pump(s).</td>
</tr>
</tbody>
</table>
Enter the type of equipment used to drive the feedwater (boiler feed) pump:

1 – Motor – single speed
2 – Motor – two speed
3 – Motor – variable speed
4 – Steam turbine
5 – Shaft
6 – Motor gear
7 – Steam gear
8 – Shaft gear
9 – Other, describe ________________________________

Specify coupling type used for feedwater (boiler feed) pump:

1 – Hydraulic
2 – Mechanical
9 – Other, describe ________________________________

64. **Auxiliary Systems – Startup Feedwater (Boiler Feed) Pumps**
Enter the following information for the startup feedwater pump(s) at the unit:

- Startup feedwater pump(s) manufacturer(s).
- Manufacturer(s) of the motor(s) that drives the startup feedwater pump(s).
- TOTAL number of startup feedwater pumps for the unit.
- PERCENT (%) of the unit’s maximum capacity that can be achieved using a single startup feedwater pump.

Indicate the additional capabilities of the startup feedwater pump:

1 – ADDITIVE: operated in conjunction with the feedwater (boiler feed) pumps.
2 – REPLACEMENT: can carry load for the feedwater (boiler feed) pumps at such times when the feedwater pumps are inoperative.
3 – STARTUP ONLY: cannot be used in lieu of the feedwater pumps.
9 – Other, describe ________________________________

65. **Auxiliary Systems – High Pressure Feedwater Heaters**
High pressure feedwater heaters are those heat exchangers between the feedwater (boiler feed) pumps discharge and the economizer inlet. Enter the following information for the HIGH pressure feedwater heaters at the unit:

- High pressure feedwater heater(s) manufacturer(s).
- Number of high pressure feedwater heaters per manufacturer.
Appendix E2: Unit Design Data – Fluidized Bed Combustion

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**Auxiliary Systems – Intermediate Pressure Feedwater Heaters**

Intermediate pressure feedwater heaters are those heat exchangers between the condensate booster pump discharge and the deaerator. Enter the following information for the INTERMEDIATE pressure feedwater heaters at the unit:

__________________________ Intermediate pressure feedwater heater(s) manufacturer(s).
__________________________ Number of intermediate pressure feedwater heaters per manufacturer.
__________________________ Feedwater heater tube materials used in 50% or more of the tubes, per manufacturer.
__________________________ TOTAL number of intermediate pressure feedwater heaters for the unit.

Enter the type of INTERMEDIATE pressure feedwater heater(s):

M1  M2

1 – *Horizontal* – longitudinal axis of the heater shell is horizontal.
2 – *Vertical* – longitudinal axis of the heater shell is vertical.
3 – *Both*
9 – *Other, describe*

---

**Auxiliary Systems – Low Pressure Feedwater Heaters**

Low pressure feedwater heaters are those heat exchangers between the condensate pump discharge and the condensate booster pump inlet. If the unit does not have condensate booster pumps, the low pressure feedwater heaters are located between the condensate pumps and the deaerator. Enter the following information for the LOW pressure feedwater heaters at the unit:

__________________________ Low pressure feedwater heater(s) manufacturer(s).
__________________________ Number of low pressure feedwater heaters per manufacturer.
__________________________ Feedwater heater tube materials used in 50% or more of the tubes, per manufacturer.
__________________________ TOTAL number of low pressure feedwater heaters for the unit.

Enter the type of LOW pressure feedwater heater(s):

M1  M2

1 – *Horizontal* – longitudinal axis of the heater shell is horizontal.
2 – *Vertical* – longitudinal axis of the heater shell is vertical.
3 – *Both*
9 – *Other, describe*
1 – *Horizontal* – longitudinal axis of the heater shell is horizontal.
2 – *Vertical* – longitudinal axis of the heater shell is vertical.
3 – *Both*
9 – *Other, describe* ___________________________________________________________________

68. **Auxiliary Systems – Deaerator Heater**
Enter the following information on the deaerator heater at the unit:

______________________________ Deaerator manufacturer(s)

__________________________ Enter the type of deaerator heater(s):

M1  M2

1 – *Spray* – high-velocity stream jet atomizes and scrubs the condensate.
2 – *Tray* – series of trays over which the condensate passes and is deaerated.
3 – *Vacuum* – a vacuum condition inside the shell for deaeration.
4 – *Combination*
9 – *Other, describe* ____________________________________________________________________

69. **Auxiliary Systems – Heater Drain Pumps**
Enter the following information for the heater drain pumps at the unit:

______________________________ Heater drain pump(s) manufacturer(s).

______________________________ Manufacturer(s) of the motor(s) that drives the heater drain pump(s).

70. **Auxiliary Systems – Circulating Water Pumps**
Enter the following information for the circulating water pumps:

______________________________ Circulating water pump(s) manufacturer(s).

______________________________ Manufacturer(s) of the motor(s) that drives the circulating water pump(s).

______________________________ Number of circulating water pumps per manufacturer; include installed spares.

______________________________ TOTAL number of circulating water pumps for the unit.

______________________________ MINIMUM number of circulating water pumps required to obtain maximum capacity from the unit DURING WINTER SEASON.

71. **Auxiliary Systems – Cooling Tower and Auxiliaries**
Enter the following information for the cooling tower and all its related auxiliary equipment at the unit:

______________________________ Cooling tower manufacturer(s)

______________________________ Cooling tower fan(s) manufacturer(s).

______________________________ Manufacturer(s) of the motor(s) that drives the cooling tower fan(s).

71. **Auxiliary Systems – Cooling Tower and Auxiliaries** (Continued)
Enter the type of cooling tower used by the unit:

M1  M2

1 – Mechanical draft (induced, forced, cross-flow and counter-flow) – fan(s) used to move ambient air through the tower.

2 – Atmospheric spray – air movement is dependent on atmospheric conditions and the aspirating effect of the spray nozzles.

3 – Hyperbolic (natural draft) – temperature difference between condenser circulating water and ambient air conditions, aided by hyperbolic tower shape, creates natural draft of air through the tower to cool the water.

4 – Deck-filled – wetted surfaces such as tiers of splash bars or decks aid in the breakup and retention of water drops to increase the evaporation rate.

5 – Coil shed – a combination structure of a cooling tower installed over a substructure that houses atmospheric coils or sections.

9 – Other, describe ____________________________________________________________

The cooling tower booster pumps increase the pressure of the circulating water and force the water to the top of the cooling tower.

___________________________________________________________________________ Cooling tower booster pump(s) manufacturer(s).

___________________________________________________________________________ Manufacturer(s) of the motor(s) that drives the cooling tower booster pump(s).

___________________________________________________________________________ Number of cooling tower booster pumps per manufacturer; include installed spares.

___________________________________________________________________________ TOTAL number of cooling tower booster pumps for the unit.

___________________________________________________________________________ MINIMUM number of cooling tower booster pumps required to obtain maximum capacity from the unit.

72. **Balance of Plant – Main Transformer**

The “main transformer” is the unit step-up transformer connecting the generator (or multiple generators if unit is cross compound) to the transmission system. Enter the following information for the MAIN transformer(s) at the unit:

___________________________________________________________________________ Main transformer(s) manufacturer(s).

___________________________________________________________________________ TOTAL number of main transformers per manufacturer; include installed spares.

___________________________________________________________________________ Megavolt ampere (MVA) size of the main transformer(s); per manufacturer

___________________________________________________________________________

Enter the type of MAIN transformer at the unit

M1  M2

1 – Single phase

2 – Three phase

9 – Other, describe ____________________________________________________________
73. **Balance of Plant – Unit Auxiliary Transformer**
   The “unit auxiliary transformer” supplies the auxiliaries when the unit is synchronized. Enter the following information for this transformer:

   _________________  
   Unit auxiliary transformer(s) manufacturer(s).

   _________________  
   TOTAL number of unit auxiliary transformers per manufacturer.

   _________________  
   LOW SIDE voltage in kilovolts (kV) of the unit auxiliary transformer(s) at 55 °F, per manufacturer

74. **Balance of Plant – Station Service Transformer**
   The “station service (start-up) transformer” supplies power from a station high voltage bus to the station auxiliaries and also to the unit auxiliaries during unit start-up and shutdown. It also may be used when the unit auxiliary transformer is not available (or nonexistent).

   _________________  
   Station service transformer(s) manufacturer(s).

   _________________  
   TOTAL number of station service transformers per manufacturer.

   _________________  
   HIGH SIDE voltage in kilovolts (kV) of the station service transformer(s) at 55 °F, per manufacturer

   _________________  
   LOW SIDE voltage in kilovolts (kV) of the station service transformer(s) at 55 °F, per manufacturer

75. **Balance of Plant – Auxiliary (Start-up) Boiler**
   Enter the following information on the auxiliary boiler at the unit:

   _________________  
   Auxiliary boiler manufacturer(s).

76. **Balance of Plant – Auxiliary Generator**
   Enter the following information on the auxiliary generator at the unit:

   _________________  
   Auxiliary generator manufacturer(s).

   ____________  
   Is the auxiliary generator shaft driven?

   M1  M2

   1 – Yes
   2 – No

77. **Balance of Plant – Plant Process Computer**
   Enter the following information for the plant process computer(s):

   _________________  
   Plant process computer manufacturer(s).

   ____________  
   Enter the number of plant process computers available to the unit

   M1  M2

   1 – One computer for this unit only.
Appendix E2: Unit Design Data – Fluidized Bed Combustion

2 – Two computers for this unit only.
3 – One computer shared by one or more units.
4 – Two computers shared by one or more units.
9 – Other, describe ________________________________

_____________________________ Describe how the plant process computers are linked within the plant:

M1   M2

1 – Centralized
2 – Distributive
3 – Stand alone
9 – Other, describe ________________________________

77. Balance of Plant – Plant Process Computer (Cont.)

_____________________________ Enter the system capability of the plant process computer:

M1   M2

1 – Monitor only
2 – Monitor and control
9 – Other, describe ________________________________

_____________________________ System vendor

First certified date

__________________________
Year          Month          Day

__________________________ Monitoring technique

1 – Extractive
2 – Dilution
3 – In Situ

__________________________ Analysis Method

1 – Wet
2 – Dry
9 – Other, describe ________________________________

79. CEMS – Pollutant Gas and Diluent Gas Analyzers/Monitors

**Sulfur Dioxide (SO₂) Analyzers**

_____________________________ Manufacturer(s)

_____________________________ Model number(s)
### Number of installed analyzers

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

### Number of installed spare analyzers

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

### Type(s)

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

1 – Ultraviolet
2 – Infrared
3 – Fluorescence
9 – Other, describe

### Instrument range (parts per million)

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

1 – 0-50
2 – 0-150
3 – 0-500
9 – Other, describe

### Shared? (1 - Yes, 2 – No)

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

### Oxides of Nitrogen (NOx) Analyzers

<table>
<thead>
<tr>
<th></th>
<th>Manufacturer(s)</th>
<th>Model number(s)</th>
</tr>
</thead>
</table>

### Number of installed analyzers

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

### Number of installed spare analyzers

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

### Type(s)

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>

1 – Infrared
2 – Chemiluminescent
9 – Other, describe

### Instrument range (parts per million)

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
</table>
### Carbon Monoxide (CO) Analyzers

<table>
<thead>
<tr>
<th>Manufacturer(s)</th>
<th>Model number(s)</th>
<th>Number of installed analyzers</th>
<th>Number of installed spare analyzers</th>
<th>Type(s)</th>
<th>Instrument range (parts per million)</th>
<th>Shared?</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>M2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 – Infrared solid state  
2 – Infrared luft  
3 – Gas filter correlation  
9 – Other, describe

### Carbon Dioxide (CO₂) Analyzers

<table>
<thead>
<tr>
<th>Manufacturer(s)</th>
<th>Model number(s)</th>
<th>Number of installed analyzers</th>
<th>Number of installed spare analyzers</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>M2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix E2: Unit Design Data – Fluidized Bed Combustion

#### Oxygen (O₂) Analyzers

<table>
<thead>
<tr>
<th>Manufacturer(s)</th>
<th>Model number(s)</th>
</tr>
</thead>
</table>

Number of installed analyzers

Number of installed spare analyzers

Type(s)

| 1 | Zirconia oxide |
| 2 | Paramagnetic   |
| 3 | Fuel cell      |

#### Opacity Monitors

<table>
<thead>
<tr>
<th>Manufacturer(s)</th>
<th>Model number(s)</th>
</tr>
</thead>
</table>

Number of installed analyzers

Instrument range (parts per million)

| 1 | 0-50 |
| 2 | 0-150 |
| 3 | 0-500 |

Shared? (1 - Yes, 2 – No)
80. **CEMS – Flue Gas Flow Monitors**

Manufacturers

Model number(s)

Number of installed monitors

Number of installed spare monitors

Volumetric Flow Rate (ACFM):

Flow rate measurement technique

1 – Thermal sensing (hot-wire anemometer or dispersion)
2 – Differential pressure array
3 – Acoustic velocimetry (ultrasonic transducers)
4 – Combination
9 – Other, describe

81. **CEMS – Data Acquisition and Reporting System**

Hardware manufacturer(s)

Hardware architecture

1 – Vendor-supplied dedicated system
2 – Modified existing plant computer
3 – Stand alone, pc-based system not supplied by CEMS system vendor
9 – Other, describe

Software supplier

Shared? (1 - Yes, 2 – No)
NOₓ REDUCTION SYSTEMS

These systems include Selective Non-catalytic Reduction, Selective Catalytic Reduction, Catalytic Air Heaters, and Staged NOₓ Reduction, which is a combination of the three methods. Excluded from this category are Low NOₓ burners, combustion modifications, and flue gas recirculation.

Please complete the following information for the NOₓ Reduction Systems installed on your unit. (The appropriate items under each method should be completed for a Staged NOₓ Reduction System).

82. Selective Non-Catalytic Reduction System (SNCR)

_______ Reagent

1 – Ammonia
2 – Urea
9 – Other, describe 

_______ Injector Type

1 – Wall nozzles
2 – Lance
9 – Other, describe 

_______ Injection Equipment Location

1 – Furnace
2 – Superheater
3 – Economizer
9 – Other, describe 

_______ Number of Injectors

_______ Carrier Gas Type

1 – Steam
2 – Air
9 – Other, describe 

_________________________________________ Total flow rate (lb/hr)

_________________________________________ Pressure at nozzle (psi)

_________________________________________ Nozzle exit velocity (ft/sec)

83. Selective Catalytic Reduction System (SCR)
<table>
<thead>
<tr>
<th>Reactor</th>
<th>1 – Separate</th>
<th>2 – In Duct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flue gas take-off location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reagent</td>
<td>1 – Ammonia</td>
<td>2 – Urea</td>
</tr>
<tr>
<td></td>
<td>9 – <em>Other, describe</em></td>
<td></td>
</tr>
<tr>
<td>Ammonia Injection Grid Location</td>
<td>1 – Furnace</td>
<td>2 – Superheater</td>
</tr>
<tr>
<td></td>
<td>3 – Economizer</td>
<td>4 – Zoned</td>
</tr>
<tr>
<td>Duct Configuration</td>
<td>1 – Flow straighteners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 – Turning vanes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 – Dampers</td>
<td></td>
</tr>
<tr>
<td>Catalyst Element Type</td>
<td>1 – Plate</td>
<td>2 – Honeycomb</td>
</tr>
<tr>
<td></td>
<td>9 – <em>Other, describe</em></td>
<td></td>
</tr>
<tr>
<td>Catalyst Support Material</td>
<td>1 – Stainless steel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 – Carbon steel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 – <em>Other, describe</em></td>
<td></td>
</tr>
<tr>
<td>Catalytic Material Configuration</td>
<td>1 – Vertical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 – Horizontal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 – <em>Other, describe</em></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E2: Unit Design Data – Fluidized Bed Combustion

________________________ Surface face area (sq. ft.)
________________________ Catalyst volume (cu. ft.)
________________________ Number of layers
________________________ Layer thickness (inches)

_____ Soot blowers (if applicable)

1 – Air
2 – Steam
3 – Both air and steam

________________________ Manufacturer(s)
________________________ Number of soot blowers

84. Catalytic Air Heaters

_____ Element Type

1 – Laminar surface
2 – Turbulent surface
9 – Other, describe __________________________

_____ Support Material, if any

1 – Stainless steel
2 – Carbon steel
9 – Other, describe __________________________

_____ Catalyst Material Configuration

1 – Horizontal air shaft
2 – Carbon steel
9 – Other, describe __________________________

________________________ Total face area (sq. ft.)
________________________ Open face area (sq. ft.)
________________________ Layer thickness (inches)