Commercial Biomass Boiler Technology

2nd Maine Modern Wood Heat Symposium

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Bede W. Wellford

Renewable and Sustainable Business Development Manager

Viessmann Manufacturing Company (U.S.), Inc.

wefb@viessmann.com

207-965-2799

Important Topics for Biomass Boiler Selection and Performance

- Matching Equipment to Wood Fuel
- Combustion Technology
- Controls
- Hydronics, including Buffer Tanks, Thermal Storage and System Integration
- Testing and Certification
- Commissioning and Tuning
- Maintenance and Cleaning

Wood Fuels

- Fuel type determines efficiency and emissions potential
- Pellets
  - Inherently Dry and Dense
  - Highest Yield
  - Lowest Emissions
- Dry Chips
  - Lower moisture content than wet chips means better yield and lower emissions than “forest chips”
- Wet Chips
- Mechanical dimensions (for chips)

Fuel System Considerations

Pellet and Chip Specification and Delivery

- Really should be question #1! “What are you going to burn and how/where will you get it?
- Pellets
  - System Size
  - Minimize Capital Investment
  - Bulk Delivery Available?
- Dry Chips
  - Impact on Equipment Choices
  - Availability?
- Wet Chips
  - Sources
  - Supplier Capabilities?
  - Supplier “Discipline”

Biomass Boiler Technology

- “Gasification”
- Firetube Construction
- Refractory
- Jacket Insulation
- Moving Grate
- Automatic Deashing
- Pneumatic Tube Cleaning
- O2 Sensor and Temperature feedback for combustion control
- Safety Systems

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Codes and Standards Certification

- ASME “H” stamp and traceable certification for the boiler vessel itself
- UL 2523 for safety and assured compliance with local, state and federal codes
- Test results to EN 303-5 and independent performance certification available (or the equivalent) including efficiency and emissions

Biomass Boiler Technology

The Big Picture

Biomass Boiler Technology

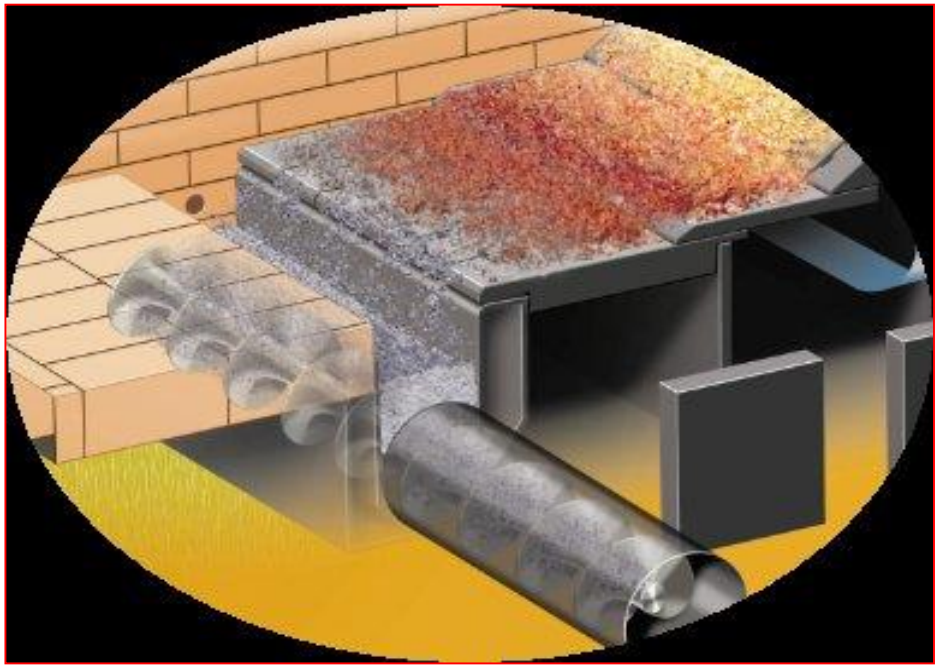
Construction for Efficiency

- Refractory
- Jacket Insulation

Biomass Boiler Technology

Moving Grates and Automatic De-ashing

- Moving Grates suitable for the fuel allow for untended operation and maximum efficiency.
- Automatic De-ashing is essential to these goals and is highly cost effective over a short time based on labor costs.



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Pneumatic Tube Cleaning

- Pneumatic Cleaning essentially doubles the service interval for tube brushing in a horizontal firetube boiler– 300 to 600 hours.
- Vertical firetube boilers incorporate mechanical cleaning.
- Automatic cleaning also provides more consistent and higher efficiency heat transfer.

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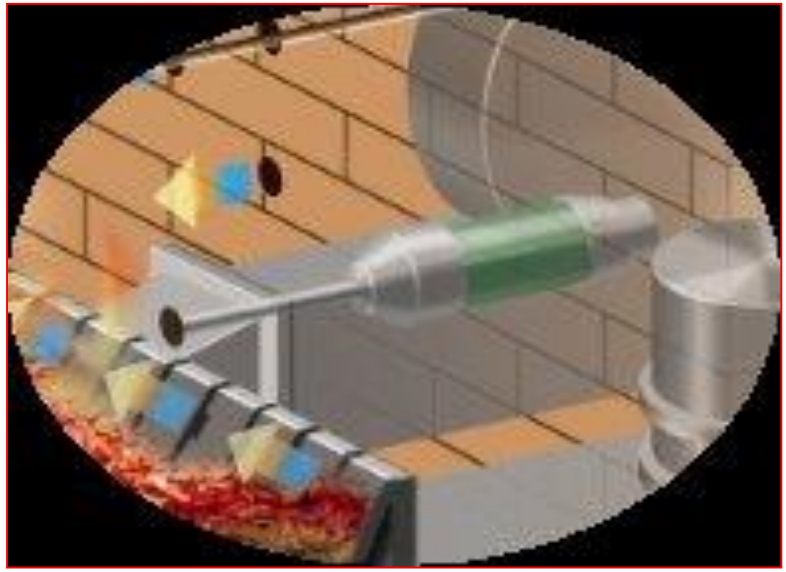
Automatic Ignition

- Automatic Ignition:
  - - enables hands off operation
  - - eliminates stand by fuel waste
  - - permits operation only at high combustion efficiency, minimizing fuel use and emissions



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O2 Sensor and Temperature Sensing

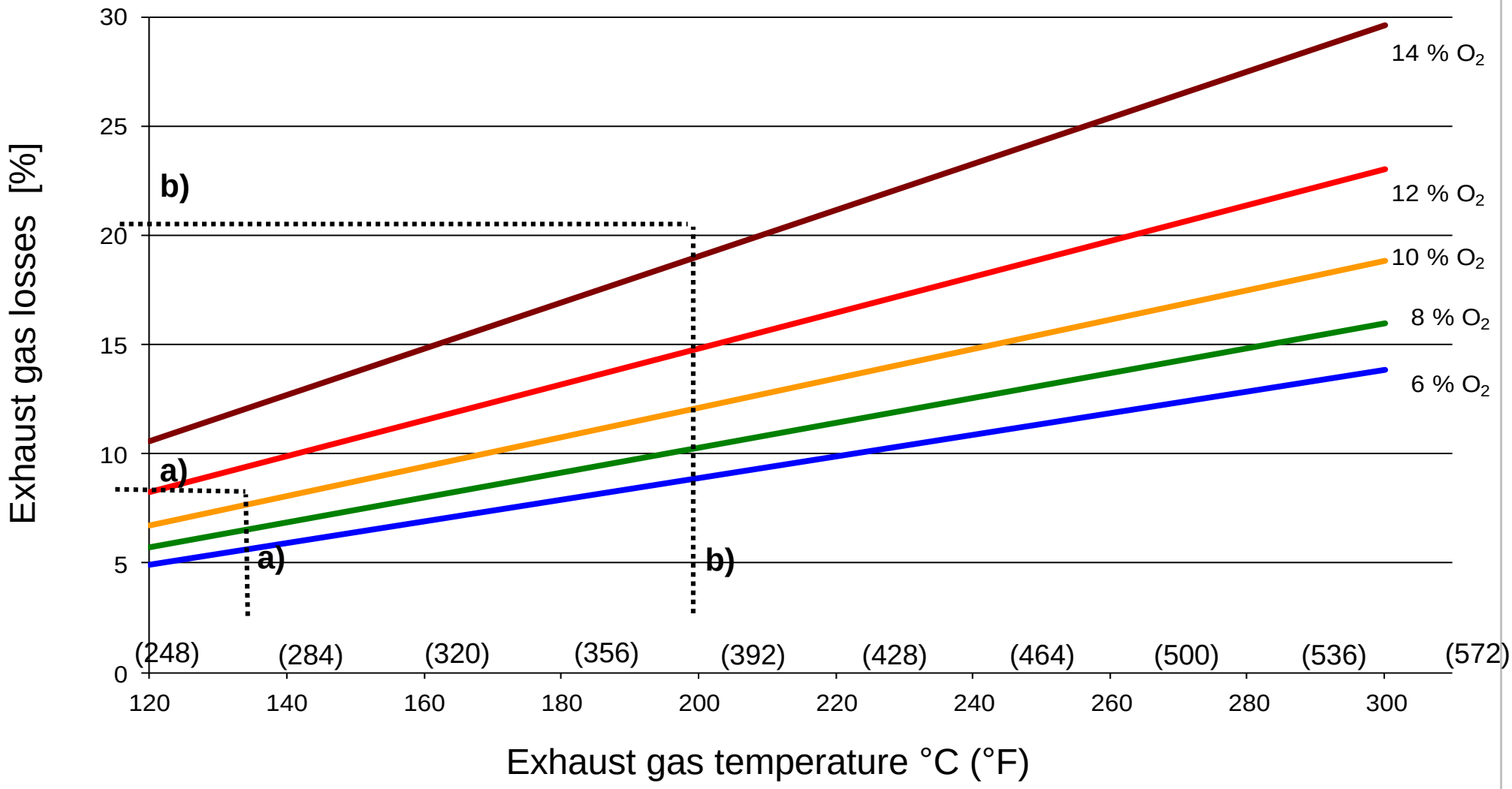
- The combination of temperature sensing and O2 (lambda) measurement along with variable speed exhaust fan control is essential to achieving the highest possible utilization of fuel and minimizing waste heat.

Biomass Boiler Technology

Elements of Combustion Control

- Discrete primary and secondary combustion
- Control grate temperature to prevent clinkering (especially with drier fuels)
- Fuel feed rate via feedback loop to match output and minimize O2
- Minimize excess O2 in exhaust gases minimizes exhaust volume
- Minimize exhaust gas temperature through properly sized heat exchanger (and cleanliness)
- Firebox pressure regulation is dependent on technology
- Turn down ratio of 4:1 is desirable; widest possible without “smoldering”
- Automatic ignition and hydronic buffering expand the effective turndown

Impact of exhaust gas temperature and excess air on efficiency



a) Good Control **b) Poor Control**

Biomass Boiler Technology

Emissions

- Discrete Gasification
- Primary Combustion Temperature Control
- Multi-Cyclone
- Additional controls only if required for very stringent local applications: Electrostatic and Baghouse filters

Hydraulic and System Design

- Boiler Sizing – The 60/90 Rule – always applicable?
- Multiple boiler approaches and rationale – economics?
- Boiler pump and 3-way valve
- Buffer tank advantage
- Buffer tank sizing
- Buffer tank sensing
- “Hydraulic Switching”
- Integration with the building heating loop
- OA and Night Setback?
- Integration and control of back-up fossil fuel boilers
- Integration of solar thermal?

Hydraulic and System Design

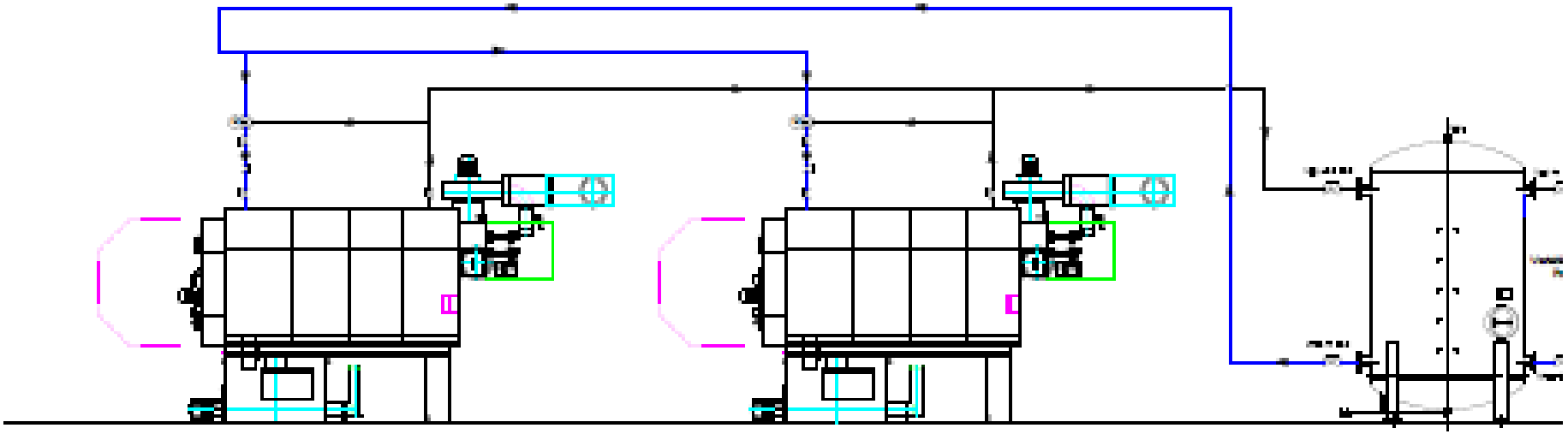
Sizing and Multiple Boilers

- Boiler Sizing “60 90 Rule”
  - In general for space conditioning applications in commercial/institutional buildings: sizing boiler output to 60% of design load will offset 90% of fossil fuel use.
  - Caveats:
    - Morning warm up should be staged to allow wood to catch up
    - Spaces dominated by process loads
- Multiple Boiler Approaches
  - Pony Boiler
  - Cascade

Hydraulic and System Design

Boiler Pump and 3-way Valve

- Each boiler supplied with its own dedicated valve and 3-way pump



Hydraulic and System Design

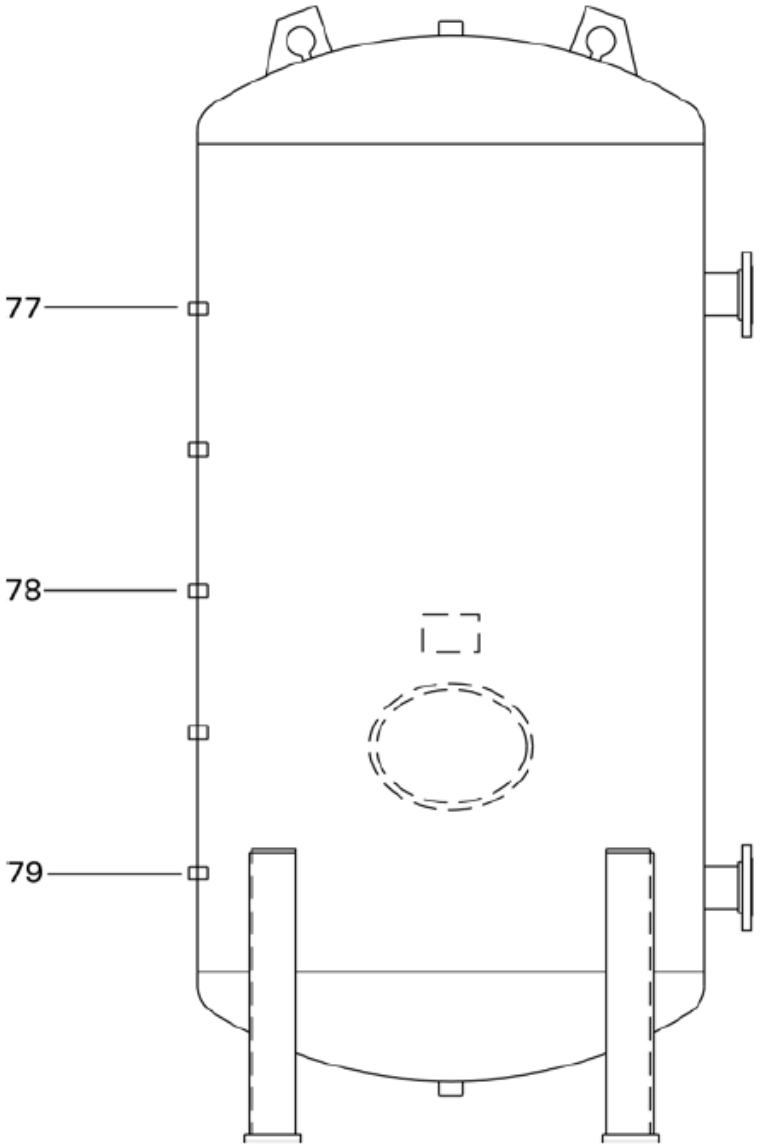
Buffer or Thermal Storage Tank

- Size at a minimum of 10 liters per kW
- Some programs will require as much as twice this volume, based on understanding of the impact of simplified control strategies.
- Pressurized systems for commercial buildings will require the ASME “U” stamp
- Provide code required PRV

Hydraulic and System Design

“Hydraulic Switching”

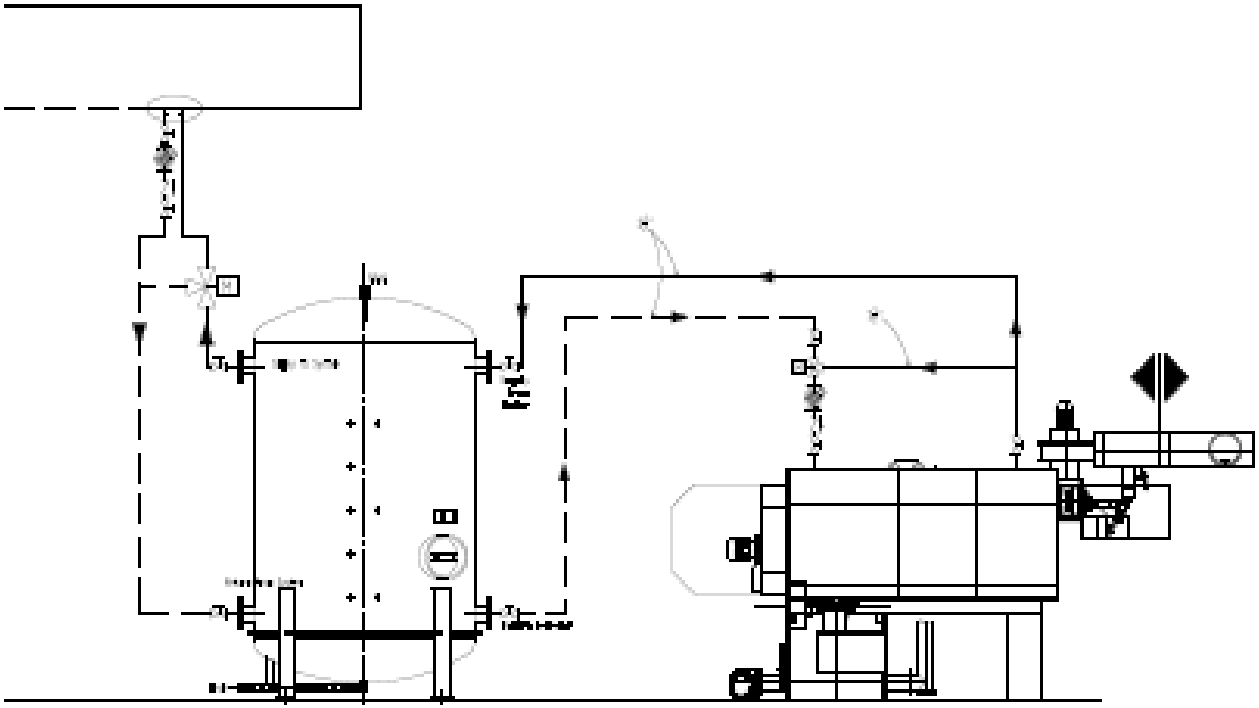
- Hydraulic switching is dependent on how we look at the thermal storage tank and what we do with the information.
- Three to five sensors are used.
- Goals are essentially three:
  1. Anticipate load with stored heat
  2. Anticipate absence of load with ability to store excess heat
  3. Modulate boiler output in the transition



Hydraulic and System Design

Integration with the Building Heating Loop

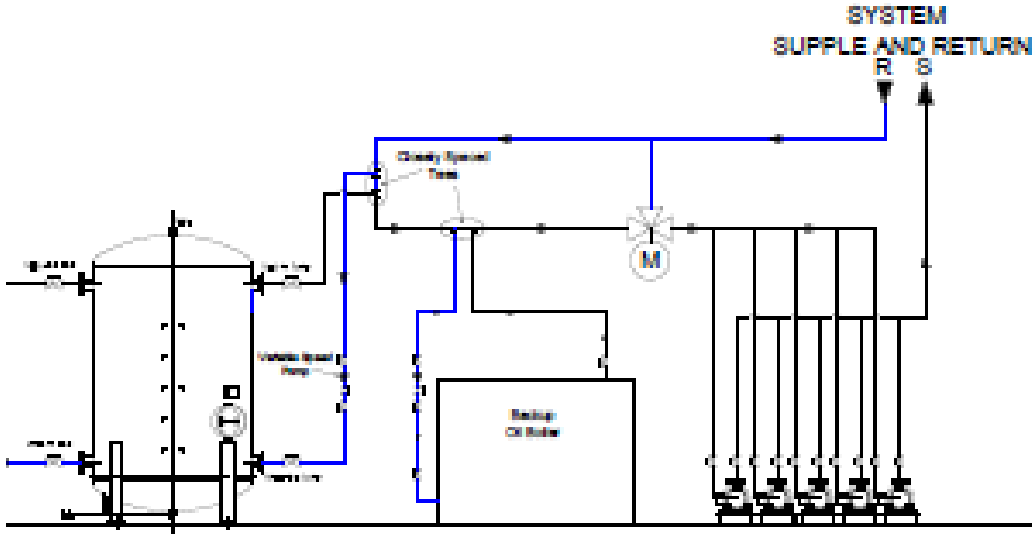
- Do connect the buffer tank to the loop via closely spaced tees.
- Do not run the entire loop through the buffer tank.
- Do utilize a three way valve and/or injection pump to “meter” heat from the buffer to the loop.



Hydraulic and System Design

Integration and Control of Fossil Fuel Back Up Boiler(s)

- Do connect the fossil fuel boiler to the loop via closely spaced tees.
- Do utilize the boilers' three way valve and boiler pump to control. Depends on boiler type and controls.
- Do set the fossil fuel boiler set points sufficiently below the buffer tank temperature to preclude their overriding the buffer at the return and preventing the wood boiler from firing.



Commissioning and Tuning

- Modern automatic wood boilers can be complex and require sophisticated set up for optimal performance
- Some parameters are well documented; others may require some experience or experimentation:
  - Changing boiler setpoints for swing and mid-winter heating seasons
  - Timing for start up settings
  - Watching the firebox for a given boiler and fuel to optimize automatic grate speeds
  - Tuning with stack analyzer at full load to optimize CO and Nox levels

Maintenance and Cleaning

- Active Involvement with your Modern Automatic Wood Boiler – your system will be unique and you will be best equipped to understand if it is doing the job in the most efficient way
- Regular PM – example of tube cleaning every 300 to 600 hours – elevated exhaust temperature indicates cleaning is required
- Annual PM – Follow manufacturers instructions for annual maintenance and operation – example of leaving power on to controls to preserve touchscreen life and cycle exhaust fans to prevent condensation

Conclusions

- Optimization is important to performance, emissions and economics.
- Fuel selection/specification circumscribes what you can accomplish.
- Modern biomass boiler technology specification is an essential starting point. Match systems (boilers and storage/retrieval/conveyance to fuels.
- Water side design can make or break the system.
- Commissioning! Continuous Commissioning!
- Preventive Maintenance!

Questions?

Thank you for your interest.

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