PACKAGED COMMERCIAL WATERTUBE BOILERS

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FOREWORD

This document was originally prepared by the Packaged Commercial Watertube Boiler Manufacturers Subcommittee of the Commercial Systems Group of the American Boiler Manufacturers Association. This update has been reviewed and editorially revised by the Commercial Systems Group for re-release. The contents are offered for information and as guidance only. The ABMA does not assume responsibility or liability for consequences arising from implementation or failure to implement the information or guidance contained herein. Also, the contents of this guide should not be construed as an endorsement by ABMA of any product or manufacturer.

THE PACKAGED COMMERCIAL WATERTUBE BOILER

HISTORY

Since its initial design in the latter half of the Eighteenth Century, the Watertube boiler has undergone a myriad of changes, all of which were essentially driven by the demand for higher capabilities, increased safety, and longer useful life. The early part of the Nineteenth Century saw the first use of boiler drums and defined water circulation. Higher-pressure requirements that appeared in the late Nineteenth Century led industry to move away from cast and wrought iron to steel. Development continued with the elimination of brick settings, the introduction of bent tubes and multi-drum units, the application of forced circulation technology, as well as the introduction of counter flow (flue gas to water) designs to maximize heat transfer and improve efficiency.

Because there was divided responsibility in this earlier arrangement the industry was ready for the introduction of the Packaged Commercial Watertube Boiler (PCWT) unit. Modern Packaged Commercial Watertube boilers are engineered, constructed, and guaranteed in material, workmanship, and performance by one firm, with one manufacturer furnishing and assuming responsibility for all components in the assembled unit, such as burner, boiler, controls and auxiliaries. PCWT boilers are usually fire tested prior to shipment.

DEVELOPMENT

Most packaged Watertube boilers are the lineal descendants of the basic Nineteenth Century designs modified for packaged application. It is interesting to note that essentially all of Stephen Wilcox's (of Babcock & Wilcox) original twelve design rules that were established in 1875 still apply today. They are:

- Proper workmanship utilizing the best methods and simplest construction;
- The inclusion of a drop-out area (i.e. mud drum) for steam boilers to aid in accumulating and removing waterside impurities;
- Steam and water capacities large enough to preclude swings in pressure and/or water level;
- Adequate steam release space to prevent carryover and foaming;
- Proper circulation to maintain the metals at uniform temperatures;
- The division of water space into several sections to prevent a general steam explosion in the event that one section fails;
- Design with excess strength;
- Provide an adequate furnace to ensure complete combustion within the furnace proper;
- Provide for cross flow of the gases to the tubes to create turbulence and maximize heat transfer;

- Provide easy access for cleaning and repairing;
- Maximize capacity and efficiency;
- Include the best accessories.

Many different designs have evolved over the years. In today's market, however, the following designs predominate:

- Serpentine tube two drum type;
- Stay bolted firebox type with inclined tubes and water legs;
- "D" or "O" type;
- Straight tube – box header*;*
- Coil Tube – "steam generators".

These designs employ natural circulation (except coil tube) and have been continuously refined to improve boiler life and fuel utilization efficiency, while minimizing initial cost and maintenance.

Furnace heat absorption and volumetric release rates continued to increase as engineering progress provided for improvements in heat utilization, better water circulation and better distribution and flow of the products of combustion.

Units are rated in evaporation rate (pounds of steam per hour) or in British thermal units per hour (Btuh) output. Smaller units may be rated in boiler horsepower, or Btuh input.

In the commercial Watertube markets, the unit is shipped completely assembled on a structural steel base and often includes the fuel-burning system and control plus selected auxiliaries.

Improvements in fuel burning and control equipment have enabled manufacturers to offer more compact and efficient units. Burners are matched to the various furnace configurations to ensure compatibility, maximum efficiency and complete combustion.

This matching, coupled with sensitive, sophisticated control systems has resulted in a significant reduction of air pollutant emissions.

Standard designs are offered for gaseous fuels and for light fuel oils. Some designs are also available for burning residual oil and solid fuels such as coal or wood. With minor modifications these units can be fired with special fuels or used in wasteheat recovery projects.

MODERN PACKAGED WATERTUBE UNITS

Evolution, advancing technology and customer demands have resulted in the present day packaged Watertube boiler. The Watertube design is employed in boilers from the very smallest used for residential heating through packaged units of 33,480,000 Btuh (1000 boiler horsepower) and greater.

Packaged Watertube boilers have several features that recommend them to an end user.

1. Low radiant heat loss due to the design of the package.
2. Low water capacity resulting in quicker heat-up from a cold start
3. Compact design, which means a smaller footprint in the boiler room and lower headroom requirements.
4. The design of many Watertube boilers provides for natural circulation, which allows for large temperature differentials
5. High temperature / pressure capabilities.
6. Faster response to changing loads**.**

Fuel burning and combustion control equipment have been continuously improved. A majority of packaged Watertube units utilize forced draft fans. An increasing number of the units are equipped with modulating control systems to match the firing rate to load demands as nearly as possible. Flame safeguard control systems are generally of the programming type and are frequently microprocessor-based.

Such systems may include LED displays for self-diagnosis of system problems. Flame detectors have been improved and are matched to the unit.

Since the various unit components complement each other the PCWT assemblies are quite compact and can be shipped complete with several auxiliary components. The only size restrictions are common carrier shipping clearance and weight restrictions.

APPLICATION

Packaged Watertube boilers are available in sizes from residential use to industrial applications of 35,000 lb/hr (1000 boiler horsepower). . They can be ordered for low-pressure steam or hot water application (ASME Section IV) or for industrial use at steam pressures of 700 psig and higher (ASME Section I)
They are suitable for heating, both steam or hot water, or process application.
The quick-steaming ability of the Watertube boiler makes it particularly suitable for process work where, because of its low residual water content, it is not necessary to have the boiler running during off hours or on weekend**,** or in cases where the demand varies widely.

Watertube boilers, depending on size, may be fired by atmospheric gas burners, power gas burners, mechanical or air or steam atomizing oil burners, or combination gas/oil firing. Units to fire either natural gas or fuel oil may be arranged for either manual or

automatic fuel changeover. This versatility in firing arrangements allows the customer to decide on the mode of firing desired that best suits his needs.

Control systems and fuel valve trains to meet the requirements of customers or various insurance or control codes are also available. These requirements include but are not necessarily limited to:

- American National Standards Institute (ANSI Z21.13)
- American Society of Mechanical Engineers (CSD-1)
- National Fire Protection Association (NFPA 85 – 2001)
- Underwriters Laboratories (UL 726 and/or 795)
- Factory Mutual (FM)
- Industrial Risk Insurers (IRI)

The Watertube units are frequently tested and listed or labeled by nationally recognized testing laboratories such as AGA or UL as complying with an appropriate national standard, thus minimizing the work of the application engineer in determining compliance with specifications.

The boiler vessel is constructed to comply with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Power Boilers Section I, or Heating Boilers Section IV.

The ASME Code Symbol is stamped on the boiler pressure vessel after testing and inspection by an authorized third-party inspector to insure compliance with the Code. Most boilers are stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors (NBBI) in compliance with jurisdictional Requirements.

ECONOMICS

When analyzing the costs of various types of boiler systems the following should be carefully considered:

- Space requirements for PCWT units are frequently less than for other types due to their compact design and low head room the design requires. Tubes are normally removable in the normal access space provided around and between boilers and with certain types of coil or serpentine tubes, Code welding may not be required in a repair situation;
- No special foundations are required;
- The manufacturer of the completely assembled packaged boiler unit usually fire tests the assembled unit prior to shipment. This procedure assures the operational testing of all components.
- Fire testing may be performed at the boiler factory allowing the unit to be adjusted and set to approximate the field operating conditions, thus minimizing start-up costs.

- The equipment is adjusted for maximum efficiency (80 to 85%) assuring minimum fuel consumption, thus reducing life-cycle costs;
- Normal unit life with proper maintenance and boiler water treatment may exceed that of other heating systems, again reducing life-cycle costs;
- The unit is fuel-flexible – it can be ordered to burn a variety of fuels or to utilize electric energy – thus the most economical fuel for the time can be selected;
- If the unit is not ordered equipped to burn a particular fuel it can be modified at modest cost should burning an alternate fuel become economically attractive;
- Due to standardization complete wiring and piping diagrams are available prior to equipment purchase; thus allowing the application engineer to design the entire system properly;
- The unit can be located anywhere from basement to penthouse to a remote location;
- Modern control systems can be arranged for remote monitoring of the unit;
- While some direct attention to the automatically controlled unit is required, it is minimal and training programs are available for personnel affected;
- Factory trained service technicians are available through the local unit distributor.
- Reduced steaming time from a cold start.
- High turndown (output) ratios are available for certain sizes of boiler.

ADVANTAGES OF PACKAGED WATERTUBE BOILERS

1. Low maintenance
2. High pressure capabilities
3. Small size per Btu input
4. Knockdown units available for field assembly
5. More “forgiving” when it comes to large temperature differentials within the system
6. Fuel flexibility
7. Standard designs
8. Factory service available
9. Fast start-up

CONCLUSION

Summary of Characteristics

1. The heavy steel structural base distributes weight evenly on the boiler room floor; therefore, no special foundation is needed.
2. The units include a burner designed to match the boiler available for any grade of fuel oil, gas or combination gas-oil.
3. A totally enclosed and pre-wired control cabinet is mounted on the unit containing the latest electronic programming and flame failure safety controls. This control system may be microprocessor-based and can contain self-diagnostics. Operating controls, limits, interlocks, motor

starters and similar equipment wired and ready for electric service to be connected are included.

4. The owner can select the control system, from the very simplest to the latest self-checking microprocessor that best fits his requirements.
5. Forced draft designs require minimum stack to vent combustion gases. Low stack temperatures assure high operating efficiency.
6. The unit design provides gas-tight or neutral to negative firebox operation for added safety assurance.
7. Boiler pressure vessels constructed to the ASME boiler and Pressure Vessel Code, the ASME Code Symbol is stamped on the boiler pressure vessel after testing and inspecting by an authorized third party inspector to insure compliance with the ASME Code requirements. Most such boilers are stamped and registered with the NBBI.
8. Heavy lifting attachments are provided to facilitate positioning the unit.
9. Good internal water circulation provides better heat transfer.
10. The steel outer jacket over insulation protects the unit and provides a neat appearance.

When thorough consideration of the above factors is taken, the packaged Watertube boiler meets every modern requirement for the generation of steam or hot water.