For many years, the University of Wisconsin-Madison (UW-Madison) operated a coal-fired, steam boiler plant at its on-campus powerhouse. Facing stricter emissions regulations, UW-Madison began to explore its options. The choices were to retrofit the existing infrastructure or invest in an entirely new system. After evaluating its options, UW-Madison chose to pursue the latter. The university decided to install an eco-friendly, biomass-fired boiler designed to operate in concert with a pair of packaged boilers firing natural gas.

UW-Madison approached the industry to determine “state of the art” in gas-fired packaged boiler/burner technology. The steam generators had to achieve less than 9 ppm NOx emissions to comply with EPA regulations requiring Best Available Control Technology (BACT).

Meeting such low emissions can be accomplished using ultra low-NOx burner technology or selective catalytic reduction (SCR), the latter of which requires on-site ammonia storage. Because UW-Madison’s boiler system is located on campus, the added traffic with the delivery of aqueous ammonia and the increased capital cost and long-term maintenance required for the SCR system, the university opted to explore available burner technology to meet its needs.

The UW-Madison team met with multiple manufacturers, including Cleaver-Brooks Engineered Boiler Systems (EBS), manufacturer of Nebraska Boilers and NATCOM Burners. During the next year, the Cleaver-Brooks EBS team, in partnership with CBK & Associates, Chicago, Ill., worked closely with the university’s consulting engineer to develop the packaged boiler portion of the project.

UW-Madison issued a specification for a pair of 225,000 lb/hr power boilers to produce 650 psig/750°F steam firing natural gas with No. 2 fuel-oil back-up. The Cleaver-Brooks bid was submitted for a thorough evaluation against several competitors.

Cleaver-Brooks proposed integrated boiler/burner packages utilizing its ultra low-NOx, dual-burner approach (2x150 MMBTU/hr) with CO catalyst for each unit. Each boiler included standard 100% membrane boiler construction with refractory-free front/rear walls, gas seals and burner throats to essentially eliminate refractory maintenance.
After reviewing the proposals, UW-Madison awarded Cleaver-Brooks the project. According to Jason Jacobi, sales manager for the Engineered Boiler Systems division of Cleaver-Brooks, there were a number of reasons why the company won the project. First, Cleaver-Brooks has the ability to provide a single-source, custom-designed solution optimized for performance and efficiency, and the company can ship its boiler vessels fully shop-assembled, significantly reducing on-site labor time and cost, compared to field-erected boilers. In addition, Cleaver-Brooks unique warranty, covering both the boiler and burner components it manufactures, also played a role in providing UW-Madison with peace of mind.

When Cleaver-Brooks delivered the first boiler to the job site, PBBS Equipment Corp., located in Menomonee Falls, Wis., performed the delivery inspection and supervised the installation. Cleaver-Brooks provided proprietary burner management (flame safety) and combustion control programming, which was implemented into the plant distributed control system to ensure safe, stable and efficient operation at all load points.

Both units were successfully placed online by April 2012. “These are the largest known shop-assembled, ultra low-NOx packaged boilers in North America,” said Jacobi.

The boilers met all specified performance parameters, including NOx and CO emissions, superheat temperatures, and thermal efficiencies.

The new boiler equipment was designed with many innovative features. For example, each boiler included the ability to perform gas-to-oil fuel transfer online, which was a major benefit to operation, eliminating the need to take a boiler off-line to switch fuels.

The units also included dual-stage convective superheater systems with interstage spray attemperation to maintain a steady steam temperature over turndown. Sweetwater condensers inject pure spray water prior to the second-stage superheaters, thus mitigating the risk of potential damage to the electric turbine generator downstream. Boiler internal tube spacing was optimized to ensure proper heat transfer surface with minimum gas-side dP, thus reducing fan power consumption.

In addition, included on one unit was a dual-drive, forced-draft fan capable of using an electric motor or steam turbine drive for increased safety and flexibility should there be a site-wide power outage.

Initially, only two units were required. After the biomass portion of the project was cancelled, UW-Madison needed additional units to make up for the steam demand. Satisfied with the design of the first pair of boilers, the university ordered two more duplicate boiler systems from Cleaver-Brooks, for a total of four units, producing a combined total of 900,000 lb/hr of steam.

Shortly thereafter, a local utility ordered a near-duplicate unit for service at its biomass power plant in Rothschild, Wis. This fifth “sister” unit is capable of achieving a slightly higher steam capacity of 250,000 lb/hr at the same ultra low-NOx level of 9 ppm.

For nearly 90 years, Cleaver-Brooks goal has been to offer custom-designed, steam-generating solutions to its clients that maximize efficiency, reduce emissions, and ultimately provide the safest and most reliable steam-generating systems in the world. Jacobi added, “The success of this project validates this philosophy, and we look forward to continuing this tradition for many years to come.”