

SmartSensor™

A SmartClean™ Solution



Sensors Determine Furnace Cleanliness

Having **reliable** and **current** knowledge of the cleanliness of each section of a boiler is absolutely necessary for getting any sootblowing system to operate efficiently even while boiler conditions are changing. In the furnace area this means having real time and accurate information about the heat transfer between furnace gas and boiler wall. Our **SmartSensors™** provide just that and thus help taking the guesswork out of boiler cleaning.

As part of Clyde Bergemann's **SmartClean™**, our intelligent boiler cleaning system, the **SmartSensors™** accurately measure heat flux and tube temperature of a particular furnace wall area. The input from each sensor is forwarded to our **SmartControls™** for processing using especially developed algorithms to determine whether an area is clean or dirty. Only when and where necessary **SmartControls™** then activates the local sootblower, whether it is a water cannon, a water lance or a steam wallblower. In addition, based on the sensor feedback, suitable cleaning parameters such as blowing pressures and operating speeds will be selected.

A network of **SmartSensors™** is installed within the water walls of your furnace. Although more sensors provide better resolution, for a typical 500MW boiler, the range of 16-24 are required for a well-balanced system. We recommend optimal sensor locations and suitable quantities for your specific requirement. Even more important we make the **SmartSensors™** part of the cleaning solution and take responsibility for its results.

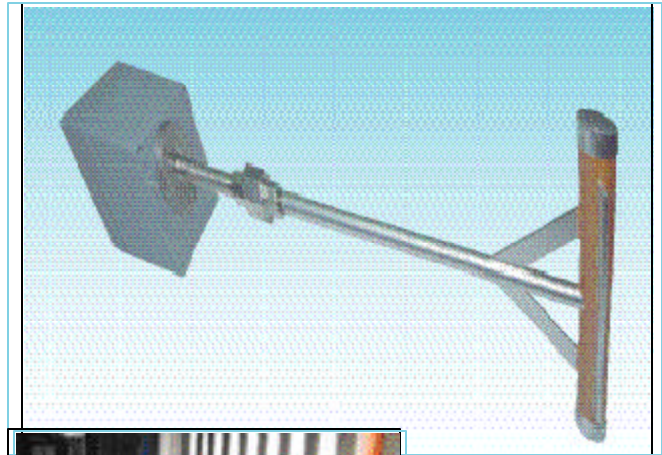


Figure 1
Smart Flux Sensor as delivered (including lead out tube and connection box for wiring)



Figure 2
Smart Flux Sensor lead out tube and connection box for wiring

Integration in SmartClean™ System

The heat flux data from each of the **SmartSensors™** are collected in the **Sensor Interface Module (SIM)**. This module in turn communicates via standard Ethernet protocol with the **SmartControls™**, intelligent central command system. Typically, each sensor is monitored at a lower scan rate to determine heat flux trending information (refer to Figure 4 heat flux graph). But when a specific cleaning device is activated, the SIM will automatically adjust to maximum high-speed scan rate ensuring that the temperature specific information is obtained real-time from one of the integrated thermocouples. This is especially important for monitoring the thermal impact that water cleaning devices such as water lances and cannons have on boiler tubes. By having **all** thermocouples wired directly through to the controls, any changes or discrepancies in readings can be determined remotely from the software interface *without* any local terminal switch changes.

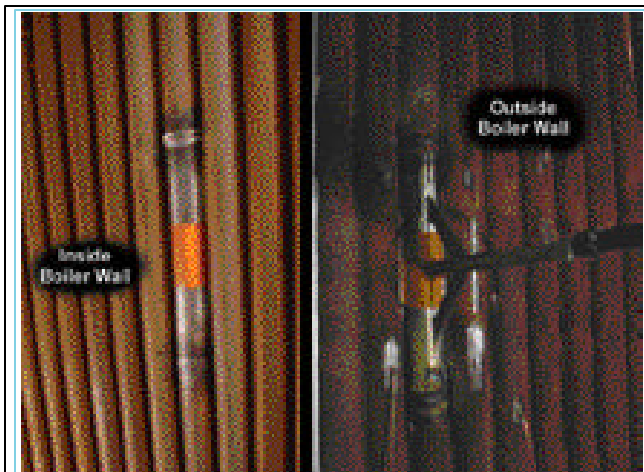


Figure 3 SmartSensors During Installation

The Benefits of an Intelligent System

Typically, the addition of **cleaning intelligence** will enhance the cleaning capability of any cleaning system by a factor of two, ie, the system increases its average heat transfer increase capability by about 100%. This stands in addition to the mitigation of the potentially damaging effects of overcleaning, like erosion or thermal cracking.

The relatively small investment (at about 30% additional cost over non-intelligent cleaning) for this significant boost in performance typically renders the commercial payback for this technology, typically under one year. The reporting and logging capabilities of the **SmartControls™** system can enable a progressive and precise actual versus expected payback calculation to help justify the costs of such a system transparently.

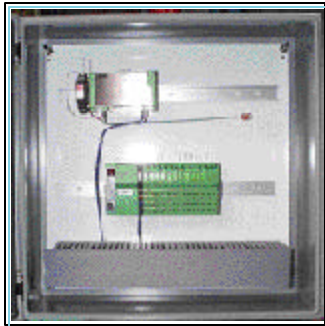


Figure 5

Sensor Interface Module (SIM)

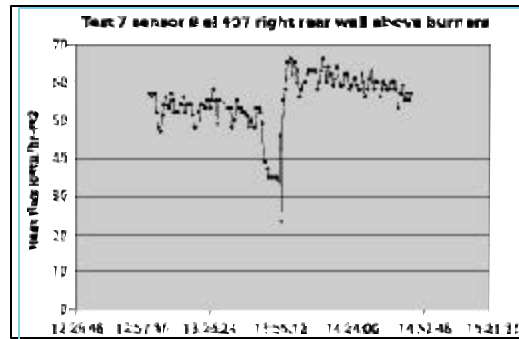
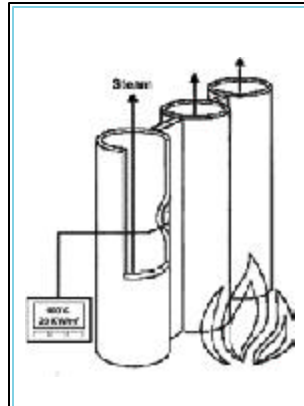


Figure 4
Heat Flux
Graph

Technical Specifications

Base Material/Tube Wall Material

Tube Dimension	Same as boiler wall
Tube Material	Same as boiler wall

Sensor Unit

Sensor	4 special thermocouples -high redundancy
Precision of Measurement	+/-2%
Measurement Range	0 to 120 10 ³ BTU/sq.ft./hr
Output Signal	mV
Calibration	Single calibrated in mV/BTU/sq.ft./hr

Connection

Housing	Metal 4" x 3"
Protection Class	NEMA 4
	IP 67 (EN 60529/IEC 529)

Installation Position

Installation Position	As determined by evaluation
Certificates	Certificates of origin Hydrostatic testing

SmartClean™ Intelligent Feedback Module using SmartSensors™:

Clyde Bergemann has developed and optimized special configuration **SmartSensor™** sensors. In tandem with specially developed algorithms the historical output from each sensor provides insight into the clean or dirty state of each zone, and hence determines which zone is to be cleaned at which time, regardless of the cleanliness state of other zones within the furnace, which has been proven unreliable at best with conventional chordal thermocouple designs. The benefits of this system addition are significant and twofold:

- Cleaning performance enhancement: as the cannons will only attempt to clean areas which are specifically in need of cleaning, no time will be wasted on already clean areas. This permits more immediate response and hence provides a better retention of the optimal furnace heat absorption.
- Thermal Impact reduction: as the thermal impact (defined as delta-T downspike) on a clean tube is twice as high as on a dirty tube, the magnifying effects of the relationship between tube crack growth propagation rate and delta-T⁻¹ indicates that targeting dirty tubes only will statistically increase tube life by a factor of eight (8).

The system consists of the allotted number of **SmartSensors™** whose output is fed into the **SmartClean™** module. Each sensor has an expected life of over 10 years operationally. This module traces and records the progress of **SmartSensor™** within each area and determines individually which zone must be cleaned at what time, hence obviating the need for sequence or time-based on control entirely. When coupled with the Anyspeed™ pump technology, the system will additionally and automatically adapt the required parametric settings for each zone individually based on localized need.

$$\frac{da}{dn} = C (\Delta K)^n$$

Where:

- a: crack depth
- n: number of cycles
- ΔK: cyclic stress magnitude
- C: constant (material dependant)
- a₀: constant (material dependant)
- ΔT: thermal "excursion"