Controls & Electrical Product Support Group

Titanium™ Performance Suite
Intelligent Sootblowing Controls

As offered by

The Babcock & Wilcox Company

Babcock & Wilcox

Executive Summary

Diamond Power International Incorporated and The Babcock & Wilcox Company have joined our Controls and Intelligent Sootblowing Departments into one group: ***B&W Controls and Electrical.*** We have collaborated to develop the most powerful sootblower controls and ISB product yet for advanced boiler cleaning optimization:

Titanium™ Performance Suite Intelligent Sootblowing Controls

The Titanium Performance Suite is an integrated suite of plant control and process optimization technology solutions. The system replaces and integrates B&W's legacy SentrySeries® and Power Clean® systems into a modern platform. Built upon nearly 150 years of the combined B&W/Diamond Power knowledge and experience with all aspects of advanced boiler design, operation, and environmental process optimization, it provides the user with straightforward solutions for increased reliability and enhanced process performance.

The base Titanium system provides the user with B&W's Advanced Sootblower Controls module, which includes the following components and advantages:

- Supervisory Control PLC
- Option for either new PLC I/O for the sootblowers, or interface to the existing plant DCS I/O.
- Operator interface computer (HMI) or touchscreen PanelView
- Automatic operation of furnace cleaning devices (wallblowers, waterlances, or HydroJets) to control Furnace Exit Gas Temperature or other indicator of proper furnace heat balance
- Automatic operation of Superheat, Reheat, and Convection cleaning devices (sootblowers) to control Economizer Exit Gas Temperature and Steam Temperatures for efficiency optimization.

Additionally, the Titanium Performance Suite provides the user with Premium System Options including:

- Heat Transfer Manager Model to calculate cleanliness throughout the unit, along with calculating FEGT and interbank gas temperatures. This includes an upgrade to a server class computer to run the live Heat Transfer Manager model with interfacing to the supervisory PLC.
- An appropriate complement of Heat Transfer Sensors for use with a furnace water cleaning system
- GasTemp® XT Furnace Exit Gas Temperature Pyrometer(s)
- Variable Flow control in an additional CompactLogix PLC to optimize the steam blowing profile for each sootblower

System Benefits & Details

Benefits of the B&W Intelligent Sootblowing Approach

As compared to traditional, operator initiated sootblowing, the benefits of ISB can include:

- Focused blowing where needed most with potential for steam savings
- Reduced blowing of heating surfaces for reduced wear and erosion
- Reduced sootblower maintenance due to lower cleaning frequencies
- Improved superheat and reheat steam temperature control
- Improved control of heating surface fouling and slagging
- Consistency of unit performance across changes in operators, fuel variations and other operating parameters.

The newly designed suite of software and hardware solutions is built upon two foundational elements – Controls & Process Optimization. The following diagram demonstrates the architecture of the Titanium Performance Suite. The control systems will have seamless and advantageous integration (where applicable) that have rarely been seen in the industry while the process optimization is all constructed in a modular fashion that can easily be enhanced with additional features over time because all the modules operate on the same base process optimization software platform.

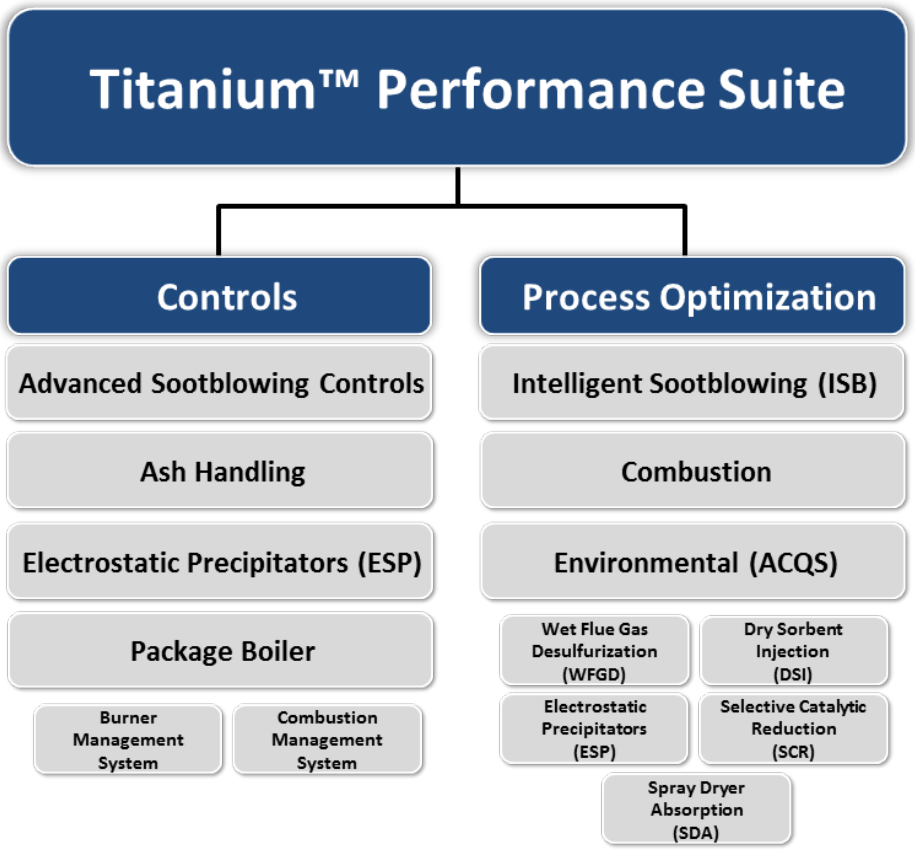

Figure 1 - Titanium™ Performance Suite Controls & Process Optimization Product Offerings

Titanium™ Boiler Cleaning System Intelligent Sootblowing: The Next Generation

B&W's new Titanium boiler cleaning system is comprised of the Advanced Sootblower Control module as well as the Titanium Intelligent Sootblower Optimization (ISB) module. This fully integrated system possesses all of the benefits and features that have historically been seen in Diamond Power's SentrySeries sootblower control system as well as B&W's Power Clean ISB system, while adding a tighter and more seamless operation on a modern platform. This system is the most comprehensive approach to Sootblower Controls and ISB that is available on the market today. Why? Please consider the following:

1. ***Some customers prefer simplicity***
   With the basic version of the Titanium™ Performance Suite, the Advanced Sootblower Controls system initiates sootblowing to control boiler parameters that operators understand well, such as gas temperatures and steam temperatures (formerly Goal-Based ISB)
2. ***Some customers prefer to implement their own knowledge and experience into the ISB decisions***
   The system uses our long-standing ability for the users to build knowledge of what works well in sootblowing into the system's flexible cleaning logic system (rules set)
3. ***Some customers will want the additional performance from the B&W Performance Model (Formerly Power Clean)***
   This option provides a powerful additional determination of Furnace Exit Gas Temperature, Cleanliness Factors of each boiler section, and interbank gas temperatures. These will provide extra analysis and action capability, especially valuable for high fouling units
4. ***All plants need an ISB system that properly responds at full load or reduced loads***
   Titanium™ Performance Suite, whether in its most basic or advanced forms is designed to make the right boiler cleaning decisions at whatever unit load ISB is used
5. ***All plants will benefit from a system that is fast to commission and can be easily adjusted & tuned by plant staff after installation***
6. ***It can be expanded to add Optimization of many other plant systems***

Standardization Leads to Competitive Pricing, Fast Delivery, and Reliability

One key benefit of a Titanium Performance Suite is its robust architecture. As with past products, B&W utilizes a rugged Allen-Bradley PLC and a flexible and easy to use Rockwell FactoryTalk HMI. The standardization of code provides for quicker delivery and quicker support. The Intelligent Sootblowing Controls reside within the PLC, and the B&W Model can seamlessly integrate with the system for advanced optimization. Unlike expensive DCS Systems, a Titanium system provides more powerful and flexible sootblowing control features, and better ISB results at a better price.

The Greatest Experience in Intelligent Sootblowing Solutions

Diamond Power was the original supplier of Intelligent Sootblowing dating back to the early 1990's. Likewise, the Power Clean Heat Transfer Manager model has been used since the 1970s as a critical tool by B&W's boiler design experts. In the last 20 years, Diamond and B&W have supplied ISB systems for over 250 different units worldwide. We have continued to lead the way in ISB in ways such as:

- ✓ Offering the most reliable advanced heat transfer sensors on the market
- ✓ Supporting our ISB users with tuning support from expert engineers
- ✓ Developing a powerful and elegant ISB approach that optimizes the boiler based on well-understood plant parameters such as gas and steam temperatures with an option for B&W's boiler model for advanced monitoring of heat transfer performance in each section of the boiler to enhance cleaning optimization

Users of our ISB systems have presented their results at many technical conferences and copies of the papers or presentations can be forwarded upon request. Some of the recent Industry conferences where presentations or technical papers were authored by customer users of Diamond / B&W Intelligent Sootblowing Systems include:

• Coal Combustion Residuals Conference	July 2016, Denver CO
• Coal Combustion Residuals Conference	August 2015, Atlanta, GA
• NTPC Global Energy Tech Summit	Nov 2015, Delhi India
• Powergen India & Central Asia	May 2014, Delhi India
• Powergen International	November 2013, Orlando FL
• Coal Combustion Residuals Conference	August 2013, Nashville TN
• PRB Coal Users Group Annual Meeting	May 2013, Chicago IL
• Powergen International	December 2011, Las Vegas NV
• Numerous additional and previous venues	

Titanium™ Advanced Sootblower Control System Design Features

- New Look – Operator Interface Screens – These screens are designed following the ISA-101.01 standard for operator screen development. Screens are developed to only provide indications with eye-catching graphics and notifications if action is to be taken by the operator.
- Visual tool tips – Simply hover over any button or input value and easily determine what controls action can be taken.
- Mobile Device Capability – Connect to your Titanium™ system via any smartphone or tablet that has network permissions. Optional engineering setup is required.
- Advanced Sequence Operation - 30+ easily programmable sequences with:
  - Time of day start
  - Interval start
  - Sequence within a sequence start
  - Continuous operation
  - Custom time delays between each operation within a sequence
  - Change between one-at-a-time operation to n-at-a-time operation within same sequence

- New alarm structure – Focuses the notifications to the operator on only critical alarms and notifications. Operator presentation of alarms has been simplified to aid in operator understanding and training.
- Enhanced Operator Troubleshooting Assistance – Every alarm that can be generated in the Advanced Sootblower Control system is displayed with an Operator Guidance action to assist in troubleshooting and clearing the alarm. This feature also helps in protecting value assets that could be damaged if certain suggested actions were initiated in a timely manner.

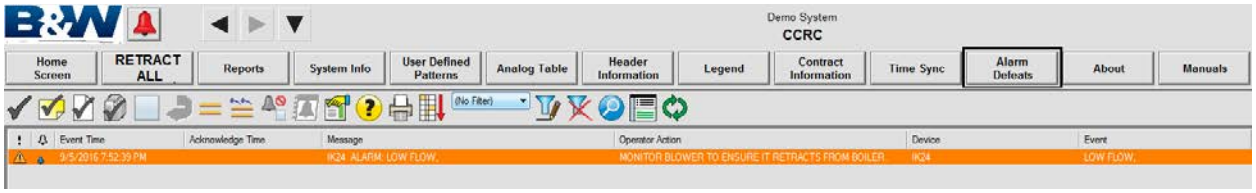

Figure 2 - Titanium™ Advanced Sootblower Controls Operator Interface

- E-mail push notifications- The Advanced Sootblower Control System has the capability to email selected users information when alarms are triggered. Optional engineering setup is required.

Note: See the following page for the Titanium™ Sootblower Controls operator interface (HMI).

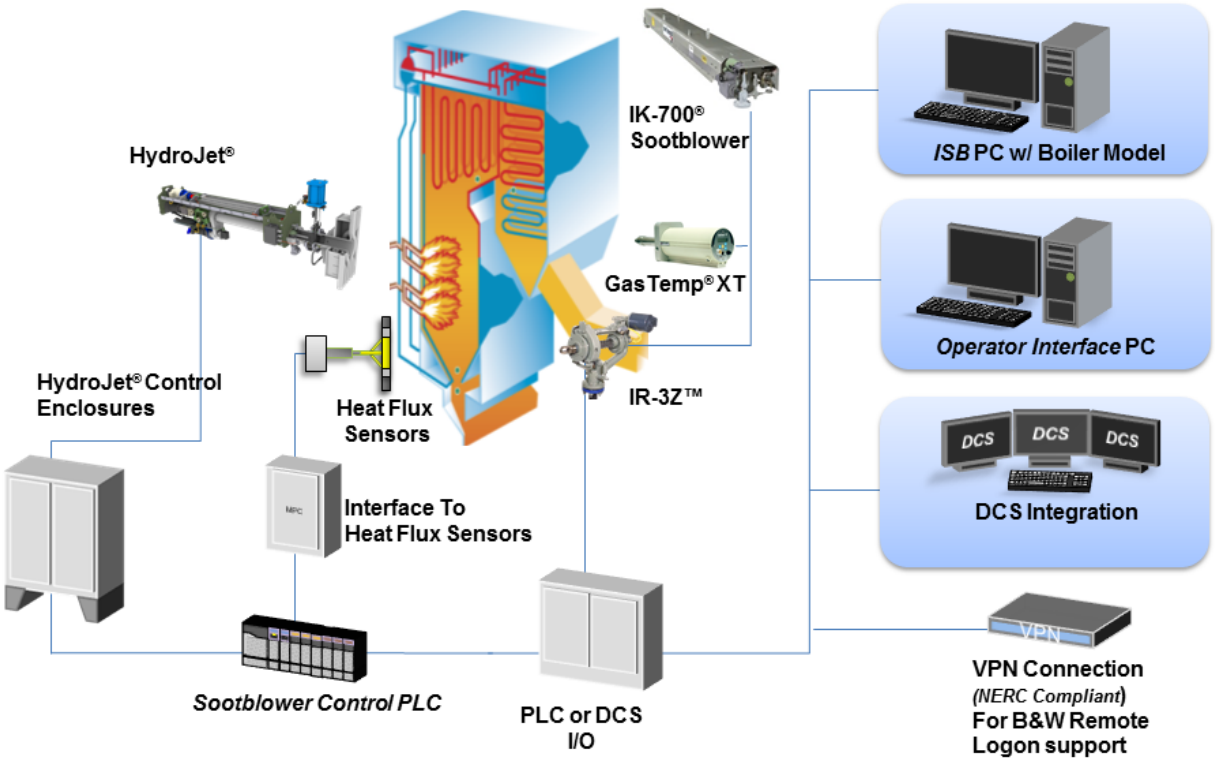

Figure 3 - Typical System Interconnecting and Communication Schematic

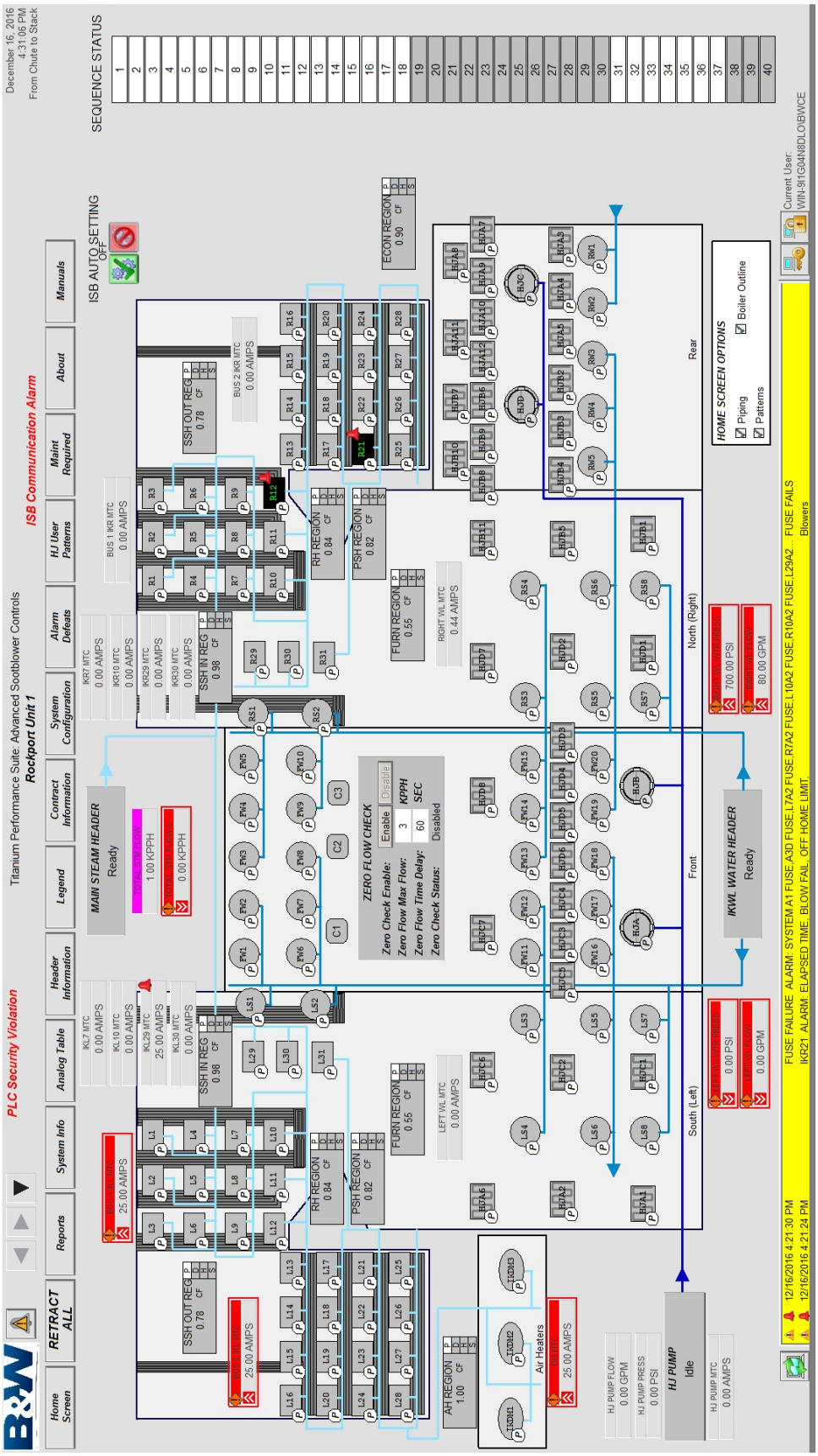

Figure 4 - Titanium HMI Home Screen Interface

Premium DCS Interface Support Package (Optional)

To support the interface between the Titanium Performance Suite PLC and DCS sootblower controls (DCS Programming & Screen Development to be done by others), we can include a package of the following items:

- Complete unit specific spreadsheet listing all tags (separated by function, direction, etc.)
- Interface Manual (Word document) containing screenshots with tag tables and verbal descriptions of operation to facilitate understanding of all system tags
- Customer specific Titanium operations manual using the customer generated DCS screens. Manual directly represents the graphics utilized onsite by the unit operators
- Up to (8) hours of no-charge phone / email Q&A support during screen generation
- Minor logic modifications to our PLC code as may prove necessary to facilitate the DCS migration (provided on a one-time basis)
- One revision each to the spreadsheet, interface manual, and operations manual to incorporate the desired changes

Titanium™ Advanced Sootblower Controls Approach

Cleaning Logic – Optimizing Boiler Performance

The Titanium Advanced Sootblower Controls for the convection region utilizes preconfigured goals to best determine where, when, and how cleaning should be conducted. Cleaning decisions are sent to the control PLC, where past cleaning performance is used to dynamically build a sootblowing sequence operated to attain current goals.

Achieving Operational Goals

Unit operating goals from plant operations personnel are captured and implemented in the Titanium Advanced Sootblower Controls system. For example, operators typically have goals for unit operation such as a target economizer exit gas temperature range or maintaining superheat and reheat temperatures. By working directly with plant operations and engineering personnel, these goals are included in the Titanium System cleaning strategies and rigorously implemented. With reliable determination of heat transfer surface cleanliness, coupled with plant operating data and calculated boiler performance, the system is setup to proactively guide cleaning operations within defined constraints.

When Titanium ISB is implemented, its performance data, along with boiler operating data, is used in conjunction with the Advanced Sootblower Controls system to govern cleaning operations within both the furnace and convection pass to provide the very best cleaning solution.

Priority Sootblowing (Dynamic Blower Sequencing)

An important feature of the Advanced Sootblower Controls system is Priority Sootblowing. The major function of priority sootblowing is to establish the order and frequency of individual sootblower operations. This is done by considering the effectiveness of each sootblower and the time since its last operation. Using this information, it prioritizes the blowers to operate the most effective blowers more often while still ensuring that no blowers go excessively long periods between operations. This optimizes the ability of the sequence and drives performance goals.

Furnace Component:

The Titanium Advanced Sootblower Control System will automatically operate furnace cleaning devices (HydroJets, wallblowers, waterlances) to drive particular plant parameters (goals) toward setpoint values.

Common Furnace Goals:

- Furnace Exit Gas Temperature (FEGT)
  - When FEGT is high, initiate furnace cleaning to drive FEGT back to within setpoints
- Average Heat Flux (relies upon the installation and upkeep of furnace heat transfer sensors)
  - When Average Heat Flux is low, initiate furnace cleaning to drive value back to within setpoints

Note: Reheat Spray is used as a secondary furnace parameter in addition to the primary goal of FEGT or Average Heat Flux.

When the system is placed into Automatic, the cleaning devices that control a particular furnace goal are operated to keep the goal's value between the low and high setpoints. For example: If the FEGT is above the configured high setpoint, then furnace blowers will be operated until the FEGT falls below the configured low setpoint, where blowers will then be paused until the temperature again rises above the high setpoint. Setpoints are configured for numerous load ranges to account for different boiler operating conditions. This assists with maintaining temperatures where desired during load swings as well base loading.

Numerous studies have shown that a sootblower controls / ISB system can effectively reduce FEGT. The data below represents a recent evaluation on an 830MW supercritical unit. The blue data set corresponds to FEGT during manual operator sootblowing, and the red data set corresponds to FEGT during ISB initiated sootblowing. The results show that ISB operation effectively reduced the FEGT by 40-45°C. In addition to this (not pictured) is that the Reheat Spray Flow was also reduced by approximately 66%.

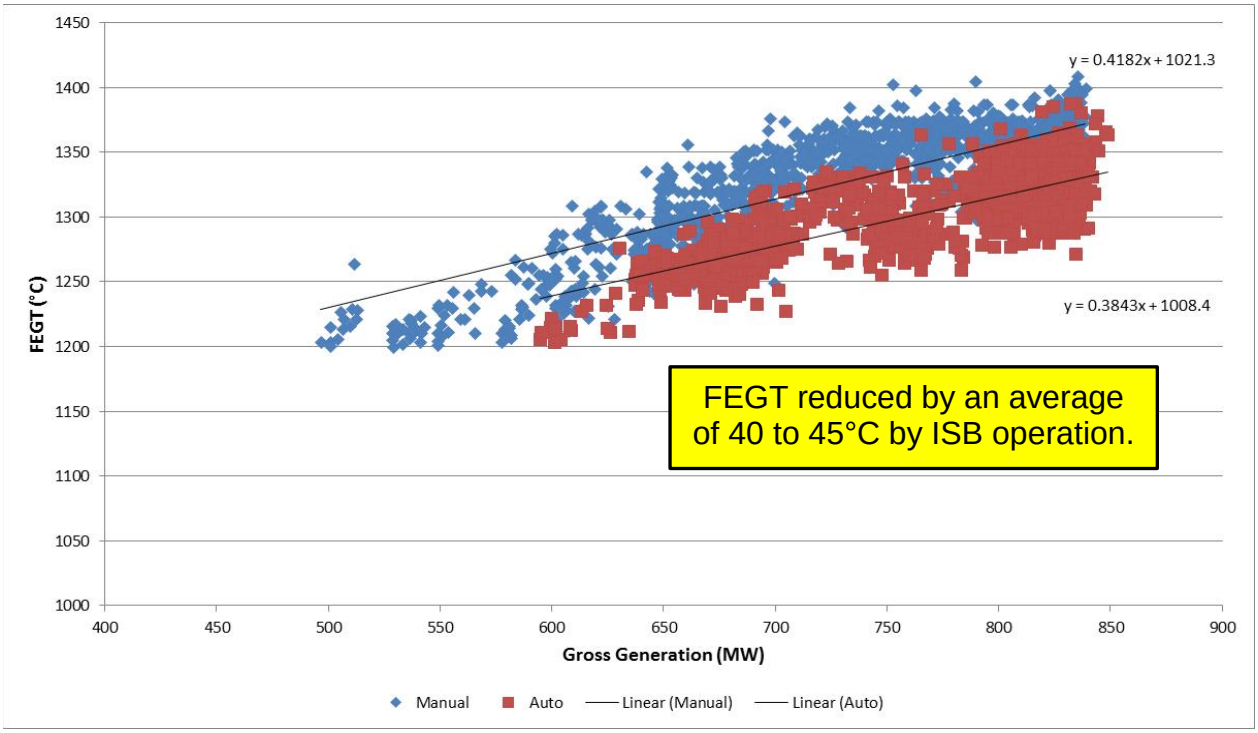

Figure 5 - Comparison of FEGT between Manual and Automatic Sootblowing

Titanium and Use of Heat Transfer Sensors

Heat transfer sensors are an integral part of the Titanium system when water cleaning is used. By use of heat transfer sensors, the Advanced Sootblower Controls system monitors the heat transfer before and after cleaning events and automatically tunes the furnace cleaning frequency and aggressiveness such that areas that slag quickly or have a larger impact on the primary furnace goal will be operated more often. Likewise, regions that slag slowly or make have a smaller impact on the primary goal will be operated less often.

Heat flux "setpoints" are no longer utilized, reducing the complexity of system start up compared to older generation systems or competitor systems.

Figure 6 - Typical Heat Transfer Sensor

Titanium and Thermal Impact Monitoring Control

With heat transfer sensors installed within the furnace water wall tubes, the Advanced Sootblower Controls system will additionally monitor the thermal transient (cooling and reheating) caused by water cleaning events. When a transient is too high, the system will automatically adapt the water flow and jet progression velocity (JPV) for that cleaning pattern accordingly for avoidance of thermal fatigue cracking based on our patented approach. This self-tuning was invented by B&W and ensures that large transients are eliminated and that long term tube life protection occurs. 30 to 50 year tube life is expected using B&W's furnace water cleaning, heat transfer sensors, and Titanium system.

Figure 7 - Furnace Tube showing Thermal Fatigue Cracking

How is Over or Under Blowing Avoided?

Additionally, there are “safety stops” built in to ensure that no cleaning device operates too often (thereby threatening excessive erosion damage and steam wastage) or sits idle too long (threatening local pluggage). For this, minimum and maximum timers are used for each device during enhanced automatic operation.

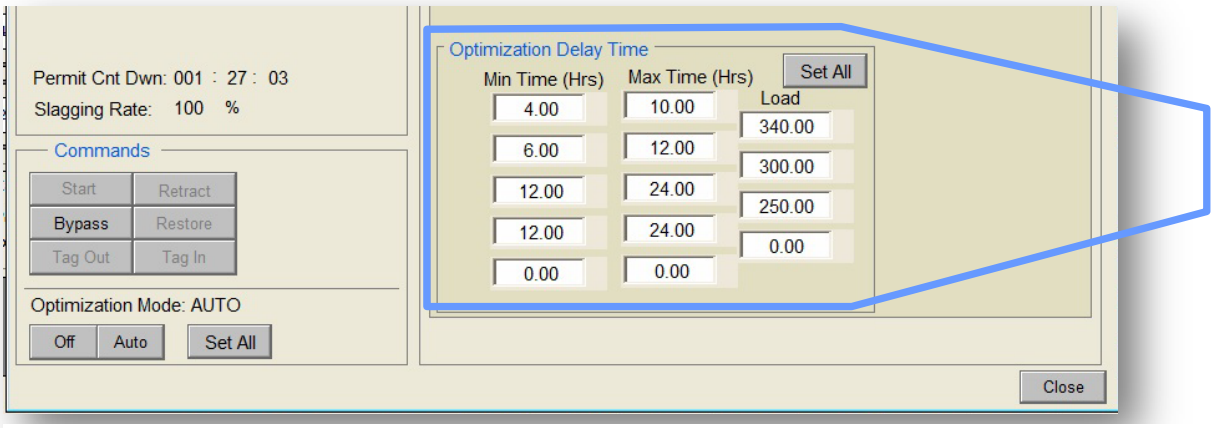

Figure 8 - System Minimum/Maximum Timers within Optimization Screens

Each sootblower has its own permit countdown timer which begins immediately following its operation. The minimum and maximum delay times are used in conjunction with this timer. The figure above shows the configuration of these timers for a given sootblower. Each sootblower can have its own timer, or groups can use the same values. See the figure above for an example configuration screen.

Minimum Timer: After its last operation, each cleaning device must wait at least as long as its minimum timer before the ISB can operate it again. This prevents over blowing during enhanced automatic operation.

Maximum Timer: If the advanced sootblower controls does not call for a device to operate, and the device sits idle as long as its maximum timer, then it will be operated automatically even if its goals are all satisfied. This prevents under blowing and ensures that no cleaning device sits idle indefinitely during enhanced automatic operation.

Convection Component:

Similar to the furnace component, the Advanced Sootblower Controls System will automatically operate convection cleaning devices to drive particular plant parameters (goals) toward setpoint values.

Common Convection Goals:

- Economizer Gas Outlet Temperature (EGOT)
  - When EGOT is high, sootblowing is initiated to reduce it to within setpoints
- Superheat Steam Temperature
  - When SH steam temperature is low, sootblowing is initiated in the appropriate regions to increase steam temperature to within setpoints
- Reheat Steam Temperature
  - When RH steam temperature is low, sootblowing is initiated in the appropriate regions to increase steam temperature to within setpoints

Regions are setup for each goal (EGOT, Steam Temperatures, etc.) where individual sootblowers are assigned to each of these regions based off of their effect on these goal parameters. When in enhanced automatic operation, the blowers within a region in need of operating are run to maintain that goal's parameters within its preconfigured setpoints.

Titanium™ ISB Approach

When implemented, the Titanium ISB system can provide maximum boiler performance through B&W's industry leading real time boiler modeling technology which is incorporated into the ISB. The Titanium ISB uses the generated boiler model to track the cleanliness of each boiler heat trap, calculate FEGT along with interbank gas temperatures back to the economizer, and provide unit performance information. This diagnostic information is fed to the Advanced Sootblower Controls system where it is used by the logic as part of the automatic cleaning decisions.

The ISB includes a boiler model based on the as-built, specific configuration of the boiler. Using data from the plant DCS or historian, the Titanium ISB provides the user with robust performance data including:

- Platen Inlet Gas Temperature (PIGT)
- Furnace Exit Gas Temperature (FEGT)
- Furnace Cleanliness Factor
- Convection pass component Cleanliness Factors
- Interbank Gas Temperatures
- Boiler Efficiency
- Boiler Heat Rate

All models are based on B&W's boiler research and design standards that have been developed and evolved over B&W's 150+ years of boiler experience. The core software code for the Titanium ISB has been in use for designing boilers and analyzing actual boiler performance in the field since the 1970's. The modeling software is still used every day by B&W engineers to design, analyze and upgrade B&W boilers and non-B&W boilers.

Intelligent Sootblowing System Requirements

The Titanium ISB system uses existing plant parameters to calculate real time performance data. An analog tag list of all the points available is usually required to determine which are needed. In addition to these plant inputs, other information may need to be collected. This information includes steam/water circuit drawings, boiler gas path drawings, boiler piping & instrumentation data (P&ID) drawings, coal analysis, heat balance diagram, and heat transfer section geometry information.

For a Titanium system without the boiler model, the number of plant data points required is relatively small, typically (10) or less. When a boiler model is utilized, the number of monitored data points is larger.

These plant parameters can be provided to the Titanium Performance Suite system via Ethernet or a serial connection and the communication protocol can be OPC or any number of other common protocols, depending on the customer's preference.

Scope of Supply

Titanium Performance Suite System – *Base Scope typically includes*:

- **Titanium Advanced Sootblower Controls**
  - Standard features include new PLC and I/O components, along with the operator interface unit (HMI). **Provides capability for enhanced automatic furnace and convection cleaning for maintaining of goal parameters.** Hardware supply will typically include:
    - Allen-Bradley ControlLogix 1756-L83 PLC with PLC configuration code developed and installed by B&W engineers using RSLogix 5000
    - ControlLogix rack with Power Supply
    - DCS communication card
    - Ethernet card(s) for communication with additional system components
    - Ethernet switch
    - PanelView 600 Emergency Backup HMI
    - Hardware provided within a wall-mount NEMA 4 enclosure
  - Operator Interface Unit (HMI) – Desktop PC (Dell)
    - Operator Interface Screens developed using Allen-Bradley FactoryTalk View SE. Developed and installed by B&W
    - Includes Redundant Hard Drive – One hard drive is solely used as a backup in the event of a hard drive failure. Backup hard drive image created during startup
    - Alternate option for a remote or door mounted PanelView 1500 touchscreen HMI instead of the standard operator interface computer
  - Historian® Data Logging Package
    - Includes: Event and alarm history, historical trends, sootblower operation trending, basic sootblower reporting
  - One-year of Engineering and Software Maintenance Support Included
    - Software Maintenance – The Titanium software is occasionally updated to include new features and capabilities. Software maintenance permits the user to receive all software program updates and upgrades that may become available
    - Engineering Support – Experience with optimization systems has shown that system support is important to realizing long term system benefits. This support utilizes VPN access to the system and provides the user with options for onsite, telephone, and VPN support for system troubleshooting
  - Complete set of Drawings and Manuals

Titanium Performance Suite System – Additional Scope Options that are available:

- **Titanium ISB** – Supplied via engineering workstation PC with software and HMI screens developed and installed by B&W personnel
  - Includes Intelligent Sootblowing by use of existing plant parameters to track cleanliness of each boiler heat trap while calculating FEGT, interbank gas temperatures, etc. for providing a full unit performance evaluation
  - Includes generation of customer specific Boiler Model
  - Provides maximum system performance through integration with Advanced Sootblower Controls
- **Additional Titanium Performance Suite Options include but are not limited to:** Full PLC I/O for control of all sootblowers, Variable Flow, Premium DCS Interface Support Package

Scan for further product information:

http://www.babcock.com/en/technology/boiler-cleaning