

# Breakthrough in Boiler System Efficiencies through New Integrated Control Technology

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**Editor's Note:** This year's technological leap to integrated boiler control systems marks the most important advance in boiler control since the 1940s. One system, Honeywell's new SYSNet™ Facilities Integration System, allows plant operators to manage the water quality, combustion safety, and steam distribution systems in their industrial plant from a single location.

This single-point access-on-site or remote-can increase productivity and efficiency and provide major operating advantages economically. For example, according to studies of Armstrong International, a manufacturer of steam traps and steam specialty products, early and accurate detection of faulty steam traps and the minimizing of steam loss can result in annual savings of more than \$2,000 per steam trap in industrial sites. This article describes the technology that makes the economy possible.

## NETWORKED CONTROL SYSTEM

The new integrated system (SYSNet™) is an open-architecture combination of hardware and software that creates a networked system for diagnostic monitoring and control of boiler plant and combustion process equipment (see Figs. 1 and 2). The key computer hardware/software components of this system include:

(1) 486 or higher PC running Microsoft® Windows® 3.X, Windows® 95/NT, or IBM OS/2®. (A touchscreen is possible for the simulated virtual control panel.);

(2) network interface unit;

(3) graphical user interface software;

(4) interface cards for compatible combustion safety, steam distribution

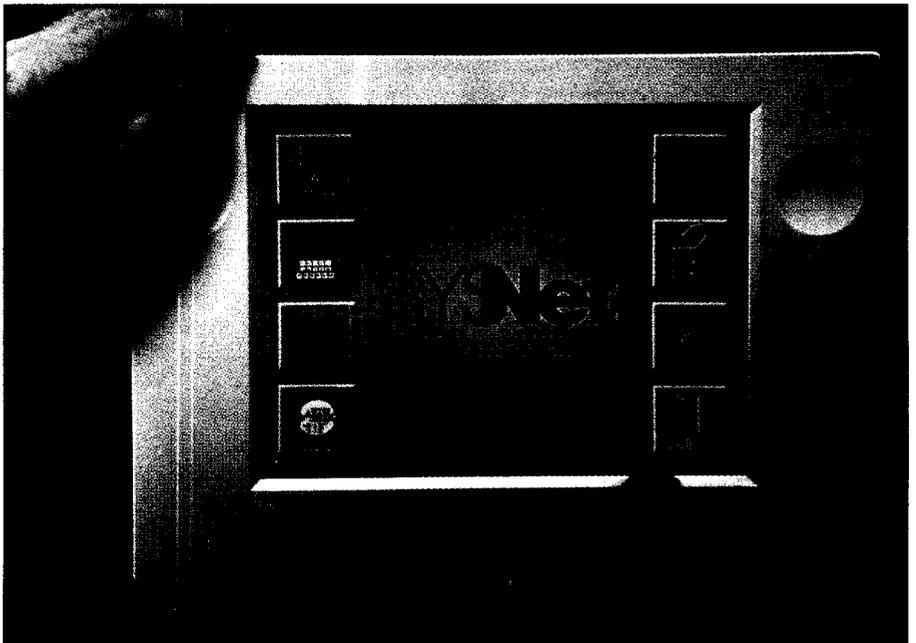


Fig. 1 Touchscreen main menu displays icons for information on various integrated components for advanced control of boiler system. System provides for control of water quality, combustion and safety, and effective steam utilization.

and water quality systems;

(5) data acquisition module(s) for monitoring third-party sensors.

The system's software and interface units allow the creation of an easy to use, economical, networkable control system for boiler plant and combustion safety process equipment such as:

(1) burner controls (7800 series), boiler control system (BCS7700), and data acquisition modules-(all Honeywell);

(2) series of steam traps (Armstrong International's TrapScan™);

(3) family of water treatment controls (Pulsafeeder Inc.'s PULSAtrol™) and chemical injection pumps (PULSAtron®).

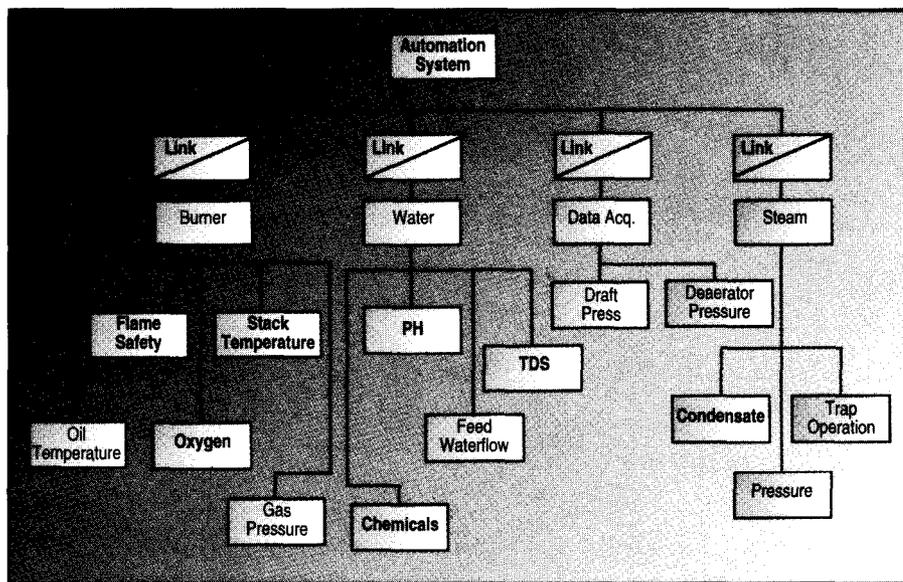


Fig. 2 Simplified diagram linking burner, water, data acquisition and steam components for automated, integrated system for boiler control.

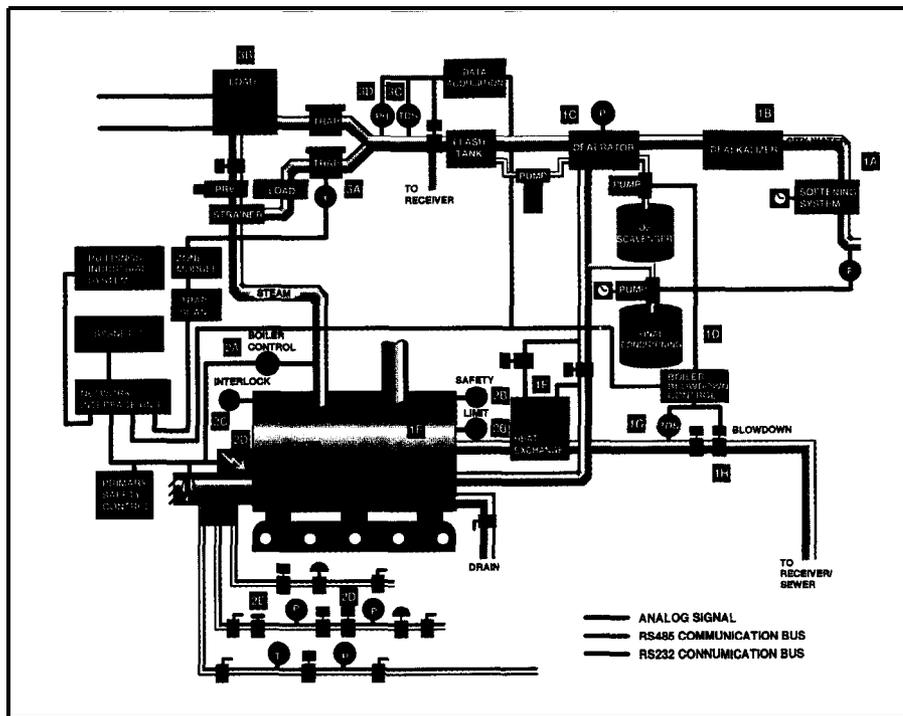


Fig. 3 Diagram of water quality, combustion and steam distribution loops as integrated in advanced boiler control system. System uses the latest technology in hardware and software to provide integration of the control loops.

Fig. 3 shows a typical boiler control system, utilizing advanced technology and incorporating the components indicated above. The following sections focus on three of the control loops integrated by the system: water conditioning, water quality control, and combustion control.

### WATER CONDITIONING

Water conditioning is the first step in water quality control (Fig. 3, points 1A-1H). Raw water entering the system is

softened, neutralized, and deaerated. Conditioned water is free of the hardness and acidity that can cause scale to accumulate on heat-transfer surfaces, and the dissolved oxygen that contributes to corrosion.

A water quality improvement that prevents as little as 1/64 in. scale buildup on heat transfer surfaces is estimated by Pulsafeeder, Inc., manufacturer of water quality controls and pumps, to translate into savings of tens of thousands of dollars per year (site dependent).

### Softening

Water is first pumped through a softening system [1A] to eliminate the hardness caused by calcium and magnesium. Water can be softened either mechanically or chemically.

The two main chemical softening methods are the phosphate cycle, which is recommended for systems operating above 125 psi, and the carbonate cycle, recommended for systems operating below 125 psi.

In both the phosphate and carbonate cycles, the calcium and magnesium precipitate is formed and then conditioned as a sludge through the use of synthetic or natural polymers. The physical reactions involve one polymer molecule and many calcium phosphate molecules (in phosphate conditioning) or calcium carbonate molecules (in carbonate conditioning).

In phosphate conditioning, boiler water pH must be maintained above 9.5, and a phosphate residual should be maintained to cover any unexpected hardness. Both the phosphate and carbonate softening processes require proper levels of sludge conditioners to ensure that hardness salts are conditioned into a fluid sludge. An effective automatic boiler blowdown schedule is also required to ensure that the conditioned sludge is removed from the boiler.

### Neutralization

Alkalinity is the measure of alkaline dissolved solids. Water is neutral when the levels of acid ions and alkaline ions are the same. Alkalinity results most commonly from carbonate and bicarbonate anions. These alkalinities can combine with calcium and magnesium hardness to form scale.

A dealkalyzer [1B] neutralizes water to protect equipment from acidic corrosion, to ensure the proper pH for the necessary chemical reactions to occur, and to provide the needed hydroxyl ions to maintain the protective ferrous hydroxide film.

### Deaeration

Dissolved oxygen in a boiler system can cause severe pitting and contributes to the corrosion process. To ensure that all dissolved oxygen is removed from the water before it enters the boiler system, the water passes through a deaerator [1C]. Two common chemicals for removing dis-

solved oxygen internally are sodium sulfite and hydrazine.

If required, final conditioning [1D] can be used to suspend particulates. At this point, the fully conditioned water is ready for preheating in the heat exchanger [1E] before it enters the boiler [1F] to be heated.

#### WATER QUALITY CONTROL

Water quality is a measure of all of the impurities or total dissolved solids (TDS) dissolved in a boiler system. The level of TDS present and their composition can be measured by how easily an electrical current passes through the water. Sensors at the boiler discharge and in the return-water line [1G] use this conductivity principle to monitor TDS.

Measurement of the water's conductivity can be either timed or continuous. When the TDS measurement exceeds a setpoint, a controlled amount of water leaves the system through a valve [1H] and flows into the sewer.

Makeup water is added to replace the water that is removed during this blowdown process. When blowdown is not closely controlled, an unnecessarily large amount of unconditioned water enters the system.

Boiler blowdown removes sediment and TDS from the boiler. The key to effective boiler operation is the ability to blowdown the right amount of water for efficient boiler treatment without excessive use of water and chemicals. Efficient blowdown maximizes water quality to reduce scale buildup on heat-transfer surfaces.

Blowdown may be automatic or manual. Manual blowdown cannot be closely controlled and typically wastes energy by dumping too much hot water out of the boiler at one time. It also may cause the TDS concentration to rise above the scaling level. Automatic blowdown control removes less water more frequently and thus eliminates the inefficiencies of manual blowdown (see Fig. 4).

#### COMBUSTION SAFETY CONTROL

State-of-the-art combustion safety control provides economy and improves performance. It can optimize safety, minimize troubleshooting, and speed the communication of key operational data to the rest of an industrial system.

A typical burner control loop, featuring a Honeywell 7800 series burner

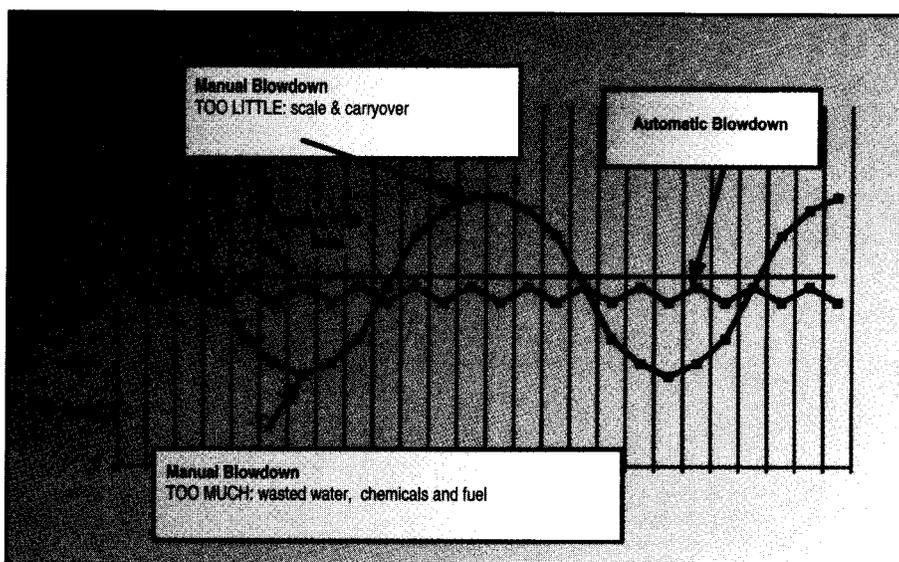


Fig. 4 Comparison of manual and automatic blowdown for water quality control. Automatic blowdown provides desired level of total dissolved solids (TDS) while minimizing waste of water, chemicals and fuel.

control as the primary control, is shown in Fig. 3, points 2A-2E. The primary control or programmer, with its associated flame detector, is the heart of the burner control system (see Fig. 5). It provides a means of starting the burner in its proper sequence, sensing that the flame has been established, and supervising the flame during burner operation. It also monitors and controls all combustion activities, including boiler control, limits and safety control, interlock control, fuel valves and ignition control, and firing rate control:

(1) **Boiler control** [2A] functions to sense temperature or pressure and start/stop the burner to maintain set limits of pressure, water temperature, or air temperature, depending on the medium being heated.

(2) **Limit and safety control** [2B] responds either to temperature or pressure and provides a maximum limit beyond which the burner will not operate. Boilers require a low-water cutoff to prevent burner operation if the water level drops below safe limits. The control also actuates the feed water or condensate return pump prior to low-water cutoff in order to return the boiler water to the desired level.

(3) **Interlock control** [2C] ensures that the conditions for combustion are established, that the burner is ready to be started, and that conditions are satisfactory for burner operation to continue. Large burners can use all three

types of interlock controls: start interlocks, running interlocks, and lockout interlocks.

(4) **Fuel valve and ignition control** [2D] opens, closes, or modulates the fuel supply and, on oil-burning systems, may have delayed opening features. Gas valves may be slow-opening or fast-opening.

(5) **Firing rate control** [2E] varies the firing rate according to the load demand by regulating supply of both air and fuel simultaneously in changing from high fire to low fire. Or, it can modulate the firing rate as system demand changes.

#### EFFECTIVE STEAM UTILIZATION

Steam traps play a major role in the efficient use of steam. Returning the condensate retrieved by steam traps keeps conditioning and heating costs down. Using "smart" steam traps [3A], which detect plugged traps and trap blow-through, can result in substantial annual savings.

Steam leaves the boiler and enters the "load" (heat transfer equipment) [3B], which might be a series of radiators, for example. In well designed systems, the condensate returns through steam traps located throughout the system. As the condensate leaves the traps to return to the boiler, TDS [3C] and pH [3D] sensors check condensate quality and control the amount of make-up water needed to supplement the return water.

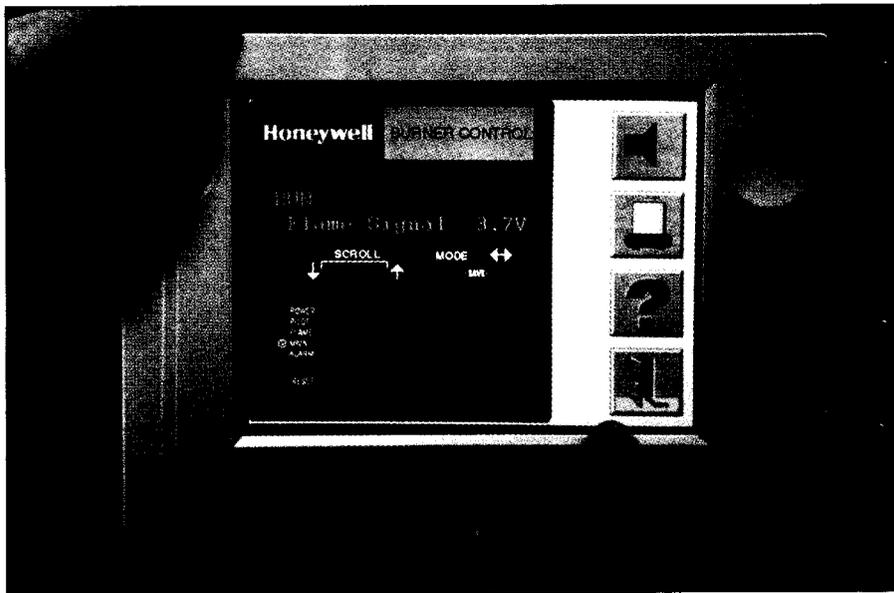


Fig. 5 Display for burner control.

Condensate left in the system for too long can cause significant problems. For example, condensate in the heat transfer unit takes up space and reduces the heat transfer area and capacity of the equipment.

In addition, condensate lying in the bottom of steam lines can cause a type

of water hammer when rapidly moving steam passes over. If enough condensate forms, high-speed steam pushes it along, creating a dangerous "slug" which grows larger as it picks up liquid moving along. Regulating valves, pipe fittings, elbows, and tees, which change the direction of the steam flow, can be

damaged or destroyed.

There is another type of water hammer-called thermal shock-that can occur when steam that is not drained from a system comes into contact with the cooler condensate. Under this condition, steam, which occupies a greater volume than the condensate, collapses suddenly. That quick reduction in steam volume can send "shock waves" through the system that can damage equipment. Removing condensate quickly keeps the unit full of steam, prevents water hammer and prevents a detrimental film of chemicals, dirt, and scale from building up on heat-transfer surfaces.

### CONCLUSION

The primary benefit of integrated water quality control, combustion control, and smart steam traps is improved efficiency without sacrificing responsiveness or safety. This technological breakthrough of an integrated system for advanced boiler system control can provide substantial economy. □