A proven method to detect small leaks in the recovery boiler

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ABSTRACT

A proven leak detection system uses the principle of material balance closure around the steam drum. It statistically compares moving average values of the drum balance within a short interval and a longer interval—windows. A significant difference between the moving averages denotes a possible leak. During each sample period, a model compensates for shrink and swell in the drum. The model uses moving window pairs to indicate a possible leak with a confidence level of 99.9%.

Application:

A leak detection system using a material balance can accurately find leaks in recovery boilers.

A BOILER TUBE LEAK CAN CAUSE a catastrophic smelt water explosion in the lower section of the recovery boiler (RB). An RB explosion threatens human safety. It can cause substantial damage to the RB and loss of production. The industry has long tried to find ways for early leak indication. Present systems fall into three groups—the acoustic leak detection system, chemicals to trace the leak, and rule-based advisory systems. They all require over US$ 100,000 initial investment with additional costs of maintenance. Payback with an early leak detection system would come from increased safety, improved operation, and reduced insurance costs.

SAFETY AND OPERATION

The paper industry suffered seven major RB smelt water explosions during 1984–1988. These totaled over US$ 220 million in damages and the deaths of three employees.

There were 45 RB smelt water explosions from 1970–93. Of these, 20 were major, 15 were moderate, and 10 were minor. From May 1988 to September 1993, there were 43 RB emergency shutdown procedures (ESPs) and 39 leaks reported in Union Camp Corp. mills.

INSURANCE

The cost of an RB explosion is US$ 6–7 million per occurrence. Besides eliminating this expenditure, early leak detection could save lives, the aggravation associated with a lengthy outage and major rebuild, the resulting loss of customers and market share, and the escalation of insurance cost following a loss. Each of these items can cost millions of dollars. Falsely activated ESPs cause a loss of production and put thermal stress on the RB.

LEAK DETECTION SYSTEM

The author investigated and developed a method to prevent or reduce major tube leaks in RB units by developing a leak detection system. The system can detect tube leaks early and alert operators to take proper action to avoid large tube leaks[1].

The principle of the leak detection system uses a closure of the material balance around the steam drum. The system statistically compares moving average values of the drum balance within a short interval and a longer interval—windows. A significant difference between the moving averages denotes a possible leak. For each sample period, a generated model compensates for shrink and swell in the drum. The model uses three moving window pairs—short, medium, and long—to indicate a possible leak with a confidence level of 99.9%.

The input water flow to the drum, output stream flow, and blow down flow must balance during normal operation as the following equation shows:

$$DB = (FWF + CWF) - (STF + BDF) \quad (1)$$

where

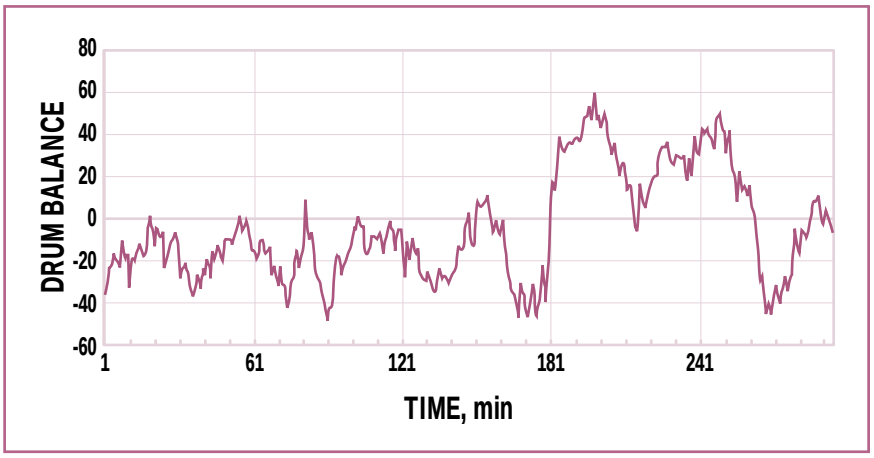
DB = drum balance
FWF = feed water flow
BDF = blow down flow
STF = steam flow
CWF = cooler flow.

If there is a 5–10 min average drum balance during normal operation that significantly differs from a 150 min average drum balance, one can attribute the cause to an RB leak with a preselected and high degree of confidence limit.

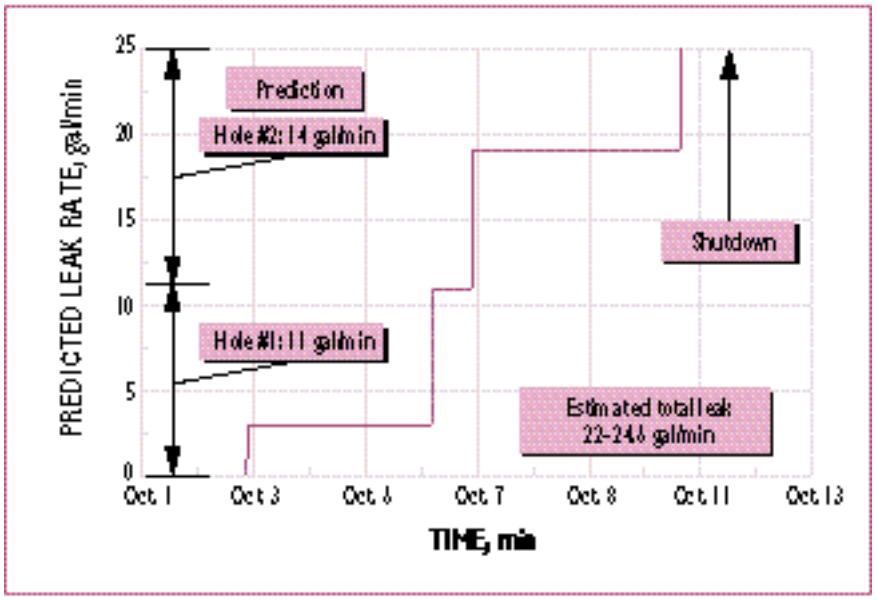
Because the system decision uses deviations, absolute accuracy in input variables is not necessary. Instruments nevertheless must respond to changes accurately and reliably.

To reduce shrink and swell effects on the drum balance variation, a model between drum balance and drum level is generated for every sampling time. This allows detection of smaller leaks.

[1] Nevruz, A. A., U.S. pat. 5,663,693 (Nov 15, 1994.)



1. Drum balance vs. time for a 5-h period



2. Successful leak detection for RB No. 1

Figure 1 shows a typical example for a drum balance vs. time for RB No. 1 at the Union Camp Corp. mill at Eastover, SC. The figure also shows the concept of window pairs.

KEYWORDS
Detection, evaluation, feed water, furnaces, leakage, material balance, recovery furnaces, water.

In October 1993, operators discovered a small leak in RB No. 1. Maintenance personnel found two holes of 1/8-in. diameter in the economizer section. The total calculated water flow from both holes was approximately 24 gal/min.

The author tested the system with real leak data from RB No. 1 without communicating with the mill personnel. Analysis of the data with the leak detection system indicated four leaks of 3, 8, 8, and 6 gal/min totaling 25 gal/min as **Fig. 2** shows. The system accurately showed both leak time and leak flow rates. The analysis indicated that the small holes started approximately 10 days before the operators detected them. The leaks enlarged during the 10 days of operation.

MILL USE

The first step of this project was discussion with the operators. Their willingness to help and complete the installation of the system ensured a smooth installation. Operator acceptance of the system has been excellent.

The leak detection system installed at the Eastover mill used their existing computer. The system can use any platform including a standby personal computer.

Two sets of interface are available for the RB operators:

- A terminal using commercially available software to display moving differences of drum balance averages for each pair of windows. This includes leak limit and leak amount when a leak occurs as **Fig. 3** shows.
- A system block diagram on the operator's main control console connected to another commercially available software system as **Fig. 4** shows. The system will detect leaks and show the status of the system to include system in operation mode, background information for a specific window pair, etc.

There were ten simulated leak trials from July 1994 to November 1994. Leak simulation involved opening a normally closed manual blow down flow valve for a preset time of 10–80 min. In all trials, the system predicted leaks accurately. Figure 3 also shows an example of a simulated leak trial. Since completion of the model, the

leak detection system has not indicated any false alarms during normal RB operation. The success of simulated leak trials continued after November 1994.

The system has been installed on RB No. 2 at Eastover, No. 6 in Franklin, and Nos. 14 and 15 in the Savannah mills. The system installation is in progress for RB Nos. 1 and 2 in the Prattville mill. The system will be installed on RB Nos. 4 and 5 in the Franklin mill after completing a DCS upgrade.

CONCLUSION

The author has developed a method to detect leaks in an RB. System acceptance by operators has been excellent.

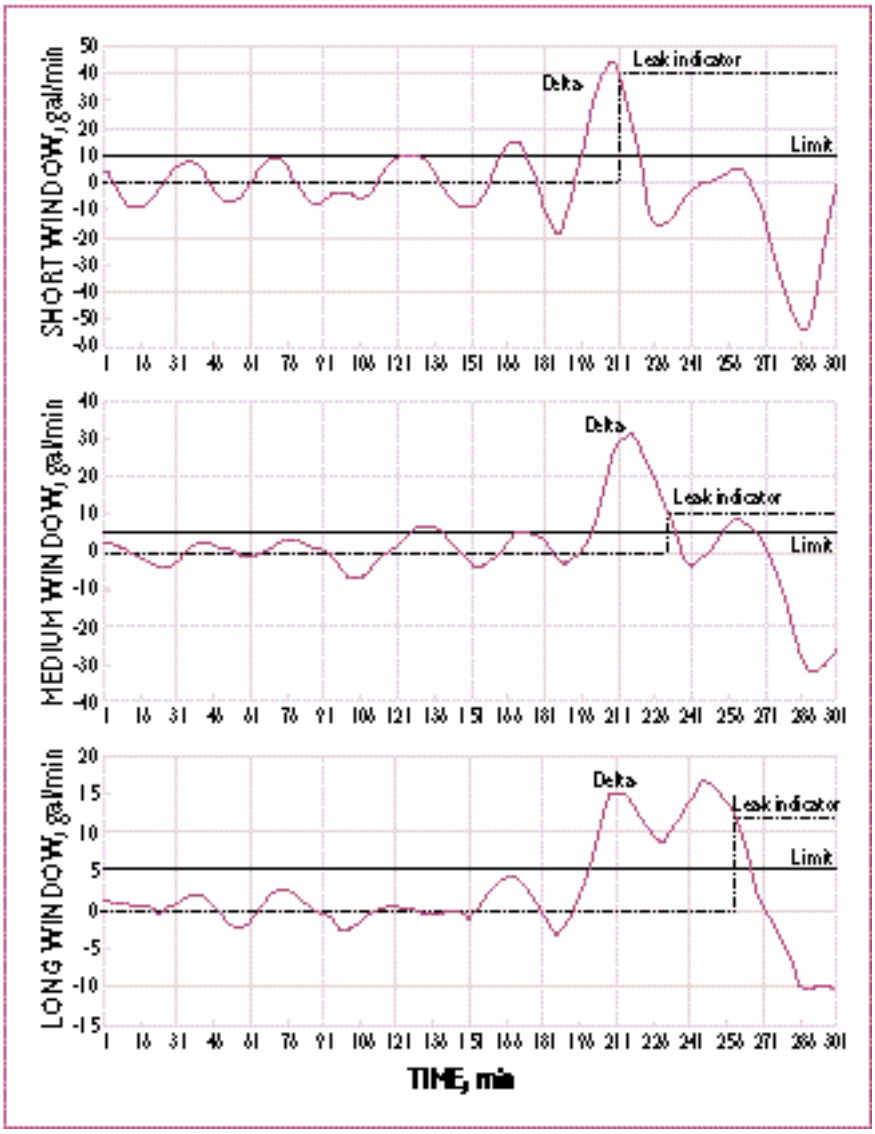
In October 1993, the system successfully detected four small leaks in the economizer section of RB No. 1 at Eastover, SC. During March 1995, it detected a leak in the economizer section of RB No. 14 at a Union Camp Corp. mill in Savannah, GA. The system has correctly detected every simulated leak in over 30 trials.

FUTURE PLANS

A new method has been developed and is being successfully tested on RB No. 1 at the Eastover mill. This new enhancement will significantly reduce the time to alert a possible leak in the recovery boiler without sacrificing a high degree of confidence.

Future work will enhance the model by adding other variables such as load, pressure, and black liquor temperature changes. This will improve the degree of confidence during load changes.

The minimum time to predict a leak depends on the drum balance cycling. Further work will try to optimize the minimum time for each RB automatically and periodically by calculating drum balance cycling time. **TJ**



3. Simulated leak trial on RB No. 1

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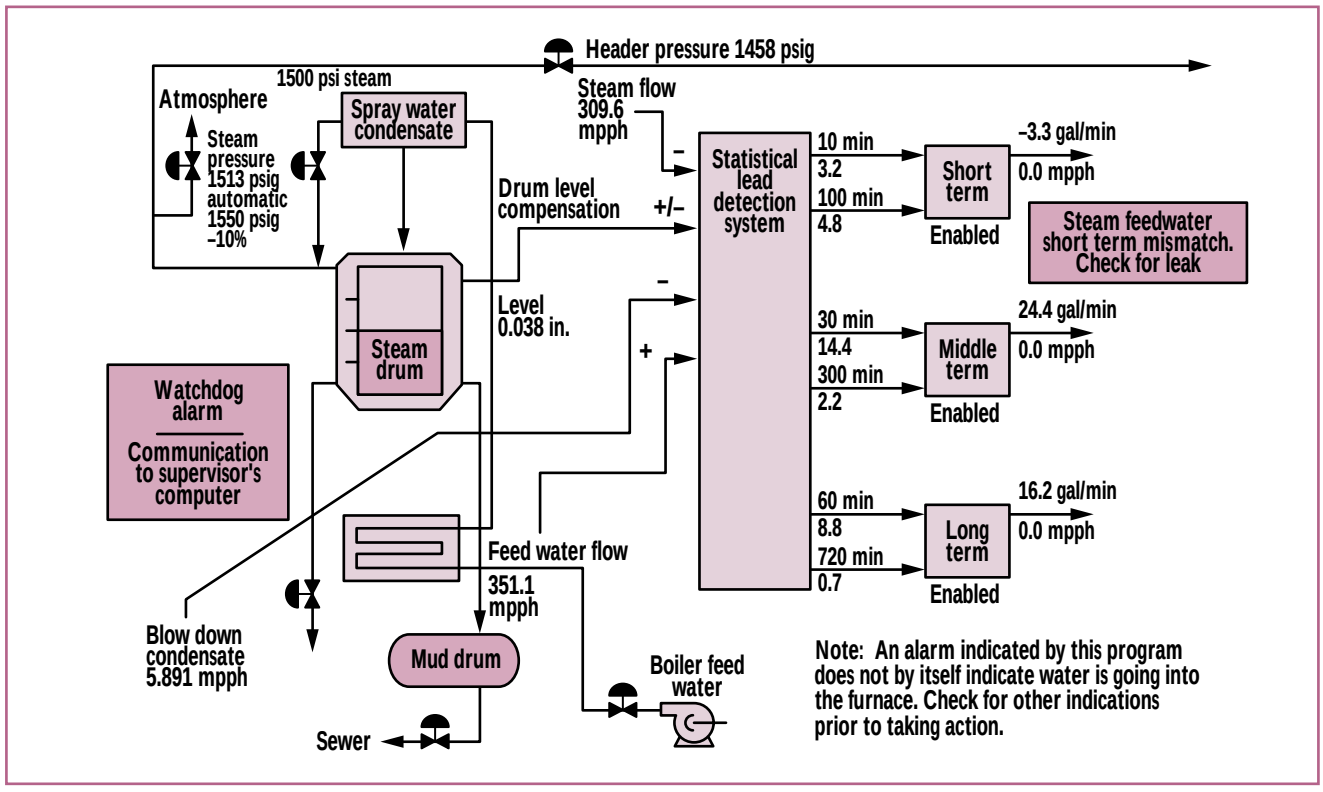

4. Leak detection system