O PAPEL vol. 76, num. 5, pp. 55 - 57 MAY 2015

CONGRUENT PHOSPHATE WATER TREATMENT CONTROL FOR RECOVERY AND POWER BOILERS BASED ON KNOWLEDGE

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Trabalho premiado ABTCP 2014

ABSTRACT

Congruent phosphate control is the boiler water internal treatment most widely used in many industries, such as pulp and paper, chemical, petrochemical and in many applications for the power generation. The great benefit lays on the ability of this program to absorb small quantities of contaminants, such as acid, caustic, liquors and others. The big challenge is to maintain the Na:PO_4 ratio inside the established limits. If the boiler chemistry is controlled within these limits, the risks of deposition and many forms of corrosion are practically neglected. Due to contaminations and steam production variation, manual systems produce irregular results of "in box time" on the control charts. The first generations of automated systems brought excellent results, with a high percentage of in box time. OnGuard iController, the controller presented in this paper, raised significantly this control, providing much more reliable results to the boiler water treatment. The system description shows the equipment benefits and its capabilities. Along with the description, two case histories are described and show precise conclusions for this controller.

Keywords: automation, congruent phosphate, in box control, Na:PO_4 ratio, OnGuard iController.

INTRODUCTION

Na:PO_4 Congruent Phosphate Control is the only treatment program for markets such as pulp, and also widely utilized in other industries where the risk of water contamination is imminent. Although it is not new, it is by far the best choice where there can be feedwater contamination in some level. The contamination can occur from the demineralization systems (acid and caustic), condensate (iron, copper, process streams), and specific processes (oils, liquors, etc.). Along with that, this program can tolerate larger quantities of solids such as iron (maximum 10 ppb in feedwater) when compared to an All Volatile Treatment-AVT- (maximum 2 ppb iron in feedwater).

Marcy and Halsted firstly established the concepts and limits for Congruent Phosphate in 1964. After that, in 1975, Rosemer and Dale optimized the recommendations based on the boiler operating pressure. Rosemer and Dale, in fact, defined the limits for each boiler pressure group, where the higher the pressure, lower will be the maximum allowable solids quantity.

OnGuard iController not only controls the phosphates blend and ratio dosed into the boiler. It also can foresee short and medium term variations on the boiler water chemistry and steam production based on a historical data registry and knowledge of many operating days.

Congruent Phosphate Program

Congruent Phosphate is one of the phosphate program options for high-pressure boilers. Initially it was developed as what is called Coordinated Phosphate, which established only the Na:PO_4 molar ratio below 3.0 as a way to prevent free caustic, and consequently reduce caustic corrosion possibility and other related problems. This was firstly described by Purcell and Whirl in 1943[1,2].

On the years after that, the new boilers were designed with higher heat transfer flux through the tubes. This demanded some changes on the phosphate based programs. In 1964, Marcy and Halsted created the congruent phosphate program by setting up limits for some of the previously described variables. However, it was only in 1975 that Rosemer and Dale upgraded the widely known pH and PO_4 ratio according the boiler operating pressure. **Figure 1** illustrates the typical pH and PO_4 operating limits depending upon the operating pressure.

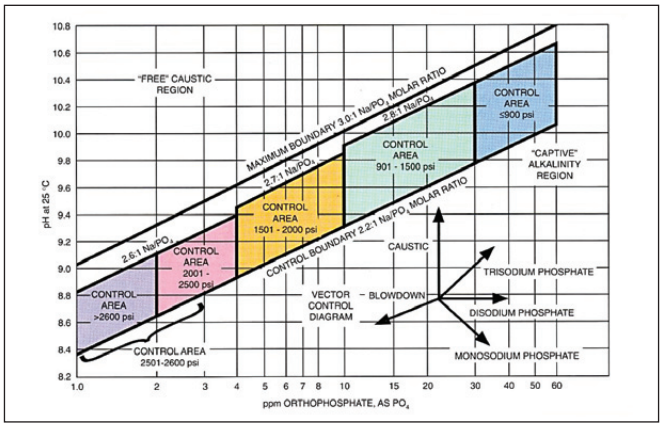

Figure 1. Congruent phosphate control diagram

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Undoubtedly, after the elaboration of this program many others were developed: Equilibrium Phosphate, Continuum Phosphate, etc. However, the Congruent Phosphate program still is by far the most adequate for systems where the risk of contamination is high and there is also need of better pH buffering.

OnGuard iController

OnGuard iController provides total solution for the needs of dosage and control associated to pH/PO_4 programs. OnGuard iController automates the dosage and simplifies the control of any program that demands a pH and phosphate ratio.

The main objective is to maintain water specifications in the pH/PO_4 treatment, automatically, maximizing reliability and safety for the boiler.

Figure 2 is a visualization of many screens available on the controller. At this specific screen, one can configure the steam generation system.

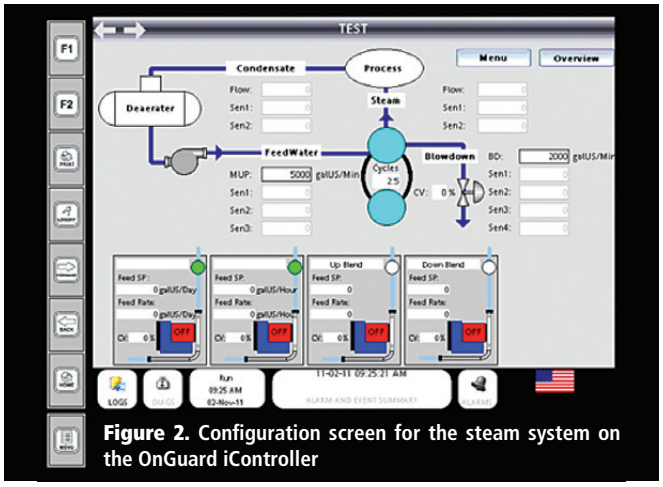

Figure 2. Configuration screen for the steam system on the OnGuard iController

Utilized Configuration

On most installations, OnGuard iController is adjusted to control the automatic dosage of the low and high pH phosphate blend, and also other regular products in chemical programs (dispersant, oxygen scavenger and neutralizing amines). **Figure 3** shows how most installations operate with a controller such as this.

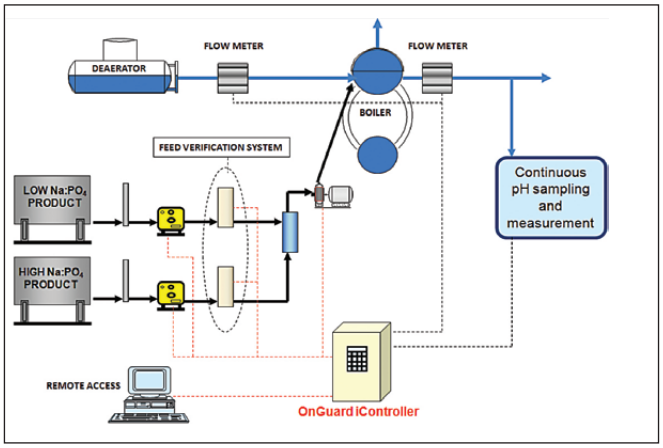

Figure 3 – Configuration of operation and control through the OnGuard iController

RESULTS AND DISCUSSION

Case #1 Pulp Plant, Recovery and Power Boilers

This plant is equipped with two high-pressure boilers (100 bar) and individual production of 250 ton/h of steam. The historical condition of this plant is a very strong instability on the steam production, especially on the power boiler. The recovery boiler, as one would expect, operates on a higher stability regarding steam production.

Customer´s goals:

→ utilize a state of the art monitoring and control system for boiler water treatment program;

→ have the ability for a remote access control for the program treatment;

→ have the ability to receive alarms for any disturbances;

→ minimize manual involvement direct on the boiler water treatment and chemical control.

Additionally, it is important to observe that the previous results of in box time were considered satisfactory for this plant, with an average of in box time over 90%. **Figure 4** shows the typical results for the recovery boiler before the installation of the OnGuard iController.

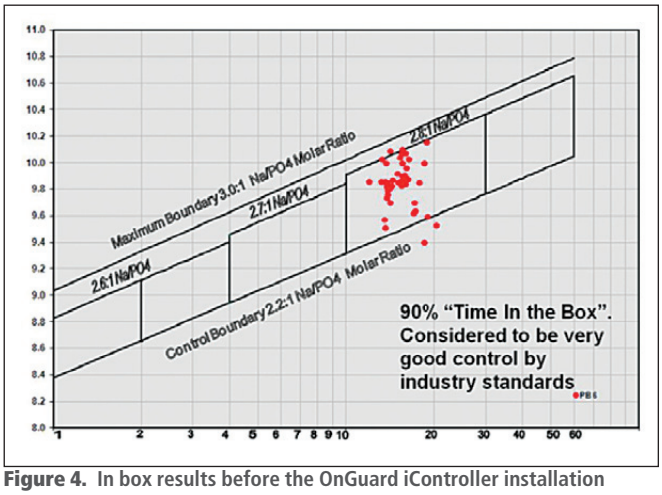

Figure 4. In box results before the OnGuard iController installation

It is important to remember that any result above 90% of in box time is considered very good and wanted for most steam generation systems. This is actually one of the greatest benefits observed after the use of this controller. There was a substantial improvement on the in box control. Not only it became able to have 100% of points in box, but also it was possible to gather a strong concentration of points very close together. **Figure 5** shows the results during the use of OnGuard iController. One can observe that the points repeated many time on the same coordinates, indicating very low variability of the system, independently on the great variations of steam production on the plant.

After the installation and operation of OnGuard iController some improvements were observed:

→ substantial raise on the in box time;

→ very little variability on the chemistry results for the boiler water;

→ high reliability independently of strong steam production variation;

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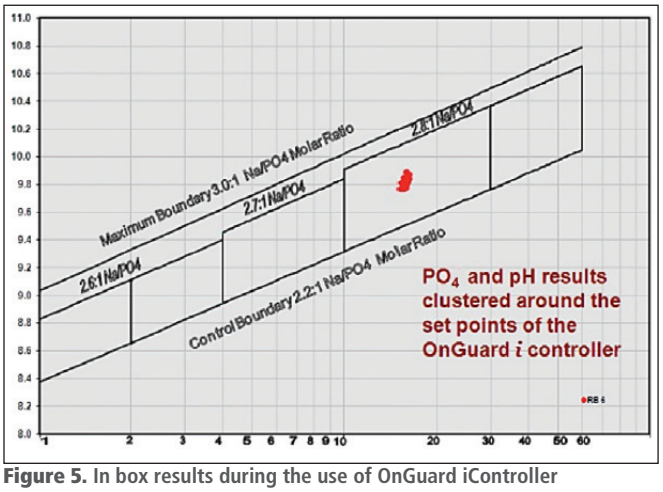

Figure 5. In box results during the use of OnGuard iController

→ the plant was able to visualize, monitor and control the system throughout a web based comm;

→ less time and availability of manual repairs for the equipment maintenance.

Case #2 Pulp Plant, Recovery and Power Boilers, Brazil

This is a pulp plant located in Brazil, where an OnGuard iController was installed along with other controller that operated other boilers in the same plant. The steam generation system is composed of several boilers, with flow rates around 200 ton/h and 90 bar of operating pressure.

The three largest boilers of the plant (Boiler #1, Boiler #6 and Boiler #3) have monitoring and control equipments. Both boilers #1 and #2 already had chemical treatment controller. An OnGuard iController was installed for Boiler #3. Both Boilers #1 and #2 are recovery (more stable regarding steam production) and Boiler #3 is a power boiler, very suitable for large steam production variation.

Customer´s goals:

→ to have a reliable chemical control system for Boiler #3, and to get at least to the same results obtained on the other boilers;

→ to enhance in box time, even though the steam production variation is known for this boiler.

Boiler #3, along with its OnGuard iController, was started in January 2013. Because of this, the results for all boilers are shown from that date forward. **Figure 6** shows the in box control results of the Na:PO_4 ratio for boilers #1 and #2 from January 2013 to March 2014.

The results show poor profiles before the above mentioned period. Historically, the in box time was approximately 85% – 90%.

The installation of OnGuard iController for Boiler #3, which suffers a strong steam production variation, resulted in an excellent control chart when compared to the other two controllers. A substantial improvement was observed regarding Na:PO_4 ratio control during this period. **Figure 7** shows the results of Na:PO_4 ratio control for Boiler #3.

The results presented on the above chart are considered excellent because of two different reasons:

→ comparison to the other boilers and their controllers at the same plant;

→ large steam production variability.

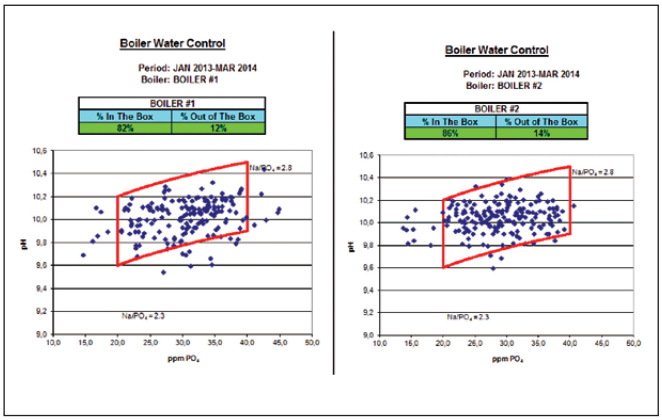

Figure 6. Results for boilers without OnGuard iController

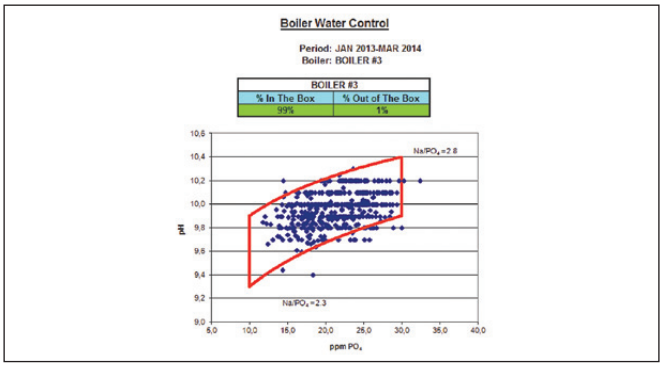

Figure 7. In box results for Boiler #3 by OnGuard iController

CONCLUSIONS

OnGuard iController was able to achieve the following results:

→ data bank acquisition and formatting for many different steam production variables (flowrates, pH, phosphate, etc.);

→ elaboration of predictability strategies for pH and/or steam production variations;

→ advanced control with high conversion results on the goals for the boiler water chemistry, not only the congruent phosphate issue.

→ larger capacity to absorb contaminations and quality interruptions;

→ deposition and many corrosion mechanisms results warranty in high pressure boilers. ■

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