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THE CDI QUARTERLY

"Technical News You Can Use"

Inside This Issue

Getting to Know Deaerators – Part I

By Jim Benzing, President

Over the years it has become apparent that many boiler plant operators, power piping contractors and power plant consultants have many unanswered questions on sizing, installing, piping, controlling and operating boiler room deaerators. Adding to the confusion is the fact that deaerators are known by various names throughout the industry, including; deaerating heaters, direct contact heaters, feedwater heaters, deaerating feed tanks or DFTs (especially among former Navy personnel), and the list goes on.

In an attempt to clarify some of these questions I have written a two-part article drawing on some 40+ years of experience spent working with deaerators. This first part will touch on how deaerators work, what they do, and the various designs available. The second part, to be published in our January newsletter, will provide greater detail regarding proper sizing and control of deaerators.

Before I begin, I should clarify that this paper will only discuss steam operated, pressurized deaerators. These deaerators account for roughly 99% of all industrial working deaerators in the US; however, I recognize there are other deaerator designs in limited use (e.g., vacuum deaerators).

HOW THEY WORK

All boiler installations whether large or small, with low pressure or high pressure steam, field erected or packaged boilers, water tube or firetube boilers, direct-fired or heat recovery boilers, require a deaerator. Even High Temperature Hot Water generators should have a small deaerator for loop system make-up to protect the generators and system piping from Oxygen (O_2) corrosion. As a result of their wide-spread applicability, deaerators are available in a variety of capacities, and both horizontal and vertical configurations to best fit just about any existing site conditions.

In their simplest form deaerators are mechanical, pressurized enclosures (may be ASME coded) designed to remove naturally dissolved corrosive gases, specifically O_2 and Carbon Dioxide (CO_2), from boiler feedwater prior to entering the feed pumps. Regardless of final design, all deaerators have three main parts; a storage section, a de-gassing chamber and a vent, and all are intended to protect the system from corrosive gases dissolved in water. From a fabrication perspective, all material in the de-gassing section, to include water spray nozzles, water manifold, cascading trays, water box, vent condenser and gas vent connection must be manufactured from stainless steel to protect against O_2 pitting and the corrosive effects of carbonic acid.

I should note that a condensate receiver with a steam sparging tube is not a deaerator, though many installations may attempt to use one as such. Depending on the temperature range over which the condensate receiver is operated, some O_2 will be liberated as the receiver temperature is increased (reference any O_2 content vs. temperature chart). This reaction is the main reason most mild steel receivers will fail from O_2 pitting within 3-4 years of operation, and failure will occur regardless if the storage tank is lined or only painted.

Boiler feedwater that has not been effectively deaerated will have O_2 concentrations greater than 5 ppb in high pressure boilers (>200 psig) and 43 ppb in low pressure boilers. *(Source: DOE/GO-102000-1118, Steam Tip #18, December 2000)* Excessive O_2 concentrations will cause

The Heating Season is Here!

Have you scheduled your annual combustion tuning yet? As temperatures begin to drop and load demands increase the efficiency of your unit(s) becomes ever more critical. There is no better time to ensure your equipment is operating as efficiently as possible.

Combustion Designs provides combustion testing, steam plant efficiency evaluations, combustion tuning and safety limit testing. Call or email us today to ensure you are prepared for tomorrow.

"…all deaerator designs are not equal and will not provide the same results."

Common Deaerator Designs

Tray-Type Chamber

corrosion pitting, regardless of boiler design, in a relatively short period of time (3-4 years). Corrosion is especially prevalent in the feedwater storage tank, water piping, control valves, economizer, boiler and steam delivery piping.

Likewise, any CO_2 gas that is dissolved in non-deaerated feedwater is highly corrosive when it is converted to steam in the boiler, forming carbonic acid. Carbonic acid is the primary cause of failed steam and condensate return piping, due to acid grooving in the bottom portion of the piping systems.

For the same reasons, hot condensate and cold O_2 rich soft water make-up should never be mixed in a mild steel condensate receiver. If O_2 rich soft water make-up is mixed with hot condensate in a condensate receiver, the entire system; receiver, transfer pumps, control valves and all piping from the receiver to the deaerator must be stainless steel or the condensate system will experience a very short life from O_2 corrosion. Instead, we recommend that our customers blend condensate (including return from condensate polishers) and make-up in a separate stainless steel mixing vessel. (Please contact us for more information regarding our proprietary Deaerator Diffuser, specifically designed to provide proper mixing of the two prior to introduction into the deaerator.)

A steam operated deaerator removes dissolved O_2 and CO_2 from the boiler returns and relatively cool make-up water by spraying and cascading this inflow water stream through low pressure steam (4-8 psig.) as it enters the deaerator. The low pressure "stripping" steam in the deaerator intimately associates the water and steam, completing the O_2 and CO_2 degassing process. The dissolved gases are then discharged to the direct contact condenser and eventually the atmosphere via the vertical gas vent pipe. This process also typically pre-heats the water in the deaerator storage section to 227º F to 240º F, depending on the deaerator operating steam pressure, eliminating any thermal shock to the feedwater heating economizer and steam boiler.

Any remaining dissolved O_2 will typically be removed by a chemical additive that has an affinity for O_2. Perhaps the most common O_2 inhibitor in use today is Sulfite. This additive is commonly introduced in the deaerator by an 18" stainless steel injection quill, though some installations may "flush" the O_2 inhibitor into the storage tank via the feed pump by-pass connection. Regardless of the method, the chemical additive should only be introduced into the storage section of the deaerator well below water level.

DESIGNS

"It's what the deaerator salesman didn't tell you that can cause endless deaerator control and feedwater problems with O_2 and CO_2 carry-over into the boiler system." Regardless of sales bulletins and claims, all deaerator designs are not equal and will not provide the same results. A properly designed and controlled tray-type deaerator will have + 10:1 turndown. Alternatively, a *cost effective* spray-type deaerator may be limited to 2:1 turndown depending on the percent make-up vs. percent condensate. The limited turndown on a spray-type deaerator is caused by non-uniform return "spray" water patterns resulting from the decreased flow rates associated with increasing turndown.

A number of field modifications can be made to spray-type deaerators to improve turndown, but they all cost extra money typically not accounted for during the original deaerator selection. To improve spray-type deaerator turndown a constant return feedwater flow pump can be added to the return water to maintain the spray nozzle flow rates and to minimize O_2 and CO_2 carry-over into the boiler feedwater. Higher quality (less cost effective) spray-type deaerators will typically provide the capability to externally select the number of spray nozzles in service to match the actual plant's feed-water flow rates.

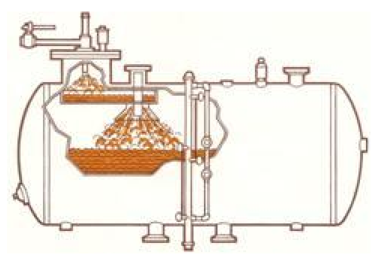
If boiler turndown is a key component in your decision-making process, the turndown of your deaerator must not be overlooked. Please see *Getting to Know Deaerators – Part II* in our January newsletter for more information regarding how to properly size and control a deaerator.

Applied Heat Recovery Economizers

By Jeff Cobb

Ecodyne Spray Tray Deaerating Heater
Photo © Ecodyne Limited
www.ecodynedeaerators.com/designs_spraytray.htm

Spray-Type Chamber



Stickle Spray Deaerater

DID YOU KNOW?

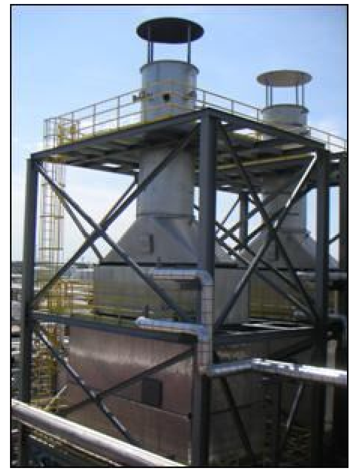
Did you know that Subpart 14-1.17 of New York Industrial Code Part 14 requires dual high steam pressure switches (one of which must be of the manual reset type) be installed on all unattended high pressure boilers?

At Combustion Designs, Inc. we take pride in establishing and maintaining quality manufacturing relationships and sales partnerships. Partnering with Applied Heat Recovery, LLC (AHR) has given us access to a wide range of high quality heat recovery products that we can offer our customers. Like our other partners, AHR combines a superior product with exceptional service and customer support; placing them at the top of their industry.

AHR specializes in heat recovery equipment including economizers, tubular air heaters, steam coil air heaters and air cooled condenser units. AHR economizers are engineered using proven propriety software that ensures top performance and competitive pricing in every product they manufacture. This process results in a high-end economizer engineered specifically for the end user's application and requirements. Units are designed for new and retrofit applications where maximum efficiencies and minimal heat losses are required. AHR Economizers typically provide a 4-6% increase in efficiency and can result in a return on investment of less than one year. In difficult economic times, economizers provide a bright spot for installations looking to improve efficiencies and reduce operating costs!

Applied Heat Recovery offers economizers for various applications including boilers, dryers, engine exhaust, ethanol production, food processing, petrochemical, pollution control, pulp & paper and rotary kilns. Various designs of AHR's economizers allow for all types of fuels including bio-fuels, gases and oils. Additionally, AHR now offers a line of pre-engineered economizers for customers where fast delivery and quick installation are paramount. The quality engineering and manufacturing that goes into each and every AHR economizer provides hot forged tube bends, a limited number of fins per inch of tube, the design capability of utilizing sootblowers, and the capability to design difficult retrofit applications regardless of the size or shapes required.

For the end user, retrofit applications targeted to increase operating efficiencies can be justified by low upfront equipment and installation costs, and are offset by the extended equipment life of each AHR product. Combustion Designs, Inc. can offer a complete turnkey package including site specific engineering, economic justifications, economizer installation, startup services and efficiency testing. Call us today to discuss how an AHR product can benefit you. 🛠



AHR Economizers are designed to fit just about any job, under any circumstances.

Click here to explore Applied Heat Recovery's automated economizer sizing tool.

Constant Differential Control

By Jeb Benzing

Combustion Designs, Inc. specializes in offering our customers tried and true combustion control systems. One control option we regularly offer is a Constant Differential Control (CDC) System. This system has been proven on hundreds of installations, providing our customers the ultimate in control reliability, safety and efficiency. Adding to the value of the CDC System are the low upfront equipment costs and long-range fuel and electrical savings.

The CDC System is not a metered fuel/air ratio control system, but rather an advanced linkage type control system with the fuel valves and windbox air control dampers mechanically linked together by a single firing rate positioner. This system ensures safe firing conditions and provides the efficiencies associated with oxygen trim and a variable speed drive on the forced draft (FD) fan, without high control costs and safety risks. An increase in steam (or hot water) demand causes the Boiler Master controller to send a signal to the positioner (electric or pneumatic), forcing it to increase, in turn increasing the pre-adjusted fuel valves and windbox air control dampers in proportion to the increased demand signal. The system reacts to this change by maintaining the preset differential between the furnace and the FD supply, thus providing sufficient combustion air throughout the entire operating range of the boiler. The mechanical link between the fuel valve and windbox air control dampers provides maximum safety in comparison to a parallel positioning and/or full metered control system.

Advantages of a CDC System

- An intrinsically fail-safe burner control system
- Correction limits are placed on the O_2 signal that can be applied to the FD ΔP controller to protect against O_2 analyzer failure, controller failure, FD DP transmitter failure and/or loss of electrical power to these loops.
- Provides for realistic FD Air Switch settings (3.0"wc) to protect against an obstructed FD fan inlet, dirty fan wheel, loose fan wheel or a FD VFD problem. Metered control systems and parallel positioning control systems must set an FD air switch to satisfy low fire conditions where the FD pressure may be <0.1"wc.
- Cost effective because fuel flow and combustion air flow elements and transmitters, controller cross limits and ratio scaling are not required.
- FD VFD provides maximum electrical power savings from "soft starts" and reduced fan speeds matched to burner inputs, while compensating for oversized fans. Also has the added advantage of quiet operation at reduced loads.

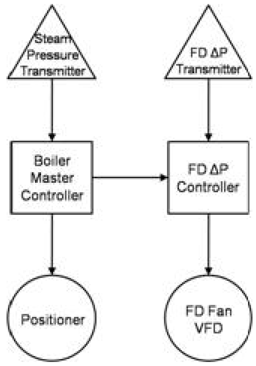


Fig. 1 - CDC Schematic

As the name implies, maintaining a constant differential (pressure) is key to the operation of this control system. To accomplish this, the CDC System is first calibrated for optimal combustion across the entire firing range while maintaining this constant FD differential. Once ideal fuel and air combinations are determined, they are mechanically linked together on the cross shaft, ensuring they will be maintained at all load points. A variable frequency drive (VFD) is used to modulate the FD fan as changes in static pressure are detected, thereby maintaining the constant FD differential.

APPLICATION

For relatively large boilers (>80,000 PPH) with substantial air and fuel control mechanisms, the precise jackshaft control required by a CDC system can be increasingly difficult. However, for single burner boilers with capacities less than 80,000 PPH, or the equivalent BTU/Hr output, CDC is an ideal control option. Additionally, CDC does not require an air flow measurement, which has proven to be very difficult for metered control systems on boiler applications below the 80,000 PPH capacity range. As a result, CDC also avoids the large expense of metered control since no air or fuel flow elements are required.

OXYGEN TRIM

To guarantee optimal control and to account for variations in available BTU's (by fuel type), as well as deviations in excess combustion air due to temperature and barometric pressure changes, Combustion Designs, Inc. often adds Oxygen Trim to the CDC System. Oxygen Trim becomes necessary because the differential pressure transmitters used to measure air differential cannot measure the density of the combustion air. Oxygen Trim is an economical upgrade that ensures safe and reliable boiler operation at all times.

When Oxygen Trim is added to the CDC System, an oxygen analyzer is used to constantly measure the oxygen content of the flue gas. As deviations from the oxygen set point are detected an output from the Oxygen Trim controller provides a secondary input into the FD computing controller telling it to trim (bias) the FD set point within safe, pre-set limits; this is not a cascade control system. Additionally, our controllers are configured to give the end user the capability to view the set point as well as the current correction (bias); providing confirmation that Oxygen Trim is working to maintain optimal combustion. 🛠

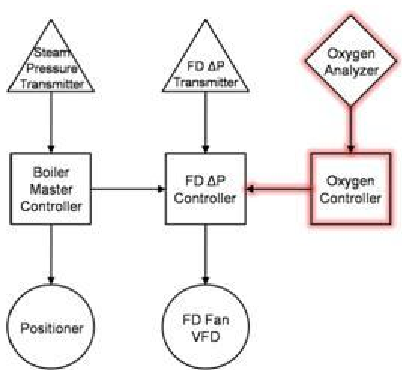


Fig. 2 - CDC Schematic with O_2 Trim

Announcing Another New Partnership Aimed at Helping You Control Your Emissions

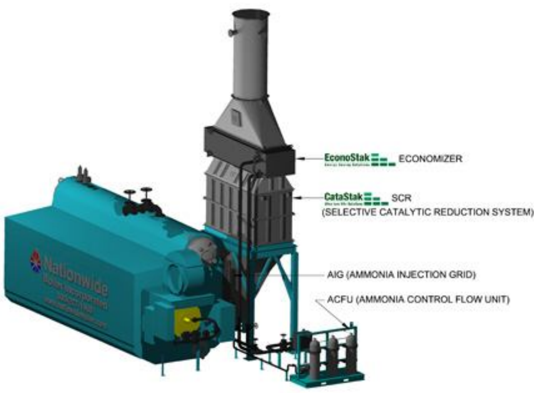
Combustion Designs is acutely aware of the industrial greenhouse gas emissions issue and as

- Turndown is not limited by ability to measure airflow as is the case with metered systems. Typically a CDC System provides a minimum of 10:1 turndown.

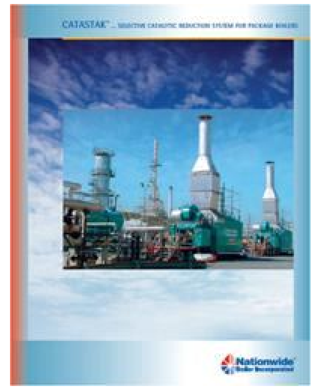
such, we are committed to helping our customers meet and exceed existing regulations while being ever mindful of potential changes our customers may face in the future. Low NOx burners upgrades are an extremely effective answer to the demand for lower emissions; however, they are not always economically justifiable nor logistically feasible. To offer our customers yet another option for reducing emissions Combustion Designs is pleased to announce our recent partnership with Nationwide Environmental Solutions.

CataStak™ Ultra Low NOx Solutions

Nationwide Environmental Solutions provides innovative, low NOx air pollution control solutions to help lower overall industrial greenhouse gas emissions. Technologies available through Nationwide Environmental Solutions include the CataStak™ selective catalytic reduction system, a modular, field-retrofit system capable of limiting NOx emissions to 2.5 ppm; the EconoStak Economizer for increased fuel efficiency; and the E2Stak package, which provides both emissions reductions and increased fuel efficiencies. Nationwide Environmental Solutions is capable of custom designs and supplies SCR systems for boilers, heaters, furnaces and gas turbines. Please contact us or visit CataStak™ for more information on products and services available. 🛠



Vertical CataStak™ Arrangement



Download the CataStak™ SCR System Brochure to learn how you can lower your NOx emissions.

This newsletter was sent to our valued customers and partners in an effort to provide them the latest industry news and information about our capabilities.

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