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Fossil Fuel Power Plant Feedwater Control System

Approved March 12, 2019

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A variety of feedwater control systems have been developed and used over the years to maintain drum level within limits and at the required setpoint. This document is intended to establish minimum requirements for feedwater controls for drum type and once-through type boilers.

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1 Scope

The standard is intended to assist in the development of design specifications covering the measurement and control of feedwater systems in boilers with steaming capacities of 200,000 lb/h (25 kg/s) or greater. The safe physical containment of the feedwater shall be in accordance with applicable piping codes and standards and is beyond the scope of this standard.

2 Purpose

The purpose of this standard is to establish the minimum criteria for the control of levels, pressures, and flow for the safe and reliable operation of feedwater systems in drum type and once-through fossil power plants.

3 Definitions

3.1 alarm:

an audible and/or visible means of indicating to the operator of equipment malfunction, process deviation, or abnormal condition requiring a response.

3.2 boiler:

the entire vessel in which steam or other vapor is generated for use external to the vessel. This includes the furnace, consisting of water wall tubes; the firebox area, including burners and dampers; the convection area, consisting of any superheater, reheater, economizer section or any combination thereof; as well as drums and headers.

3.3 cascade control:

a control action in which the output of one controller is the setpoint for another controller.

3.4 controller:

any manual or automatic device or system of devices used to regulate a process within defined parameters. If automatic, the device or system responds to variations in the process variable.

3.5 drum (steam):

a closed vessel designed to withstand internal pressure. A device for collecting and separating the steam/water mixture circulated through the boiler.

3.6 feedwater flow control system:

a control system that uses input signals derived from the process for the purpose of regulating feedwater flow to the boiler to maintain adequate drum level or water supply to the boiler according to the manufacturer's recommendations.

3.7 mass feedwater flow:

the mass flow of all water delivered to the boiler; it is derived either from direct process measurements and/or calculations from other parameters.

3.8 mass steam flow:

the mass flow of steam from the boiler, derived either from direct process measurements and/or calculations from other parameters.

3.9 protective logic circuits:

logic circuits designed to prevent damage to equipment by related system equipment malfunctions, failure, or operator errors.

3.10 pump drive control:

a control component of the final device that translates a control system demand signal into an electronic, hydraulic, pneumatic, or mechanical signal that affects pump speed.

3.11 redundant (redundancy):

duplication or repetition of elements in electronic or mechanical equipment to provide alternative functional channels in case of failure of the primary device.

3.12 runback:

action initiated by the loss of selected auxiliary equipment, in which the load is reduced automatically to a level which can be sustained with the remaining auxiliary equipment.

3.13 rundown:

an action initiated by an undesirable operating condition, in which the load is reduced until the undesirable condition has cleared.

3.14 shall, should, and may:

the word "shall" is to be understood as a requirement; the word "should" as a recommendation; and the word "may" as a permissive, neither mandatory nor recommended.

3.15 shrinkage:

a decrease (shrinkage) in drum level due to a decrease in steam-bubble volume. This condition is due to a decrease in load (steam flow), with a resulting increase in drum pressure and a decrease in heat input.

3.16 single-element feedwater control:

a control system whereby one process-variable drum level is used as the input to the control loop that regulates feedwater flow to the drum to maintain the drum level at setpoint.

3.17 steady-state:

a characteristic of a condition (such as value, rate, periodicity, or amplitude) exhibiting only negligible change over a long (arbitrarily chosen) period of time.

NOTE — It may describe a condition in which some characteristics are static, others dynamic.

3.18 swell:

an increase (swell) in drum level due to an increase in steam-bubble volume. This condition is due to an increase in load (steam flow), with a resulting decrease in drum pressure and an increase in heat input. Swelling also occurs during a cold start-up as the specific volume of the water increases.

3.19 three-element feedwater control:

a control system whereby three process variables (steam flow, feedwater flow, and drum level) are used as inputs to the control loop that regulates feedwater flow to the drum to maintain the drum level at setpoint. This is a cascaded feedforward loop with drum level as the primary variable, steam flow as the feedforward input, and feedwater flow (feedback) as the secondary variable.

3.20 transient:

the variable behavior during the transition between two steady states.

3.21 two-element feedwater control:

a control system whereby two process variables (steam flow and drum level) are used as inputs to the control loop that regulates feedwater flow to the drum to maintain the drum level at setpoint. The feedforward input is steam flow, with the output of the drum level controller as the primary control signal.

3.22 two-out-of-three logic circuit (2/3 logic circuit):

a logic circuit that employs three independent inputs and whose output of the logic circuit is the same state as any two matching input states.

4 Minimum design requirements for a feedwater control system

The control system shall meet operational requirements and correctly interface with the process. To accomplish this objective, the following requirements are defined for minimum system design:

- a) Process measurement requirements
- b) Control and logic requirements
- c) Final control device requirements
- d) System reliability and availability requirements
- e) Alarm requirements
- f) Operator interface requirements

4.1 Process measurement requirements

4.1.1 Instrument installations for feedwater control

Instruments should be installed as close as practical to the source of the measurement, with consideration given to excessive vibration, temperature, and accessibility for periodic maintenance.

Specific requirements for the location of drum water-level measuring devices are contained in Section 1 of the American Society of Mechanical Engineers' (ASME) *Boiler and Pressure Vessel Code*.

Separate process connections, isolation valves, head chambers (when used), and impulse lines shall be provided for each instrument (see Figure 1).

4.1.2 Drum-level measurement

A drum-level signal is required for single-element, two-element, and three-element drum feedwater control systems (see Figures 1, 3, 4 and 5). If the instruments used to measure drum level are sensitive to density variation, then density compensation techniques shall be employed. Please refer to ISA-TR77.42.02-2014, *Compensated Differential Pressure Based Drum Level Measurement*, for more details on level compensation methods.

4.1.3 Steam-flow measurement

A mass steam-flow signal is required for two-element and three-element feedwater control systems. If volumetric steam flow measuring techniques are employed, the measured (indicated) flow shall be compensated for flowing steam density to determine the true mass steam flow.

4.1.4 Feedwater-flow measurement

A mass feedwater flow signal is required for three-element drum feedwater control systems. Mass feedwater flow can be measured by a single transmitter at the boiler feedpump discharge or by the sum of the furnace feedwater flow and spray attemperator feedwater flow (Figure 2).

For the purpose of three-element drum level control, superheat spray flow is added to the feedwater flow (into the drum) if the flow is not already included so both inflow and outflow of the drum are balanced. Drum blowdown flow is often ignored in three-element drum level control strategy.

When volumetric feedwater flow measurement techniques are employed and the feedwater temperature at the flow-measuring element variance is equal to or greater than 100 °F (55.6 °C), the measured (indicated) flow shall be compensated for flowing feedwater density to determine the true mass feedwater flow.

4.1.5 Furnace feedwater-flow measurement

A mass furnace feedwater-flow signal is required for once-through feedwater control system (Figure 2). Furnace feedwater flow can be measured by a single transmitter at the furnace (economizer) inlet or by the difference between the boiler feedpump discharge flow and the spray attemperator flow sensors.

When volumetric furnace feedwater flow measurement techniques are employed and the feedwater temperature at the flow-measuring element variance is equal to or greater than 100 °F (55.6 °C), the measured (indicated) flow shall be compensated for flowing feedwater density to determine the true mass feedwater flow.

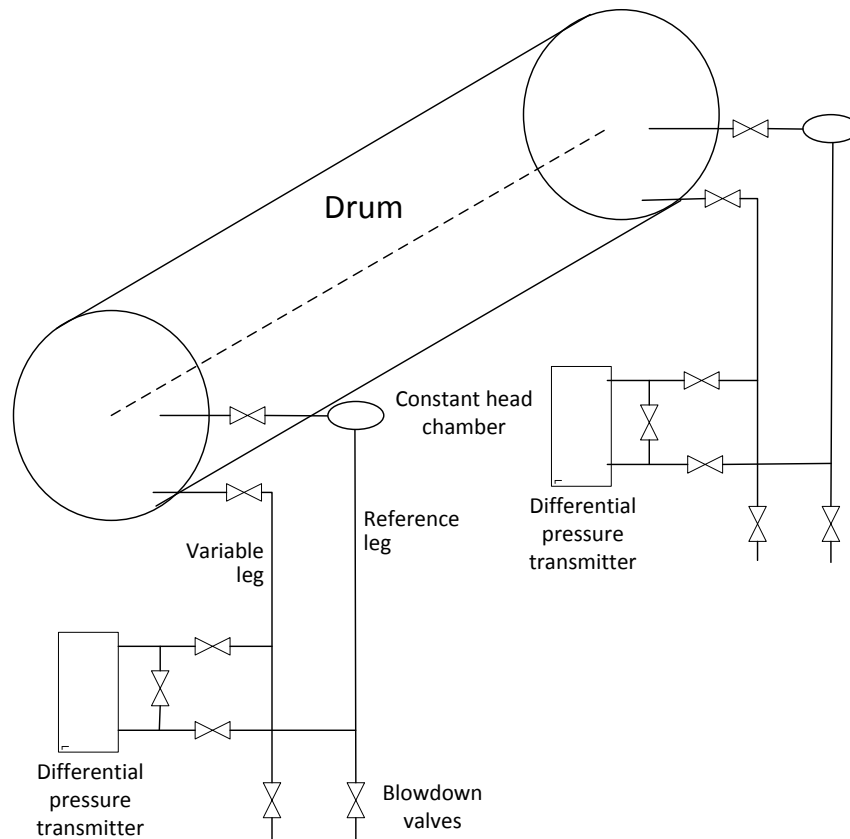


Figure 1 — Typical drum-level differential pressure transmitter connections