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American National Standard

Fossil Fuel Plant Feedwater Control System — Drum-Type



The International Society for Measurement and Control

ANSI/ISA-S77.42 — Fossil Fuel Power Plant Feedwater Control System – Drum-Type

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This preface is included for informational purposes and is not part of ANSI/ISA-S77.42.

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This standard is part of a series of standards resulting from the efforts of the ISA SP77 Fossil Power Plant Standard Committee's Subcommittee SP77.40, "Boiler Controls." It should be used in conjunction with the other SP77 series of standards for safe, reliable, and efficient design, construction, operation, and maintenance of fossil-fired power plants. It is not intended that this standard establish any procedures or practices that are contrary to any other standard in this series.

A variety of feedwater control systems have been developed and used over the years to maintain drum level within limits at the required set point. This standard is intended to establish minimum requirements for feedwater control.

The following people served as members of ISA Subcommittee SP77.42, "Feedwater Committee."

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Contents

Section Title	Section Number
Purpose	1
Scope	2
Definitions	3
Minimum design requirements for a feedwater control system	4
Process measurement requirements	4.1
Control and logic requirements	4.2
Final control device requirements	4.3
System reliability and availability	4.4
Minimum alarm requirements	4.5
Operator interface	4.6
References	5
Appendix A	Feedwater control

1 Purpose

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

2 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/hr (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.

3 Definitions

The following definitions are included to clarify their use in this standard and may not correspond to the use of the word in other texts. For other definitions, reference [ANSI/ISA S51.1-1979](#), "Process Instrumentation Terminology."

3.1 Boiler: The entire vessel in which steam or other vapor is generated for use external to itself, including the furnace, consisting of the following: waterwall tubes; the firebox area, including burners and dampers; the convection area, consisting of any superheater, reheater, and/or economizer sections, as well as drums and headers.

3.2 Cascade control: Control action in which the output of one controller is the set point for another controller.

3.3 Controller: Any manual or automatic device or system of devices for the regulation of boiler systems to keep the boiler at normal operation. If automatic, the device or system is motivated by variations in temperature, pressure, water level, time, flow, or other influences.

3.4 Drum (steam): A closed vessel designed to withstand internal pressure. A device for collecting and separating the steam/water mixture circulated through the boiler.

3.5 Feedwater control system: A control system using input signals derived from the process for the purpose of regulating feedwater flow to the boiler to maintain adequate drum level according to the manufacturer's recommendations.

3.6 Mass feedwater flow rate: The mass flow rate of all water delivered to the boiler, derived either from direct process measurements and/or calculations from other parameters. When volumetric feedwater flow rate measurement techniques are employed and the feedwater temperature at the flow-measuring element varies 100°F (37.8°C), the measured (indicated) flow shall be compensated for flowing feedwater density to determine the true mass feedwater flow rate.

3.7 Mass steam flow rate: The mass flow rate of steam from the boiler, derived either from direct process measurements and/or calculations from other parameters. If volumetric steam flow-rate measuring techniques are employed, the measured (indicated) flow shall be compensated for flowing steam density to determine the true mass steam flow rate.

3.8 Primary/secondary control loop controller: The controller which adjusts the set point for the secondary control loop controller in the cascade control action scheme.

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 which 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: An action by the boiler control system initiated by the loss of any auxiliary equipment that limits the capabilities of the unit to sustain the existing load. Upon runback initiation, the boiler demand signal is reduced at a preset rate to the capability of the remaining auxiliaries.

3.13 Rundown: An action by the boiler control system initiated by an unsafe operating condition — i.e., fuel/air limit (cross-limiting), temperature limits, etc. Upon rundown initiation, the boiler demand signal is reduced in a controlled manner to the load point where the unsafe operating condition is eliminated.

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 PERMISSIVE, neither mandatory nor recommended. (Reference: ISA-RPA-1a-1970, "Style Manual.") *

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 set point.

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 set point. This is a cascaded feedforward loop with drum level as the primary variable, steam flow as the feedforward input, and feedwater flow (feedback) as

*See Section 5 for bibliographic information on references.

the secondary variable.

3.20 Transient: The behavior variable 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 set point. 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. The 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:

- 1) Process measurement requirements
- 2) Control and logic requirements
- 3) Final control device requirements
- 4) System reliability and availability
- 5) Alarm requirements
- 6) Operator interface

4.1 Process measurement requirements

4.1.1 Instrument installation for feedwater control

4.1.1.1 Instruments should be installed as close as is practical to the source of the measurement, with consideration being given to excessive vibration, temperature, and accessibility for periodic maintenance. Recommendations for the location of instrument and control equipment connections can be found in the joint publication by SAMA (Scientific Apparatus Makers Association) and ABMA (American Boiler Manufacturers Association), "Recommendations for Location of Instrument and Control Connections for the Operation and Control of Watertube Boilers." Specific requirements for the location of drum water level measuring devices are contained in Section 1 of the American Society of Mechanical Engineers' *Boiler and Pressure Vessel Code*.

4.1.1.2 Separate 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 feedwater control systems. (See [Figures 1](#), [2](#), [3](#), and [4](#).) If the instruments used to measure drum level are sensitive to density variation, then density compensation techniques shall be employed.