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# **Fossil Fuel Power Plant - Steam Temperature Controls**

**Approved 3 August 2007**

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Fossil Fuel Power Plant – Steam Temperature Controls

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## Preface

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This edition of ANSI/ISA-77.44.01 (R2007) Fossil Fuel Power Plant - Steam Temperature Controls was prepared by the individuals on subcommittee ISA SP77.44 who contributed to the production of ANSI/ISA-77.44.01-2000, Fossil Fuel Power Plant Steam Temperature Control System - Drum Type and ANSI/ISA-77.44.02-2001, Fossil Fuel Power Plant Steam Temperature Control System - Once-Through Type. The purpose of combining these two documents was to consolidate related text. The content has been organized and updated per current practices.

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## Foreword

A variety of steam temperature control systems have been developed over the years to fit the needs of particular applications. Operating philosophy, plant layout, and type of firing must be considered before the ultimate selection of a system is made. Therefore, this standard is not intended to limit the complexity or scope of the steam temperature control system design that one might wish to implement, but rather to establish a minimum of control needed.

This standard is part of a series resulting from the efforts of the SP77 Committee on Fossil Power Plant Standards, especially subcommittee SP77.40 on 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 the power plant. It is not the intent of this standard to establish any procedures or practices that are contrary to any other standard in this series.

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## 1 Purpose

The purpose of this standard is to establish the minimum requirements for the functional design specification of steam temperature control systems for drum type and once-through type fossil fuel power plant boilers.

## 2 Scope

The scope of this standard addresses the major steam temperature control subsystems in boilers with steaming capacities of 200,000 lb/hr (25 kg/s) or greater. These subsystems include, but are not limited to, superheat temperature control and reheat temperature control. Specifically excluded from consideration are controls associated with fluidized-bed, stoker-fired furnace combustion units and mud drum desuperheaters.

## 3 Definitions

The following definitions are provided to clarify their use in this standard and may not be relevant to the use of the words in other texts. For other definitions, please refer to ISA-51.1-1979 (R1993), Process Instrumentation Terminology.

### 3.1 attemperator:

a device used for maintaining and controlling the temperature of superheated steam.

### 3.2 attemperator (direct contact type):

a device in which the steam and the cooling medium (water) are mixed.

### 3.3 boiler:

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

### 3.4 cascade control system:

a control system in which the output of one controller (the outer loop) is the setpoint for another controller (the inner loop). The outer loop is normally a slower responding process than the inner loop.

### 3.5 control loop:

a combination of field devices and control functions arranged so that a control variable is compared to a setpoint and its output returns to the process in the form of a manipulated variable.

### 3.6 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 a process variable.

### 3.7 desuperheater (direct contact type):

a device in which the steam and the cooling medium (water) are mixed.

### 3.8 deviation:

the difference between the loop setpoint and the process variable (also called error).

3.9 error:  
see 3.9 deviation.

3.10 feedback:  
a concept in which a process measurement is used to determine whether the control variable is at the desired value. A signal is produced by a measuring device that is proportional to the magnitude of a controlled variable or position of a control element.

3.11 final control element:  
component of a control system (such as a control valve) that directly regulates the flow of energy or material to or from the process.

3.12 gas pass:  
an arrangement in which the convection banks of a boiler are separated by gas-tight baffles into two or more parallel gas paths isolating portions of the superheater and reheater surfaces. The proportion of total gas flow through each gas pass may be varied by regulating dampers.

3.13 gas recirculation:  
a method by which flue gas from the boiler, economizer, or air heater outlet is reintroduced to the lower furnace to reduce furnace heat absorption while increasing convection pass heat absorption or to reduce NOx emission.

3.14 integral control action:  
an action in which the controller's output is proportional to the time integral of the error input. It is also called reset action.

3.15 integral windup:  
the saturation of the integral controller output in the presence of a continuous error, which may cause unacceptable response in returning the process to its setpoint within acceptable limits of time and overshoot.

3.16 interlock:  
a device or group of devices (hardware or software) arranged to sense a limit or off-limit condition, or improper sequence of events, and to shut down the offending or related piece of equipment, or to prevent proceeding in an improper sequence in order to avoid an undesirable condition.

3.17 linearity:  
the nearness with which the plot of a signal or other variable plotted against a prescribed linear scale approximates a straight line.

3.18 master fuel trip:  
an event resulting in the rapid shutoff of all fuel including igniters.

3.19 primary air:  
combustion air that enters the fuel-burning zone and directly supports initial combustion. On pulverized coal-fired units, the primary air is used to transport the coal from the pulverizers to the burners.

3.20 reheater:  
a heating surface receiving steam returning to the boiler from the high-pressure turbine exhaust.

3.21 secondary air:  
combustion air introduced on the edge of the burning zone to supplement the primary air for support of the combustion process.

### 3.22 setpoint:

the desired operating value of the process variable.

### 3.23 superheater:

boiler heating surface that is not part of the boiler enclosure which receives only steam already at or above its saturation temperature. (See Figure 3.23.a and Figure 3.23.b for typical steam and gas flow paths.)

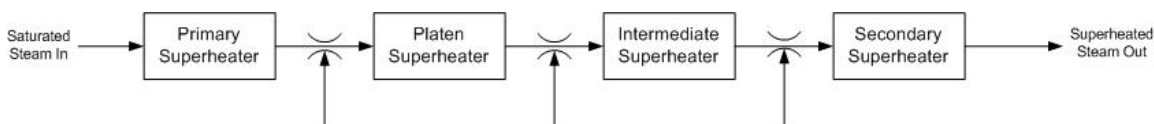


**Figure 3.23.a — Typical superheater steam flow path**

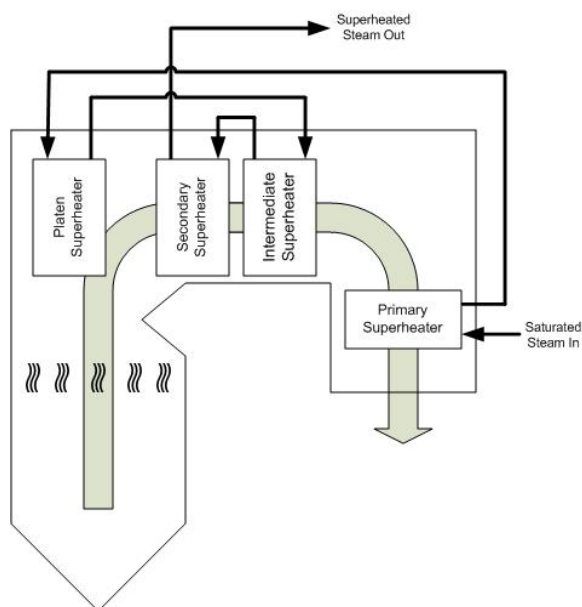


**Figure 3.26.b — Typical superheater gas flow path**

#### 3.23.1 intermediate superheater:

section or sections of superheating surface located between primary and secondary superheaters.

#### 3.23.2 platen superheater:

intermediate superheater surface which is also a radiant superheater.

#### 3.23.3 primary superheater:

first boiler heating surface to receive steam at or slightly above saturation temperature.

#### 3.23.4 secondary superheater:

final stage of boiler superheating surface.

**3.23.5 radiant superheater:**

steam superheating surface where the primary means of heat transfer to the steam is by radiation rather than convection; typically, an intermediate superheater section.

**3.24 trip:**

the automatic removal from operation of specific equipment or the automatic discontinuance of a process action or condition as the result of an interlock or operator action.

**3.25 transient correction:**

a control action specifically applied to minimize any process error resulting from a temporary process change; e.g., temperature control action applied to counter the effects of over- or under-firing during load changes.

## **4 Process measurement requirements**

### **4.1 Instrument installations for superheat and reheat steam temperature control**

Instruments should be installed as close as is practical to the source of the measurement, with consideration being given to excessive vibration, ambient temperature, and accessibility for periodic maintenance. Temperature measurement should be located at least 20 pipe diameters downstream of any attemperator.

### **4.2 Design of thermocouples and temperature sensors**

Design of thermocouples and temperature sensors shall meet the requirements of ASME Power Test Code PTC19.3 "Temperature Measurements".

Design of the attachment of the thermowell to the pipe shall meet the requirements of either ASME Boiler Pressure Vessel Code Section I "Power Boilers" for Boilers or ASME B31.1 "Power Piping" Code depending on the code jurisdiction for the pipe.

Thermowell installations shall consider location, mounting, and velocity criteria in making a proper interface with the process.

### **4.3 Isolation valves and impulse lines**

Separate isolation valves and impulse lines shall be provided for head-type instrumentation.

### **4.4 Process measurements for superheat and reheat steam temperature control**

Process measurements for superheat temperature control are listed below. For location of these measurements see figures C.1a, C.1b, C.1c, and C.1d.

#### **4.4.1 Secondary (final) superheater outlet steam temperature measurement**

A temperature measurement, taken at the outlet of the secondary (final) superheater, is required for superheat steam temperature control strategies.

#### **4.4.2 Secondary superheater inlet temperature measurement**

A temperature measurement, taken at the attemperator outlet(s) for single-stage or multiple-stage attemperation and followed by a superheater section, is required as the secondary variable in a cascade loop with feedforward control strategy.

#### **4.4.3 Primary (initial, platen) inlet temperature measurement**

A temperature measurement, taken at the primary superheater inlet (or outlet of the first stage attemperator of multiple-stage attemperation), is required as the secondary variable in a cascade loop with feedforward control strategy.

#### **4.4.4 Primary (initial, platen) outlet temperature measurement**

A temperature measurement, taken at the outlet of the primary superheater section before the first stage attemperator, is required in a single or multiple-stage attemperator control strategy.

#### **4.4.5 Primary (initial, platen, intermediate) inlet pressure measurement**

A pressure measurement is required in a multiple-stage attemperator control strategy to prevent saturation following first-stage spray attemperation. Typically, this pressure is measured at the inlet of the primary superheater. A pressure measurement is required in a two-stage attemperator control strategy to prevent saturation following first-stage spray attemperation. Typically, this pressure is measured at the inlet of the intermediate superheater; however, drum pressure may be used if the primary superheater's pressure loss is considered.

#### **4.4.6 Intermediate inlet temperature measurement**

A temperature measurement, taken at the intermediate superheater inlet (or outlet of the first stage attemperator of two-stage attemperation), is required as the secondary variable in a three-element control strategy.

#### **4.4.7 Intermediate outlet temperature measurement**

A temperature measurement, taken at the outlet of the intermediate superheater section before the second stage attemperator, is required in a two-stage attemperator control strategy.

#### **4.4.8 Reheat steam temperature measurement**

A temperature measurement, taken at the outlet of the final reheater, is required for single loop and single loop with feedforward reheat steam temperature control strategies for modulation of the reheat steam temperature control mechanisms provided by the boiler manufacturer.

#### **4.4.9 Attemperator spray water-flow measurement**

An attemperator spray water mass flow signal provides an alternative to the use of the attemperator outlet steam temperature as the secondary variable in a cascade loop with feedforward control strategy.

#### **4.4.10 Waterwall (convection pass) outlet temperature measurement**

A temperature measurement, taken at the outlet of the furnace walls (convection pass) section and followed by a superheater section, is required in a multiple-stage attemperator control strategy.

## 5 Attemperation methods – Control and logic requirements for an attemperator control system for control of steam temperatures

The function of the superheat temperature control system is to maintain superheat steam temperature within the boiler manufacturer's specified limits. Generally, the goal is to obtain a specified final superheat steam temperature over the specified boiler-load range. Control strategy must be based on the particular control mechanisms used and the boiler manufacturer's philosophy for controlling steam temperature. Although the strategies in this standard use conventional PID control techniques, it is not the intention to preclude the use of advanced control strategies. Refer to Table B.1 for summary of typical control systems.

For the control of superheat steam temperature, this standard addresses single-stage attemperation and two-stage attemperation. For typical boiler superheater attemperation arrangements, see Figures C.1a and C.1b.

Single loop steam temperature control is the minimum control strategy for reheat steam temperature leaving the boiler and shall be used only for applications where reheat spray is the secondary means of reheat temperature control.

Referring to Figure C.9, reheat steam temperature is measured and compared to a setpoint. The setpoint bias in Figures C.5-C.8, which is used to slightly increase the setpoint above the setpoint of the primary controlling mechanism, is summed with the reheat temperature error to develop the final error signal. Proportional and integral control action, along with an automatic/manual station function, completes the control scheme to regulate the valve.

Single loop with feedforward and cascade loop with feedforward steam temperature control strategy should be used in applications where reheat spray is the primary method of reheat temperature control; with variable steam pressures; and with variable spray water pressure supplies.

### 5.1 Single-stage attemperation

Single-stage attemperation refers to the boiler design that provides a single location for the introduction of spray water for the regulation of steam temperature. This application is typical of boilers with a single reheater section or a single superheat section with the attemperation at the inlet. If a boiler has two superheater sections in series (i.e., the primary and secondary superheaters), then it is normal to have the spray attemperation located between the two superheater sections. Note that a single attemperation location does not necessarily refer to a single set of spray equipment because there may be more than one parallel path for the steam leaving the drum.

#### 5.1.1 Single loop steam temperature control

Single loop steam temperature control is the minimum control strategy required to regulate the steam temperature leaving the boiler and should be used only in applications with slow load changes (e.g., approximately 0.2%/min as in building heating systems or where constant steam temperature is not critical).

Referring to Figure C.2, final steam temperature is measured and compared to a setpoint with the result used to regulate the spray valve(s).