ANSI/ISA–77.13.01–1999 (R2008)

Fossil Fuel Power Plant
Steam Turbine Bypass System

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1 Scope

This standard covers the design requirements and operator interface for steam turbine bypass systems for drum and once-through steam generators and combined cycle plants. Hardware configurations are suggested to obtain the minimum design requirements to obtain a safe and operable system. Both fixed percentage bypass and variable pressure systems are covered.

It is applicable to boilers with steam capacities of 200,000 lb/hr (25 kg/s) or greater.

2 Purpose

This standard establishes the minimum requirements for design specifications to implement steam turbine bypass systems and hardware configurations for drum and once-through, fossil fuel power plant boilers.

The turbine bypass system should provide for cold start-up, warm start, hot restart, load rejection, turbine shutdowns, and unit trips. The system shall be designed to provide pressure, temperature, and flow control of steam around and through the turbine by controlling each bypass valve, isolation valve, and associated desuperheater. The desuperheating function may be integral with the bypass valve. The turbine bypass system does not interface with the turbine control and supervisory system. The turbine bypass system is set to maintain steam pressure, and any coordination with the turbine is through interaction with the process as the turbine demands more or less steam. There is no direct interconnection of control systems.

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, see ISA-51.1, *Process Instrumentation Terminology*.

3.1 alarm:
an indication used to alert an operator about an abnormal operating condition.

3.2 automatic tracking:
the action of a control system to automatically track a setpoint or the process variable without any other corrective mechanisms.

3.3 boiler:
the entire vessel in which steam or other vapor is generated for use external to itself, including the furnace, consisting of 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, generating tubes, and headers.

3.4 condenser backpressure elements:
a multiple breakdown diffuser, normally installed in the steam condenser neck, used to generate a positive back pressure upstream of the condenser vacuum and to reduce the kinematic energy of steam from an external source other than the turbine exhaust.

3.5 controller:
any automatic, semi-automatic, or manual device or system of devices used to regulate the boiler turbine, or any other equipment within defined parameters. If automatic, the device or system responds to variations in temperature, pressure, water level, flow, or other control variables.

3.6 differential producer:
a measuring element that is inserted in a process flow path and used to create a pressure drop that is proportional to the square of the volumetric flow rate.

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3.7 fail safe:
the capability to go to a predetermined safe state in the event of a specific malfunction.

3.8 fault tolerant:
built-in capability of a system to provide continued, correct execution of its assigned function in the presence of a hardware and/or software fault.

3.9 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.

3.10 load:
a device that receives power or that power which is delivered to such a device, as in the rate of output, lb/hr (kg/s) of steam or megawatts (kilowatts) of electrical generations.

3.11 logic system:
decision-making logic equipment with its associated power supplies, I/O hardware, and sensing devices.

3.12 mode (submode):
a particular operating condition of a control system, such as manual, automatic, remote, or coordinated.

3.13 redundant (redundancy):
the duplication or repetition of elements in electrical or mechanical equipment to provide alternative functional channels in case of failure of one channel.

3.14 severe duty valve:
a mission-critical valve, typically seeing high-pressure drop service, which may see cavitating or flashing fluids, or if not properly designed, may see early trim erosion, vibration, or excess noise.

3.15 shall, should, and may:
the word “SHALL” is to be understood as a REQUIREMENT; the word “SHOULD” as a RECOMMENDATION; the word “MAY” as a PERMISSIVE, neither mandatory nor recommended.

3.16 steam quality:
the ratio of the vapor’s mass to the mixture’s mass.

3.17 turbine:
a machine that converts energy from a moving fluid into rotating mechanical energy that drives a load. In a power plant, a turbine converts energy in the steam into mechanical energy to drive an electric generator (the mechanical load).

3.18 turbine governor valves:
the primary control valves used to regulate the flow of steam through the turbine during normal operation.

3.19 turn-down ratio:
the ratio from maximum operating to minimum operating conditions, providing a controllable or measurable span. The device must perform over this range.

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4 Bypass systems

4.1 General requirements

The steam turbine bypass system requirements are defined for those components and logic systems necessary to handle steam to and around the turbine.

The design of systems to prevent water damage to steam turbines is covered by the American Society of Mechanical Engineers (ASME) standard TDP-1.

The steam should be of a minimum quality of 92 percent to avoid impingement and corrosion.

Figures E.1 and E.2 show a typical turbine steam bypass system to assist in explaining the design requirements of this clause. Other figures show specific areas to help clarify the text materials.

This standard will cover the following functions:

a) Matching with an acceptable difference the metal to steam temperatures before steam is admitted to the turbine

b) Handling the difference between the generated and consumed steam flows during transient conditions

4.1.1 High-pressure (HP) bypass system

The HP bypass system shall fulfill the following requirements:

a) Control the pressure of the steam bypassing the HP turbine

b) Control the pressure of the main steam from the boiler

c) Control the flow and temperature of steam through the cold reheat line to cool the boiler reheater tubing

d) Control the flow of steam through the main steam line to cool the boiler final superheater in case of sliding pressure operation

e) Prevent lifting of main steam and hot reheat safety valves during transient operations

4.1.2 Intermediate-pressure (IP) and low-pressure (LP) bypass system

The IP and LP bypass system shall fulfill the following requirements:

a) Control the pressure of the steam bypassing the IP and LP turbines

b) Control the pressure and temperature of the hot reheat steam from the boiler

c) Prevent the lifting of hot reheat safety valves during transient operations

d) Protect the condenser against excessive pressure, temperature, and steam kinematic energy

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4.2 Elements

The elements that make up the steam turbine bypass system are those added over the elements required for a system without the ability to bypass steam around the HP, IP, and LP turbines. Therefore, those elements that are added due to the bypass are shown in figures E.1 and E.2.

4.2.1 HP bypass elements

a) HP bypass control valve (HPB) (see notes 1 and 3)

b) Before HP bypass control valve, block valve (B) (see note 3)

c) HP bypass desuperheater (DES) (see note 1)

d) HP bypass desuperheater spray water control valve (SPV) (see notes 2 and 3)

e) HP bypass desuperheater spray water block valve (B) (see note 3)

f) HP turbine cold reheat, non-return valve (NRV)

g) HP turbine bypass control system

h) HP turbine bypass instrumentation

i) HP turbine reverse flow valve (see note 4)

NOTE 1 — The pressure control valve and desuperheater may be combined into one HP turbine mainstream bypass pressure control and desuperheating valve as shown in figure E.2.

NOTE 2 — The desuperheater may have an integral spray water control valve.

NOTE 3 — Block valves are usually required to assure that leakage does not occur through the control valve. This function could be integrated in a composite control valve, provided the block valve's purpose is not compromised.

NOTE 4 — The reverse flow valve may be necessary to prevent excessive windage heating of the HP turbine blades during a hot restart if initial loading is accomplished using the LP/IP sections.

4.2.2 IP and LP elements

a) IP/LP bypass control valve (IP/LPB) (see notes 1 and 3)

b) Before IP/LP bypass control valve, block valve (B) (see note 3)

c) IP/LP bypass desuperheater (DES) (see note 1)

d) IP/LP bypass desuperheater spray water control valve (SPV) (see notes 2 and 3)

e) IP/LP bypass desuperheater spray water block valve (B) (see note 3)

f) Condenser back pressure elements (I)

g) IP/LP pressure bypass control system

h) IP/LP bypass instrumentation

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NOTE 1 — The pressure control valve and desuperheater may be combined into one IP and LP turbine hot reheat bypass pressure control and desuperheating valve as shown in figure E.2.

NOTE 2 — The desuperheater may have an integral spray water control valve.

NOTE 3 — Block valves are usually required to assure that leakage does not occur through the control valve. This function could be integrated in a composite control valve, provided the block valve's purpose is not compromised.

4.3 Capacity

The steam flow capacity of the bypass system is governed by a number of other variables in the overall steam system. These are

a) heat distribution in the boiler;

b) turbine rotor diameter;

c) condenser internals;

d) startup, loading, unloading, and shutdown practices and requirements for the unit;

e) safety considerations; and

f) economics.

4.3.1 System size

There are a number of possibilities to size the bypass system. In this document the bypass system size or capacity to fulfill the two functions previously defined in 4.1 are as follows:

a) A bypass system that matches the steam-to-turbine metal temperatures should be sized for 15 percent of maximum continuous rated (MCR) flow at valves wide open. This system reduces the startup time by about 30 minutes.

b) A bypass system that handles the difference between the generated and consumed steam flows during upset or transient conditions should handle 40 percent of MCR flow at valves wide open or should have a greater size range.

c) A bypass system that keeps the steam generator running at full load without blowing the safety valves in case of a turbine or generator trip at full load should handle 100 percent of MCR flow at valves wide open.

4.4 Design requirements

The design requirements for each of the elements are as follows.

4.4.1 HP and IP/LP turbine bypass control valve

a) Design criteria

The design criteria for the bypass system valves shall be specified as shown in tables 4.4.1(a) and 4.4.1(b).

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