

IEEE Recommended Practice for Operation of 300 MW to 600 MW Pulverized Coal-Fired Boiler

IEEE SA Board of Governors

Developed by the
Corporate Advisory Group

IEEE Std 2777™-2021

STANDARDS

IEEE Recommended Practice for Operation of 300 MW to 600 MW Pulverized Coal-Fired Boiler

Developed by the

Corporate Advisory Group
of the
IEEE SA Board of Governors

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IEEE SA Standards Board

Abstract: General technical recommended practice for operation of pulverized coal-fired boilers in power plants is provided, including start-up, shutdown, operation and maintenance, and emergency and failure detection/handling/prevention. In this document, a boiler with existing single units with a capacity of 300 MW to 600 MW in thermal power plants, where pulverized coal is combusted to generate electricity and/or to supply heat, is discussed. Development of boiler operation code as a reference to determine detailed operation steps and/or procedures for a particular boiler in the plant is outlined. The specifications of manufacturers, successful experiences from practice, and stipulations defined in other related high-level standards/regulations/codes are also considered.

Keywords: emergence and failure, failure, IEEE 2777™, maintenance, operation, pulverized coal-fired boiler, start-up, shutdown

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Participants

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<i>Organization Represented</i>	<i>Name of Representative</i>
China Datang Corporation	Yiying Tong, <i>Chair</i>
China Energy Engineering Group Planning Engineering Co., Ltd.....	Shaohua Li
China Southern Power Grid Co., Ltd.	Yan Li
Harbin Institute of Technology	Penghua Qiu
North China Electric Power University	Yanfeng Gong
Shanghai University of Electric Power	Yuwei Zhao
State Grid Corporation of China	Zhenning Zhao, <i>Secretary</i>
Tsinghua Shenzhen International Graduate School	Junfu Lv, <i>Vice Chair</i>

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Chengwei Dai	Long Jiang	Hao Sun
Yinhui Dong	Jinjing Li	Guangzhou Yi
Zhicheng Han	Xingwang Li	Qingfeng Zhang
	Yanpeng Liu	

The following members of the entity Standards Association balloting group voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

0xSenses Corporation	China Southern Power Grid Co.,	Shanghai University of Electric
China Datang Corporation	Ltd.	Power
China Energy Engineering	Harbin Institute of Technology	State Grid Corporation of China
Group Planning Engineering	North China Electric Power	(SGCC)
CO., LTD	University	Tsinghua Shenzhen International
		Graduate School

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Daozhuang Lin
Kevin Lu
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Chenhui Niu
Damir Novosel
Annette Reilly
Jon Walter Rosdahl

Dorothy Stanley
Mehmet Ulema
Lei Wang
F. Keith Waters
Karl Weber
Sha Wei
Howard Wolfman
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 2777-2021, IEEE Recommended Practice for Operation of 300 MW to 600 MW Pulverized Coal-Fired Boiler .

This recommended practice defines the general principles, common requirements, essential steps, and other related works that need to be conducted in procedures of start-up, normal operation, shutdown, and routine inspection and maintenance for a pulverized coal-fired boiler and its main auxiliary equipment.

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1. Overview

This recommended practice defines the general principles, common requirements, essential steps, and other related works that need to be conducted for start-up, normal operation, shutdown, and routine inspection and maintenance of a pulverized coal-fired boiler and its main auxiliary equipment.

1.1 Scope

This recommended practice defines the principles and procedures for start-up, normal operation, shutdown, daily operation, and maintenance during normal and emergency conditions for a 300 MW to 600 MW pulverized coal-fired boiler and its main auxiliary equipment. This recommended practice applies to 300 MW to 600 MW pulverized coal-fired boilers with a balanced draft, including natural circulation and forced circulation; subcritical and supercritical once-through boilers; tangential-fired boilers; opposed-fired boilers; and so on. For specific applications, an additional document needs to be formulated by users based on this recommended practice to cover detailed procedures or normally so-called “operation code,” together with the instructions of manufacturers and the experiences derived from normal operation practice.

1.2 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (shall equals is required to).^{1, 2}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (should equals is recommended that).

The word *may* is used to indicate a course of action permissible within the limits of the standard (may equals is permitted to).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (can equals is able to).

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASME Section VII, Recommended Guidelines for the Care of Power Boilers.³

ASME PTC 4, Performance test code for steam generating units.

ASTM D3172, Practice for Proximate Analysis of Coal and Coke.⁴

ASTM D3173/D3173M, Test Method for Moisture in the Analysis Sample of Coal and Coke.

ASTM D3174, Test Method for Ash in the Analysis Sample of Coal and Coke from Coal.

ASTM D3175, Test Method for Volatile Matter in the Analysis Sample of Coal and Coke.

ASTM D388, Standard Classification of Coal by Rank.

ASTM D4239, Test Method for Sulfur in the Analysis Sample of Coal and Coke Using High-Temperature Tube Furnace Combustion.

ASTM D5865, Test Method for Gross Calorific Value of Coal and Coke.

NFPA 85, Boiler and Combustion Systems Hazards Code (2015 edition).⁵

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁶

authority having jurisdiction (AHJ): The organization and/or the individual responsible for reviewing and approving an operation or a procedure.

air heater (AH): A heat exchanger that transfers heat from hot gas to incoming air. Rotary air heaters, which are popular in pulverized coal-fired boilers above 300 MW, including bi-sector, tri-sector, and quad-sector types with fixed or rotating heating elements. Rotary air heaters include tubular, plate, and heat pipe types.

air preheater coils: A heat exchanger that typically uses steam and/or condensate to heat air entering the boiler and is often used to control corrosion in regenerative and rotary air heaters.

ambient temperature: The air temperature of the environment where the boiler and related equipment are kept. Normally it is represented by the temperature at the forced draft fan inlet air temperature (dry bulb temperature).

³ASME publications are available from the American Society of Mechanical Engineers (<https://www.asme.org/>).

⁴ASTM publications are available from the American Society for Testing and Materials (<https://www.astm.org/>).

⁵NFPA publications are published by the National Fire Protection Association (<http://www.nfpa.org/>).

⁶*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

autoignition temperature (AIT): The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element.

auxiliary air/peripheral air: A high-velocity curtain of secondary air envelops the primary air jet carrying the coal power from the burner to intensify the combustion and prevent the separation of the pulverized coal powder from primary air flow.

backend reburning: The combustion of deposited combustibles in the heating surfaces such as air heaters in the backend, which would lead to damage of the heating surface.

burner: A device or group of devices for the introduction of fuel and air into a furnace at the same velocity, turbulence, and concentration required to maintain ignition and combustion of fuel.

chemical cleaning: The process of cleaning the interior surface of a boiler unit by filling the unit with dilute chemical solution.

corrected theoretical air: The theoretical air adjusted for unburned carbon.

commissioning: Plant testing and operation in the period between initial operation and commercial operation.

direct-fired system: A system in which the fuel is pulverized and delivered in suspension directly to the burner(s).

design conditions: Ideal working state of a boiler based on designed fuel and ambient parameters under a maximum continuous rating.

excess air ratio: Air supplied to burn a fuel in addition to the corrected theoretical air, expressed as a percentage of the corrected theoretical air.

flame stability: A flame envelope that retains its continuity throughout the maximum rate of change within the operating range of the boiler.

flue gas desulfurization (FGD): A set of technologies used to remove sulfur dioxide (SO_2) from exhaust flue gases or from the emissions of other sulfur oxide emitting processes.

forced draft fan (FDF): A fan used to pressurize and supply ambient air to the furnace for combustion.

front firing: All the burners are arranged at the front wall, and the air–pulverized-coal mixture is injected from the front wall to form a front wall-oriented flame.

gas passage: The combined spaces of the furnace and the associated boiler passes, ducts, and fans that convey the gases of combustion to the stack.

hardgrove grindability index (HGI): The characteristic of solid fuel that indicates its relative ease of pulverization on an arbitrary scale, determined by the Hardgrove machine method according to the appropriate local standard. The larger values such as 100 on the Hardgrove grindability represent coals easy to pulverize, and the smaller values such as 40 on the Hardgrove grindability represent coals difficult to pulverize.

heat rate: Heat consumption per hour per unit output, the main performance of the Turbine generator unit, defined on the basis of the gross power output at the generator terminals.

higher heating value (HHV)/higher caloric value: The total energy liberated per unit mass of fuel upon complete combustion, determined according to appropriate local standards such as ASTM D5865, includes the latent heat of the water vapor.⁷

hold point: A certain condition in an operation when everything is held to check that the procedure is happening as planned and all safety measures have been taken.

ignition energy: Heat provided by the oil burner or low oil/oil-free burner to the jet of air and pulverized coal mixture, to raise its temperature steadily over the ignition point, leading to the ignition of the air and pulverized coal mixture that occurs on the periphery of the primary air jet.

induced draft fan (IDF): A fan downstream of the combustion process used to remove the products of combustion from the boiler.

imaginary firing circle and actual firing circle: The imaginary firing circle is the geometry axis of the injected air flow, tangential to an imaginary circle in the center of the furnace. The actual firing circle is the real strong vortex circle formed by all the air jets combining.

load increasing: By controlling the firing rate and stream parameters such as steam pressure, steam temperature, and so on to increase the load of turbine-generator; could involve many complicated operations such as switching boiler from wet state to dry state (for once through boiler), starting up pulverizers and putting them into service, and controlling air/fuel ratio.

lower heating value (LHV)/lower caloric value: The total heat liberated per unit mass of fuel minus the latent heat of the water vapor in the products of combustion, determined according to appropriate local standards.

master fuel trip (MFT): An event resulting in the rapid shutoff of all fuel, including igniters.

operation conditions: Operation states of boiler unit, represented by a set of parameters, that is, steam mass flow, pressure, temperature, and electrical current, especially parameters on boiler boundary.

opposed firing: All burners are arranged at both the front wall and the rear wall to form opposite flame and maintain furnace center combustion.

overfire air: Air supplied for combustion that is admitted into the furnace at a point above the burners, including overfire air (OFA) and separated overfire air (SOFA).

parallel flow-type pulverized coal burner: Also called “direct burners” or “tangential burners,” with fuel flow and combustion air flow sent into the boiler in parallel and without any swirling added. They are generally used in tangentially fired boilers.

peak capacity: The maximum main steam mass flow rate a boiler is capable of producing with specified steam conditions and cycle configuration (including specified blowdown and auxiliary steam flow) for intermittent operation, that is, for a specified period of time without affecting future operation of the unit.

pre-boiler system/saturate and water supply piping system: Water supply and relative piping from the condenser to the economizer inlet.

primary air: The transport and drying air or a flue-gas–air mixture for the coal from the pulverizers to the burners in pulverized coal-fired applications.

⁷Information on references can be found in [Clause 2](#).

primary air fan (PAF): A fan used to supply coal transport air to the pulverizer or to the burner lines of a storage system.

pulverized coal: Coal that is reduced to a size such that at least 50% can pass through a 200 mesh (74 microns) sieve.

purge: To introduce a flow of air or an inert medium at a rate into the furnace or the boiler flue passages that will effectively remove any gaseous or suspended combustibles and replace it with the purging medium.

recirculating pump: A pump in the Downcomer of the drum/water–steam separator to drive the flow of water, also called the “circulating pump.”

rolling the turbine: Inducing steam to the steam turbine to warm up the turbine and gradually increasing the rolling speed of the turbine generator unit until rated speed before the synchronization to the electrical grid network.

safety valve: One of the most important safety fittings of the boiler, open to release pressure when the pressure inside the boiler exceeds the maximum-allowable working pressure. The safety valve capacity is the amount of steam that can be discharged per unit time, and the sum capacity of safety valves should be greater than the boiler capacity.

safety valve setting: A testing procedure to prove the automatic open pressure and reseating pressure of the safety valves and/or pressure release valves.

selective catalytic reduction (SCR): A proven and effective method to reduce nitrogen oxides (NO_x) in flue gas by the catalyzed reaction of injected anhydrous ammonia and the nitrogen oxide when the flue gas passes through the SCR system and converts it to nitrogen and water before finally going up the smokestack.

secondary air: The balance of the combustion air not provided as primary air. Secondary air may be split into overfire air or other streams as it enters the furnace; however, it remains secondary air up to and including the wind box.

superheater (SH) and reheater (RH): The heating surface consists of all the heat-transfer apparatus in contact on one side with steam being heated and on the other side with gas or refractory being cooled, including the radiant heating surface in a furnace such as a roof, partition walls, platens, and other convection heating surface.

swirling pulverized coal burner: A pulverized coal burner that uses a set of guiding vanes to produce a swirling motion to combustion and to create a recirculation zone to help ignite the fuels and to sustain a stable flame; also used in front firing or opposed firing boilers.

synchronizing: The process of matching the speed and frequency of a turbine generator unit to the running electrical grid network to deliver power to the network.

tangential firing: A method of firing pulverized fuel in which the burners are located in the corners or walls of the furnace so that the centerlines of the burner nozzles are tangential to a horizontal circle.

theoretical air/stoichiometric air: The amount of air required to supply the exact amount of oxygen necessary for complete combustion of a given quantity of fuel. Theoretical air and stoichiometric air are synonymous.

volatile matter: The portion of mass, except water vapor, that is driven off in a gaseous form when solid fuel is heated in accordance with the applicable local standard such as ASTM D3175.

3.2 Acronyms and abbreviations

AHJ	authority having jurisdiction
AH	air heater
AIT	autoignition temperature
CCS	coordinated control system
DAS	data acquisition system
DCS	distributed control system
FDF	forced draft fan
FGD	flue gas desulfurization
FSSS	furnace safety supervisory system
HHV	high heating value
HGI	hardgrove grindability index
IDF	induced draft fan
LHV	low heating value
MCS	modulating control system
MFT	master fuel trip
OFA	overfire air
PAF	primary air fan
RH	reheater
SH	superheater
SCR	selective catalytic reduction
SCS	sequence control system
SOE	supervisory and sequence of event
SOFA	separated overfire air

4. Start-up

4.1 Preparation prior to start-up

4.1.1 Basic requirements

The basic requirements are as follows:

- Supplies of fuel (including coal, fuel oil, gas, and any other fuel), demineralized water, compressed air, and so on are ample, and their quality fulfills relevant standards or specifications.
- Means of extinguishing fire and equipment are adequate; all equipment and devices are tested and checked, accepted to be qualified, available, and ready for service.
- All temporary facilities for maintenance are removed. All access and observation doors including manholes, inspect holes, and so on are closed; no person is working inside the unit, and no tools or other things are left inside the unit. All maintenance services are finished, and their work order affecting start-up should be closed and reviewed.

- Chemical clean and steam piping blowing to remove scale and foreign matter have been finished for a newly erected unit or unit with major pressure part repairs. The safety valves have been set.
- All power supplies and their backup power supplies are checked to be available and reliable. All electrical circuits should be checked for shorts and grounds before energizing them.
- Illumination, emergency illumination, and communication equipment are checked to be available and reliable for service.
- All instruments and associated mechanical equipment are checked and available for service.
- All control logic, interlocking logic, and protection logic are software tested and operate correctly, and they are completely recorded.
- All required lubricants (lube oils and greases) and replacement of rotating equipment is performed according to the specified procedure, using the designated and correct type.
- All service air used on the boiler for operational purpose, whether for sealing, aspirating, or atomizing, are free of dirt, oil, and water to prevent plugging, rusting, oxidation, and faulty operation of equipment.
- The turbine generator is available for service and has been prepared for service according to the turbine manufacturer's specifications.
- Preparing a detailed written procedure for all possible emergencies is recommended, including the description of each step for who is responsible to the problem, how to evaluate its condition, how to solve it, and so on.

4.1.2 Pre-start-up check

The pre-start-up check includes the following:

- The onsite working area should be cleared; all walkways, stairs, ladders, and platforms should be reset to working condition. No sundries should be hazardous to the passages or equipment.
- A complete checklist of subsystems, auxiliaries, equipment or devices, and their relevant working order should be prepared. Items should include but not be limited to the following:
 - 1) Equipment's, instruments and functioning of boiler steam and water system, draft system, pulverizing system, fuel system, combustion system, soot blowing system, compressed air system, ash handling system, de-nitration system, desulfurization system, and so on.
 - 2) All valves or dampers for steam, water, oil, air, and flue gas are available for service and in start-up position. All switches are in correct position. The internal positions of these valves or dampers are matched according to their external indications.
 - 3) All pipes are well insulated, and their supporters and hangers are completely set.
 - 4) All equipment is identified completely and correctly.
- The expansion indicators of each part of the boiler should be inspected. Each indicator is required to be correctly installed. The scales of the indicator are clear, and the locations of the marker are correct. Any grating, piping, electric conduit, and so on that might restrict normal expansion of the unit should be removed.
- All water and steam heating tubes such as superheaters, reheaters, spray water, and so on should be drained out thoroughly to avoid water hammering during start-up.
- After all of these inspections and checks are accepted, the power supply of equipment, devices, and instruments can be placed into service.
- Relevant instrument interlocks and protection for safety are in service and normally operable prior to start-up.
- All safety devices including shutdown push-buttons, switches, valves, and other devices are in place and in operative mode.

4.1.3 Trial run of auxiliary equipment and system

The following equipment, if applicable, should undergo a trial run before operation:

- a) Induced draft fans, forced draft fans, air heaters, instruments and detector cooling fans, flue gas booster fans, flue gas recirculating fans of the draft system, and so on
 - b) The coal feeder, coal pulverizer, pulverizer exhausters, pulverized fuel feeder, primary air fan and seal air fan of the pulverized coal preparation system, and so on
 - c) Oil pumps and oil circulation, oil gun entry and exit devices, automatic ignition devices, low-oil/oil-free ignition device of the oil system, and so on
 - d) Open and close of all shut-off gates, control dampers, and so on of air, flue gas, and tilting of all pulverized coal burners
 - e) Oil guns properly assembled and coupled, and so on
 - f) Feed water system and circulating pumps
 - g) Bottom ash discharge equipment and its sealing
 - h) Precipitator and fly ash discharge system
 - i) Soot blowing system
 - j) Flue gas temperature probe
 - k) DeNO_x system
 - l) Desulfurization system
- The trial run of auxiliaries includes their cooling system, lubrication system, sealing boosters, hydraulic system, and control devices.
 - During the trial run of auxiliaries, make sure each fluid system is closed and ready to accept fluids before opening shutoff valves; vent valves and drain valves need to be open before admitting liquids.
 - All electrical emergency trips and shutdown devices should be tested and de-energize the circuits before admitting fluids.

4.1.4 Hydrostatic testing

4.1.4.1 Test pressure

The hydrostatic testing includes an operating pressure hydrostatic test and an overpressure hydrostatic test. The operating pressure hydrostatic test is established prior to boiler start-up upon the completion of each scheduled periodic general overhauling or repair of major pressure parts caused by heating surface leakage, and so on, or at other times when it is desirable to inspect for leaks. The initial hydrostatic test after boiler erection of the pressure parts is overpressure conducted. The testing pressure is selected according to the specifications of the manufacturer and municipal boiler code, as well as according to insurance company regulations.

4.1.4.2 Testing range

The hydrostatic testing range and relative consideration commonly include the following:

- a) The economizer, furnace water walls, and superheater are hydrostatically tested as a unit.
- b) The reheater is tested separately.

- c) The pipe accessories of the boiler, such as the drum local water level meters, only take part in the operating pressure hydrostatic testing and do not take part in the overpressure hydrostatic testing.
- d) The circulating pump for the supercritical combined circulation boiler or subcritical controlled circulation boiler should be tested with the unit during the initial overpressure hydrostatic test with the motor removed.

4.1.4.3 Testing requirements

The following requirements complete the hydrostatic test functionally:

- A specific test procedure should be prepared and authorized beforehand.
- Qualified demineralized water should be used. The water should be condensate quality and treated with hydrazine and ammonia. The reheater should be filled with the same treated water, and all operations should be handled in the same manner as in the high-pressure portion of the unit. If the unit is to be placed into service within a short time using the test water, the treatment may be as for normal operation.
- Anti-freezing measures should be taken when the ambient temperature is below 5 °C. The temperature difference between the water and the metal tube should be in accordance with the requirements of the manufacturer's specification and no less than 21 °C to help ensure that the water will not freeze during test. No drainable portions of the unit should be subjected to freezing conditions during the test.
- The hydraulic test pressure gauges should have enough accurateness, be correctly calibrated by a dead weight test, and be connected properly with valves open. The pressure base subjected to the drum boiler is the drum pressure, and the pressure subjected to the once-through boiler is the superheater outlet pressure. Two or more pressure gauges with different sampling sources are installed to be compared with one other; The uncertainty of the pressure gauge should be greater than the 0.5% of span or the measured pressure.
- All spring hangers in steam piping should be pinned and locked at a fixed position prior to filling the superheater. Remove pins from spring hangers after the test has been completed and pressure has been reduced below operating pressure.
- The superheater outlet safety valve and reheater outlet relief valve should be fixed before the pressure rises to the operating pressure to avoid the lifting of any safety valve. The valve of the pressure sampling for the PCV should be closed.
- Upon completion of a successful hydrostatic test, all temporary blanks, plugs, and gags must be removed from all safety valves prior to start-up of the unit.
- All safety valves are blanked or gagged if the hydrostatic test pressure is near to or will exceed the lifting pressure of any safety valve. Any part not designed to withstand the hydrostatic test pressure is properly isolated or blanked off from such pressure.
- All parts that do not participate in the overpressure test have been insulated. Countermeasures to avoid opening the safety valve have been taken.
- The raising and lowering rate of the testing pressure should be in accordance with the manufacturer's specifications; less than 0.35 MPa/min is recommended.
- A pressure hold point should be placed at regular intervals to check for leakage or any sign of distortion of piping that could be caused by the pressure.
- The judgment criteria for qualified hydrostatic testing is as follows:
 - 1) No water droplet or water mist is observed on the metal wall, especially at the welding point of the pressure parts.
 - 2) When the inlet valve is closed and the pressure is raised to the testing pressure, pressure reduction in 5 min is less than 0.5 MPa for the superheating system and 0.25 MPa for the reheating system.

4.1.5 Control system

The control system is now the operation center of the unit, so the functional check and trial run, including the following, are commonly needed beforehand:

- The distributed control system (DCS) and its subsystems, such as the furnace safety supervisory system (FSSS), low-oil/oil-free flame monitoring system (if equipped) and data acquisition system (DAS), coordinated control system (CCS), supervisory and sequence of event (SOE), and so on are checked to ensure they are qualified and available for service.
- Drum water-level monitoring TV, furnace flame monitoring TV, other safety monitoring equipment, such as emergency alarm, illuminating sound, and and so on, and environmental monitoring equipment, such as dust, NO_x, SO₂ concentration, and so on, are available for service.
- Both software tests (signal simulated) and actuator tests for the interlock and protection of the boiler should be conducted prior to start-up upon completion of scheduled periodic overhauls or repair. Actuator tests are conducted after relative software tests are qualified. The signal simulated software tests and actuator tests for interlock and protection of the auxiliary equipment should be finished prior to the trial test of the equipment and the systems. The main protection trial test of the boiler should be conducted prior to the unit interlocking test.
- The setting values and switching action of interlock and protection should be accurate and be reliable to interrupt the normal operation when triggering conditions are fulfilled and to maintain correct operating sequences during other times. It is strictly forbidden to take off from interlocking and protection for no reason. If any interlock is deactivated, the official application and approval procedures should be performed and the cut-out time limited, generally not more than 8 h. Alternative means should be substituted to supervise this interlock function in accordance with operating procedures and be documented in accordance with operating procedures. The special test method should be stipulated in the operation code and according to the actual conditions of the equipment.

4.1.6 Safety valve setting

The safety valve should be rechecked under operating conditions prior to initial start-up or upon the completion of maintenance. If the valve is set by an assistant device, the valve with the lowest lifting pressure should be tested under operating pressure, ensuring the accuracy of lifting pressure and reseal pressure by the aided checking method. Pressure deviation of the safety valve should be set to the allowable deviation range.

Safety valves should be regularly tested by steam exhausting to help ensure their function. Intervals between two tests are recommended once a year.

4.1.6.1 Essential condition prior to safety valve setting

Before setting the safety valve, perform the following checks:

- Check that the light off is satisfied. All safety valves and their steam vent, silencer device, instruments of the steam drum, superheater, and reheat local pressure are authorized as qualified. Also, check that the boiler emergency drain is available and ready for service.
- Authorized special security procedures should be established prior to safety valve setting.
- The technical manager or engineer responsible for the overhaul, operation, and boiler techniques should take part in the safety valve setting test.

4.1.6.2 Requirements of safety valve setting

The requirements for safety valve setting are as follows:

- The popping pressure, reseating pressure, and lifting height of each safety valve should conform to regulations or specifications, as well as be recorded and archived permanently.
- All safety valves should be set at a sequence from high pressure to low pressure. Each safety valve is locked and lead sealed immediately when the test is accepted as qualified. Removal from service is not allowed when the safety valve is in operation.
- Adjustment of the popping pressure of the safety valve is shown in [Table 1](#). If manufacturers have special regulations, they should be followed.

Table 1—Popping pressure of the safety valve

Installation position	Popping pressure
Steam drum of boiler or superheater outlet	Control safety value: 1.05 times operating pressure Working safety value: 1.08 times operating pressure
Super heater outlet of once through boiler	Control safety value: 1.05 times design pressure Working safety value: 1.10 times design pressure
Reheater	1.10 times design pressure
Start-up separator	1.10 times design pressure

4.2 Basic process of start-up

4.2.1 Start-up mode and main procedure

The start-up mode includes cold start-up and warm/hot/very hot re-start-up. The start-up mode is decided by the fluid condition (pressure and temperature parameters) at the time of boiler light off. The rate of rising temperature and pressure should conform to the start-up curve supplied by the manufacturers. For the cold start-up mode, the boiler should be controlled under sliding pressure.

The main procedures for boiler cold start-up include the following:

- a) For the once-through boiler:
 - Cleanup of pre-boiler system (condensate water and feed water system)
 - Water filling to boiler
 - Cold cleanup
 - Draft system start-up
 - Furnace purging
 - Light off
 - Rising temperature and pressure
 - Hot cleanup
 - Placing steam turbine bypass system into service
 - Rolling at rated speed of turbine
 - Synchronizing
 - Load increasing
 - Switching to once-through condition

- b) For the drum boiler:
 - Cleanup of pre boiler pipeline
 - Boiler water filling
 - Draft system start-up
 - Furnace purge
 - Light off
 - Rising temperature and pressure
 - Hot cleanup
 - Placing steam turbine bypass system into service
 - Rolling at rated speed of turbine
 - Synchronizing
 - Load increasing
 - Rated load

Warm/hot/very hot restart follows the same steps as for cold start-up, but the steps for cold cleanup, water filling, and so on are bypassed.

4.2.2 Water filling and cleanup

Sufficient cleanup can promote the reliability of the tubes of the boiler after light off, and it is commonly conducted during the work of water filling. The main considerations regarding water filling and cleanup are listed as follows:

- Enough qualified demineralized water supply should be prepared, especially for re-start-up of the once-through boiler, which needs the pre-boiler system and furnace wall cold cleanup.
- A low-pressure pump such as a condensate pump or booster pump should be utilized to fill the unit to avoid overpressure and to decrease the electrical power consumption.
- Before water filling, the vent and drain valves of the water wall, superheaters, reheaters, and so on should be placed in proper opening/closing positions to make all air trapped in the system or condensate accumulated in the system release to prevent the pipes from banging. All vents and drains except the main steam line drains should be closed according to the requirements for water filling and venting operations.
- Pre-boiler system clean and cold cleanup for the once-through boiler should be conducted together with water filling:
 - 1) Cold cleanup is a polishing of high flow-rate condensate demineralizers in about 350 Psig, which is necessary for cleaning inside the boiler system and for ensuring the quality of the water to prevent contaminants from entering the boiler–turbine cycle.
 - 2) The pre-boiler water supply pipeline should be cleaned up prior to feeding water until the water quality of the pre-boiler system is qualified and safe to the boiler.
 - 3) The main steps of cleanup include boiler water filling, system blow to outside with water quality check, circulation with water quality check (for the boiler with a start-up circulation system), and so on. Before the blow to outside starts, make sure the water draining system is in service and ready to take drained water.