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**Specification for liquid-fuels and
gaseous-fuels burners of boilers**

锅炉用液体和气体燃料燃烧器技术条件

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Specification for liquid-fuels and gaseous-fuels burners of boilers

1 Scope

This standard specifies the technical requirements for the classification and model preparation, composition and basic configuration, basic requirements, performance requirements, design and manufacture, inspection, testing and detection, technical documentation and identification, packaging, transportation and storage, installation, commissioning, use of liquid-fuels and gaseous-fuels burners of boilers.

This standard applies to forced draught burners and natural ventilation burners which use the liquid-fuels and gaseous-fuels for boilers. Power plant boiler's startup burners, various industrial furnaces, industrial heating furnaces, burners for other purposes may make reference to this standard.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this standard.

GB/T 1184 Geometrical tolerancing - Geometrical tolerance for features without individual tolerance indications

GB/T 1804 General tolerances - Tolerances for linear and angular dimensions without individual tolerance indications

GB/T 4208 Degrees of protection provided by enclosure (IP code)

GB/T 6414 Castings - Dimensional tolerances and geometrical tolerances and machining allowances

GB/T 13384 General specifications for packing of mechanical and electrical product

GB/T 13611 Classification and essential property of city gas

GB/T 14486-2008 Dimensional tolerances for molded plastic parts

GB/T 14536.1 Automatic electrical controls for household and similar use -
Part 1: General requirements

GB/T 14536.6 Automatic electrical controls for household and similar use -
Particular requirements for automatic control systems for burners

GB/T 14536.7 Automatic electrical controls for household and similar use -
Special requirements for pressure-sensitive electrical automatic controllers,
including mechanical requirements

GB 16663 Alcohol base liquid-fuel

GB 18613 Minimum allowable values of energy efficiency and energy
efficiency grades for small and medium three-phase asynchronous motors

GB/T 19212.4 Safety of transformers, reactors, power supply units and
combinations thereof - Part 4: Particular requirements and tests for gas and
oil burners, ignition transformers

GB 19517 National safety technical code for electric equipments

GB/T 19804 Welding - General tolerances for welded constructions -
Dimensions for lengths and angles - Shape and position

GB/T 24146 Rubber hoses and hose assemblies for use in oil burners -
Specification

GB 25989 Fuel oils for burners

GB/T 30597 General requirements of safety and control devices for gas
burners and gas-burning appliances

JB/T 10562 Technical specification for general purposes axial fans

JB/T 10563 Technical specification for general purposes centrifugal fans

TSG G0001 Boiler safety technical supervision administration regulation

ISO 23551-1 Safety and control devices for gas burners and gas-burning
applications - Particular requirements - Part 1: Automatic and semi-
automatic valves

ISO 23551-2 Safety and control devices for gas burners and gas-burning
appliances - Particular requirements - Part 2: Pressure regulators

ISO 23551-3 Safety and control devices for gas burners and gas-burning
appliances - Particular requirements - Part 3: Gas/air ratio controls,
pneumatic type

Gaseous-fuel

A gaseous combustible substance that generates heat when burned.

Note: The gaseous-fuels referred to in this standard include natural gas, liquefied petroleum gas, coke-oven gas, mixed city gas, bio-gas, low-calorific-value gas, combustible industrial tail-gas, hydrogen gas, methane.

3.6

Biomass pyrolysis gas

A low-calorific-value combustible gas produced by a pyrolysis process of a biomass solid fuel.

3.7

Dual fuel burner

A burner capable of burning liquid and/or gaseous-fuel simultaneously or separately.

3.8

Surface burner

A fully-premixed burner in which fuel is burned on the surface of a porous medium.

3.9

Heat output

The amount of heat as released by the burner per unit time.

Note: The heat output referred to in this standard is based on the net calorific value of the fuel, in the unit of kilowatt (kW).

3.10

Nominal heat output

The heat as released by the burner during continuous combustion per unit time under rated conditions.

Note: The nominal heat output is expressed in Q_F , in kilowatts (kW).

3.11

Maximum heat output

Flame detector device

A device for monitoring the presence of a flame.

3.19

Main flame

A flame that burns on the main combustion nozzle.

3.20

Ignition flame

The flame that is first ignited to ignite the main flame.

3.21

Controlled shutdown

When the burner does not need to supply heat, the process of shut-down by automatically cutting off the fuel supply.

3.22

Safety shutdown

After the safety device responds or the automatic control system fails, the process of shut-down by automatically cutting off the fuel supply.

3.23

Pre-ignition time

The time interval between the startup of discharge of the ignition electrode and the opening of the fuel valve.

Note: The pre-ignition time is expressed in t_y , in seconds (s).

3.24

Ignition safety time

The safe time for the burner's ignition flame to ignite, that is, when the ignition flame is not formed, the interval between the time when the ignition fuel control valve gets the opening signal and the time when it gets the closing signal.

Note: The ignition safety time is expressed in t_s , in seconds (s).

The ratio of the actual amount of supplied air to the amount of theoretical air.

3.31

Working diagram

A curve which represents the relationship between the combustion chamber's pressure and the heat output, whose enveloped zone is the working range as designed for the burner.

3.32

Original emission

Emission concentration of combustion products without any treatment determined under type test conditions.

Note: The original emission concentration is converted according to the oxygen content of the flue-gas of 3.5%, in milligrams per cubic meter (mg/m^3).

3.33

In service burner modification

The behavior of making major changes to the type of fuel, internal structure, combustion method of the burner.

4 Classification and preparation of model

4.1 Classification

The burners are divided according to the type of fuel used, the mode of adjustment, the mode of air supply, the method of atomization, the type of structure, as follows:

- a) According to the type of fuel used, it is divided into liquid-fuel burners, gaseous-fuel burners, dual (multi) fuel burners;
- b) According to the heat output's control mode, it is divided into single-stage control burner, multi-stage control burner, modulating control burner;
- c) According to the air supply mode of combustion air, it is divided into forced draught burners and natural ventilation burners;
- d) According to the atomization mode of the liquid-fuel, the liquid-fuel burner is divided into mechanical-atomization burner and medium-atomization burner;

- a) A single-stage control burner shall be provided with one safety shut-off valve, as shown in Figure B.1;
- b) A two and multi-stage control burner shall be provided with a safety shut-off valve for each nozzle, as shown in Figure B.2;
- c) The burner which uses the return nozzle shall be provided with a safety shut-off valve on the fuel supply pipeline and the fuel return pipeline, which are linked. It may use a nozzle shut-off valve to replace the safety shut-off valve, as shown in Figure B.3 and Figure B.4.

5.2.2.2 For liquid-fuel burners which have a nominal heat output > 400 kW, it shall install two automatic safety shut-off valves in serial connection on the fuel pipeline. The upstream safety shut-off valve shall be of the quick-closing type, the downstream safety shut-off valve may also be used as the flow control valve simultaneously. The closing time shall not exceed 5 s. The automatic safety shut-off valve shall be arranged in accordance with the requirements of Figure B.5 ~ Figure B.7. The specific requirements are as follows:

- a) The two and multi-stage control burners shall be equipped with two safety shut-off valves for each nozzle, as shown in Figure B.5;
- b) Burners which use return nozzles shall be fitted with two safety shut-off valves, respectively, on the fuel supply pipeline and the fuel return pipeline. One of the safety shut-off valves may be replaced by a nozzle shut-off valve, which shall comply with the requirements of ISO 23553-1. The return pipeline shall be fitted with a pressure monitoring device, as shown in Figure B.6 and Figure B.7. The safety shut-off valve shall be linked. When the safety shut-off valve on the fuel supply pipeline is opened, the safety shut-off valve on the return pipeline cannot be closed. It can be realized by the following two methods:
 - 1) A mechanical connection controlled by the actuator between the safety cut-off valve on the supply pipeline and the safety shut-off valve on the return pipeline;
 - 2) An electrical or pneumatic interlocking between the safety cut-off valve on the supply pipeline and the safety shut-off valve on the return pipeline.

If the burner has a circulating preheating nozzle head, it shall make the fuel circulate to the nozzle head. When there is only one nozzle shut-off valve, the nozzle shut-off valve shall meet the requirements of ISO 23553-1, otherwise it shall take other measures to ensure that the fuel does not ejected during circulated heating. At the same time, it shall also ensure that the return pressure will not open the nozzle shut-off valve.

5.2.3 Automatic safety shut-off valve for gaseous-fuel

A gas leak detector which has a nominal heat output greater than 1200 kW shall be provided with a valve leak detector.

6 Basic requirements

6.1 Declaration of conformity

This standard has been developed in accordance with the basic safety requirements for the liquid-fuel burner and the gaseous-fuel burner in TSG G0001.

6.2 Manufacturing organization

The manufacturing organization of the burner shall meet the following conditions simultaneously:

- a) The production equipment and production sites that are compatible with the scale of production;
- b) The basic test and detecting device of the burner;
- c) The technicians and professional commissioning personnel related to the thermal energy and electrical control trades;
- d) The sound quality management system and corresponding management policies.

6.3 Professionals

Professionals involved in such trades as manufacture, installation, commissioning, repair, modification of burners shall have expertise in thermal energy and electrical control, be familiar with the operation and commissioning process.

6.4 Type test

6.4.1 Burners shall be subjected to the type test under one of the following conditions:

- a) A newly-designed burner;
- b) Where the fuel types used by the burner or the structure and programmable control methods of burner change;
- c) The last type test of the burner is more than 4 years.

6.4.2 The type test shall be carried out by an inspection and testing institute which has the type test qualification of burner as approved by the State Special

7.1.6 Ignition of ignition burner

7.1.6.1 The ignition of the liquid-fuel shall meet the following requirements:

- a) When the ignition burner is spark-ignited, if the interval between the time when the fuel cut-off valve of the ignition burner is opened and the time when the fuel cut-off valve of the main burner exceeds 5 s, it shall monitor the ignition flame;
- b) When the flame of the liquid-fuel is not ignited, if the main fuel supply can be cut off during the safety time and the ignition valve can be closed at same time, it is not necessary to separately monitor the ignition flame during the pre-ignition time of 5 s, in which case the ignition fuel can be supplied for up to 10 s (5 s is the pre-ignition time, 5 s is the safety time).

7.1.6.2 The ignition of gaseous-fuel shall meet the following requirements:

- a) Except for valve leak detection, the ignition gas valve shall not be energized before the spark ignition device or other ignition device is energized;
- b) For burners which has a heat output greater than or equal to 120 kW, the ignition gas is drawn from between the two main gas safety shut-off valves. Before startup, the downstream main gas safety shut-off valve shall not be energized;
- c) When the ignition gas is controlled by the position of the downstream main gas safety shut-off valve, it shall install a pressure control device to make the ignition gas amount meet the requirements of this standard, meanwhile the gas-pressure shall be greater than the system's resistance;
- d) In the event of an ignition flame's failure, the system shall behave as specified in 7.1.8.

7.1.7 Startup of main burner

7.1.7.1 Direct startup

When igniting the main flame directly, it shall comply with the following requirements:

- a) When using spark ignition, the ignition source shall not be energized before the end of the purge, and it shall be de-energized before the end of the safety time;
- b) When using a hot-surface ignition device, the ignition device shall be energized first, the main gas valve can be opened after the temperature of the ignition source reaches the ignition temperature of the gas.

7.1.9.2 Safety shutdown

During startup or operation, the burner shall be safely shut-down in any of the following situations:

- a) The power supply or dynamic gas source is interrupted or abnormal;
- b) The gas-pressure is lower than the set value;
- c) Liquid-fuel burners exhibit atomization medium failure, low fuel pressure, low fuel temperature, high return pressure of burner which has return nozzle, low rotor speed when using rotary atomizer, etc.

7.1.9.3 Interlock protection

During startup and operation, it shall be safely shut-down and interlock-protected in any of the following conditions (except as listed in 7.1.8):

- a) Fault signal of flame;
- b) High-voltage protection signal of gas;
- c) Fault signal of air-flow;
- d) Abnormal position verification for a burner with position verification;
- e) Alarm signal of gas valve leak detection;
- f) Temperature overrun signal of liquid-fuel;
- g) Overrun of such parameters as pressure, water-level, temperature as related to the boiler.

7.2 Electrical safety

7.2.1 Electrical equipment's safety shall meet the requirements of GB 19517, the electrical safety shall be implemented in the order of direct safety measures, indirect safety measures, suggestive safety measures.

7.2.2 In order to ensure the normal operation and prevent the danger caused by the direct action of the current, the electrical equipment shall have sufficient insulation resistance, dielectric strength, heat resistance, moisture resistance, anti-fouling, flame retardancy, tracking resistance.

7.2.3 All parts that may be hazardous due to operating voltage, fault current, leakage current or the like shall have sufficient electric clearance and creepage distance.

7.2.4 Electrical equipment shall have sufficient mechanical strength, good

- a) The flame diameter and length of the burner shall be matched to the furnace size of the boiler;
- b) The nominal heat output of the burner shall be matched to the rated output of the boiler;
- c) It should use the online oxygen monitoring, to improve the control accuracy of air-fuel ratio.

8 Design and manufacturing

8.1 General requirements

The burner shall be designed to meet the following requirements:

- a) The materials used in each component shall be capable of withstanding the mechanical load, thermal, chemical load in the working environment;
- b) The design of each component structure shall ensure the safe and economic operation of the burner, without any occurrence of instability, deformation or cracking;
- c) For the burner which has a flame observation hole, the structure design of the flame observation hole's fitting shall have sufficient strength and reliable sealing;
- d) The components exposed to corrosive fuels shall be corrosion resistant;
- e) The burners used in cold environments shall take the necessary antifreeze measures;
- f) When burning explosive gaseous-fuels, all electrical components shall be installed in accordance with the provisions of the hazard zoning of relevant equipment, with corresponding explosion-proof grades;
- g) The burner and fuel pipelines shall be provided with the measuring-points for fuel supply pressure, fuel control pressure, fuel pressure at the burner's head, air pressure.

8.2 Connection and sealing

The connection between the burner's components and between the burner and the boiler shall comply with the following requirements:

- a) The burner shall be securely fixed to the boiler. It shall provide a sealing gasket with thermal insulation function between the burner and the boiler;
- b) Components which require regular maintenance shall be easy to

- c) The parameter setting of the air monitoring device shall be matched to the minimum heat output. The limit of volume content of carbon monoxide in the combustion products shall not exceed 1%.

8.3.4 Air-flow control device

The air-flow control device shall meet the following requirements:

- a) The burner shall be fitted with a damper adjustment device or similar device for regulating the air-flow, and the position of the damper shall be clearly marked;
- b) The manual air-flow control device shall have fixed measures to prevent mis-operation;
- c) The air-volume at the same operating point during the upward and downward movement of the control device shall be repeatable.

8.3.5 Fuel-flow control device

The fuel-flow control device shall be able to accurately adjust within the design pressure range, the fuel-flow is stable and reliable. At the same operating point during the upward and downward movement of the control device, the fuel-flow shall be repeatable.

8.3.6 Control device of air/fuel ratio

The control device of air/fuel ratio shall comply with the relevant requirements of ISO 23551-3 and ISO 23552-1 and shall meet the following requirements:

- a) The air-flow and fuel-flow shall be linkage-controlled, meanwhile it shall ensure that the operating point of the burner is repeatable;
- b) If using a dual-servo control system, it shall monitor in a real-time manner the position of the fuel-flow regulating valve and the air-flow regulating valve;
- c) For two and multi-stage control burners, it shall first increase the air-volume before increasing load; it shall first reduce fuel before reducing load;
- d) At the ignition of burner, it shall verify the fuel and air ignition positions. The setting of ignition setting shall comply with the requirements of start heat output in 7.1.5;
- e) The air/fuel ratio control device may, in case of failure, still receive the control signals, to ensure that the system supplies sufficient air or a safety shutdown.

8.3.10.1 For the burners which burn the high-viscosity liquid-fuel, the fuel shall be preheated.

8.3.10.2 The heat source for liquid-fuel preheating shall meet the following requirements:

- a) The heat output shall be automatically controlled and shall be cut off immediately as needed;
- b) It shall not be heated by an open flame.

8.3.10.3 The preheating temperature of liquid-fuels shall meet the following requirements:

- a) Under normal pressure, the maximum preheating temperature of liquid-fuel shall be lower than its opening ignition point, meanwhile it shall not exceed 90 °C;
- b) The maximum preheating temperature of the pressurized preheater shall be at least 5 °C lower than the saturation temperature of the water at the corresponding pressure.

8.3.11 Automatic safety shut-off valve of gaseous-fuel

The automatic safety shut-off valve of gaseous-fuel shall comply with the relevant requirements of ISO 23551-1 and ISO 23551-4 and shall meet the following requirements:

- a) The automatic safety shut-off valve is a normally-closed valve, which shall be quickly and automatically closed when the driving force is lost;
- b) If the nominal diameter of the valve is less than or equal to 200 mm, the valve shall be safely closed within a period of not more than 1 s; if the nominal diameter of the valve is more than 200 mm but less than or equal to 300 mm, the valve shall be safely closed within 3 s; if the nominal diameter of the valve is more than 300 mm, the valve shall be safely closed within 5 s.

8.3.12 Valve leak detector

The valve leak detector shall comply with the relevant requirements of ISO 23551-4 and ensure that the opening time of the downstream valve of the two series-connected gas valves during the leak detection process does not exceed 3 s. Valve leak detection shall be performed during or before the pre-purge.

8.3.13 Low-pressure protection device of gas

The low-pressure protection device of gas shall comply with the relevant

indicated positional tolerance shall be in accordance with the relevant provisions of GB/T 1184. It shall meet the following requirements:

- a) The injection-molded parts shall not have obviously-visible surface defects such as flow marks, fusion marks, pores, delamination, carbonization scorch;
- b) The injection-molded parts shall be full and shall not have defects such as depressions, cracks, warpage, flashing;
- c) The appearance of the injection-molded parts shall not have any shrinkage marks that affect the appearance;
- d) The structural dimensions shall comply with the requirements of the technical drawings or the retained sample.

8.4.4 Machined parts

The dimensional tolerances of machined parts shall comply with the relevant levels in GB/T 1804.

8.4.5 Castings

The dimensional tolerance of castings shall comply with the relevant provisions of GB/T 6414 and shall meet the following requirements:

- a) The casting shall not have cracks. The casting sand, core sand, pouring gate, riser, package bump, scale, slag inclusion on the surface of the casting shall all be removed.
- b) The machined surface of the castings which have sealing requirements shall be free from defects such as pinholes, blisters or slag inclusions. The diameter of defects such as pinholes, blisters or slag inclusions on other surfaces shall be less than or equal to 3 mm, the depth shall be less than or equal to 10% of the thickness and less than or equal to 3 mm. The number of defects shall be less than or equal to 2 on the surface of 100 cm². The spacing between defects shall be more than or equal to 20 mm. The total number of defects for a single casting shall be less than or equal to 10.
- c) Except as indicated in the design document, all corners on the casting shall be rounded, where the inner radius of the fillet shall be more than or equal to 6 mm, the outer radius of the fillet shall be more than or equal to 4 mm. There shall be no acute angle and sharp transition on the casting.
- d) The castings shall be subjected to heat-treatment to eliminate residual stress. When the castings need to be machined, the heat-treatment shall be carried out before machining.

requirements in Table 12. Meanwhile it shall prevent the generation of pollutants such as aldehydes.

9.2 Biomass pyrolysis gas burner

In addition to meeting the general requirements for gaseous-fuel burners, the design of biomass pyrolysis gas burners shall also meet the following additional requirements:

- a) Set up a reliable ignition burner to ignite by high calorific value fuel such as light oil, natural gas or liquefied petroleum gas;
- b) In terms of structural design, it shall provide a tar cleaning port.

9.3 Surface burner

9.3.1 Design requirements

In addition to complying with the general requirements for gaseous-fuel burners, surface burners shall also meet the following requirements:

- a) The premixing stage shall ensure that the gas and air are evenly mixed. The premixing stage shall strictly ensure the airtightness and prevent the premixed gas from leaking.
- b) When the nominal heat output is more than 2100 kW, the premixing stage shall be located at the outlet of the fan. When the premixing stage is located at the inlet of the fan, the fan shall be an explosion-proof fan.
- c) It shall provide gas and air-filtration devices. The pores of the filtration device shall not be larger than the pores of the burner head, to ensure the safe operation.
- d) It shall provide a negative-pressure monitoring device, flow monitoring device, or other devices which may reflect the actual air-supply status in a real-time manner at the outlet of the air filter. The filter shall be interlocked and protected when it is blocked.
- e) It shall provide the anti-backfire monitoring devices inside the flame tube, such as temperature monitoring, light monitoring, ion monitoring, etc. If the anti-backfire monitoring device detects a signal, it shall be able to cut off the fuel supply immediately.
- f) The post-purge time of burner shall be more than or equal to 30 s.
- g) Burners which have a nominal heat output more than 400 kW shall be ignited by an ignition flame.

- 1) For an integrated burner which has a heat output less than or equal to 7000 kW, in principle, it shall carry out the type test on the tested furnace;
- 2) For split burners and burners which have a heat output more than 7000 kW, it may carry out test on the associated boiler. However, it shall describe the model, parameter, and manufacturer of the boiler in the test report;
- 3) Test the structure, function and operating characteristics of the burner, meanwhile test all specified operating conditions.

b) Exit-factory inspection

- 1) The manufacturer of burner will carry out inspection and issue the corresponding report;
- 2) Perform cold-function flow inspection and hot-safety control function verification test;
- 3) The product can only be exit-factory after passing inspection.

c) In-use detection

- 1) The user unit of the burner or its authorized qualified institute will carry out detection and issue a corresponding report;
- 2) The inspection period of the in-use burner is 1 year;
- 3) Check whether the performance of the control and safety devices is reliable.

10.2 Type test

10.2.1 Number of prototypes

The number of prototypes for the type test is one for each model.

10.2.2 Principle of coverage

10.2.2.1 The principle of coverage of the burner's type test is that the type test for different models of burners of the same power class in the same series are covered by each other.

10.2.2.2 For the covered burner, the type test institute shall, after reviewing the product's safety declaration information and the exit-factory technical documents provided by the manufacturer, indicate the coverable model of burners in the type test certificate and report of the burner that has passed the type test.

The inspection items of in-use burner after modification shall be in accordance with the Appendix H. It shall carry out test according to the actual modifications. The test results shall comply with the relevant requirements of this standard.

11 Technical documents and markings

11.1 Product's exit-factory technical documents

During exit-factory, the burner shall be accompanied with at least the following exit-factory technical documents (in Chinese and in SI units):

- a) Product's shape and installation dimension drawing;
- b) Electrical wiring diagram;
- c) Product's instruction manual;
- d) Product qualification certificate;
- e) Product's type test certificate or spot-check certificate (duplicated copy);
- f) Product's packing list.

11.2 Product's instruction manual

The product's instruction manual shall include the following:

- a) Product's structure and working principle;
- b) Product's performance description (including burner's operating curve or heat output range);
- c) Installation requirements;
- d) Detailed description of the operation method;
- e) Maintenance instructions;
- f) Warnings and precautions.

11.3 Nameplate

It shall install a nameplate at a prominent position on the burner, to indicate the following (in Chinese and in SI units):

- a) Product's model;
- b) Product number;

12.3 Storage

The product shall be stored in an indoor place that is ventilated, dry, free from corrosive gases.

13 Installation, commissioning and use

13.1 Installation

13.1.1 Installation of burner

The installation of burner shall meet the following requirements:

- a) The burner shall be installed by a professional in accordance with the technical documentation provided by the manufacturer;
- b) External wiring shall be carried out in accordance with the wiring diagram provided by the manufacturer;
- c) The handling and installation of the burner and its components shall be smooth, to avoid shocks and collisions;
- d) The components of the burner shall be properly installed and fixed, all components shall be able to return to their original positions after disassembly and reassembly.

13.1.2 Installation of fuel pipeline

The installation of fuel pipelines shall meet the following requirements:

- a) The component's installation position on the fuel pipeline shall be easy to operate and maintain;
- b) Components on gas pipelines that require periodic inspection may be mechanically connected to ensure their stability;
- c) The burner and the fuel supply pipeline shall be connected by a hard pipe or a metal hose. If a non-metallic hose is used, the outside shall be wrapped by corrosion-resistant metal braid. Meanwhile the length shall be as short as possible, the bending radius complies with the minimum bending radius requirements of the hard pipe connection, it shall also comply with the pressure resistance requirements of the fuel pipeline.

13.1.3 Others

Other installation requirements shall meet the following requirements:

- a) Between the installation flange of the burner and the installation flange of

- 1) Verify the functional status of each component of the burner;
- 2) Verify that the operating procedure of the burner system meets the design requirements;
- 3) Verify that the action of the safety interlock protection device is correct and reliable;
- d) When an abnormal situation occurs during commissioning, it shall find the causes and make adjustment or replacement, until it is qualified;
- e) Record the commissioning results.

13.2.2 Hot-state commissioning

Perform ignition operation on the boiler (or tested furnace), to test and adjust the combustion performance of the burner, to meet the design requirements. Hot-state commissioning shall meet the following requirements:

- a) It shall be carried out on the basis of qualified cold-state commissioning;
- b) The main contents of hot-state commissioning include:
 - 1) The reliability of ignition;
 - 2) Combustion performance during normal operation: flame monitoring is reliable; flame shape meets design requirements; load adjustment is flexible, combustion is stable; flue-gas emissions meet design requirements;
 - 3) Confirm that the safety interlock protection function is normal and reliable;
- c) When an abnormal situation occurs during commissioning, it shall be shut-down safely, identify the cause and make adjustments or replacements, perform test again, until it meets the design requirements;
- d) Record the debugging process and results.

13.3 Maintenance

13.3.1 Troubleshooting

The troubleshooting shall meet the following requirements:

- a) In the product's technical documentation, it shall list the common fault phenomena, cause analysis and troubleshooting methods;
- b) When there is a fault during commissioning or operation of product, it shall

Appendix E

(Informative)

Measurement of flue-gas's blackness

E.1 Equipment

E.1.1 Suction pump (manual)

The manual suction pump shall be able to accommodate a single-suction smoking volume $(160 \pm 8) \text{ cm}^3$ of an effective filtration area (0.6 cm in diameter) [approximately the volume of smoke passing through the effective filtration area per cm^2 is $(570 \pm 28.5) \text{ cm}^3$]. The piston stroke of the pump is approximately 20 cm.

In order to prevent condensate and temperature increase during the first operation of the suction pump, the components to fix the filter paper shall be guaranteed to be free of water leak.

The distance from the sampling point to the filter paper shall not exceed 40 cm. When this distance exceeds 40 cm due to the use of a specially structured flue, it shall be stated in the test report.

E.1.2 Sampling tube

The inner diameter of the sampling tube is 6 mm and shall meet the requirements of E.1.1.

E.1.3 Filter paper

The reflectance of the filter paper to light is $(85 \pm 2.5) \%$. The filter paper shall be placed on a white surface which has a reflectance more than or equal to 75%.

When air passes through the filter paper at a flow-rate of $3 \text{ dm}^3/\text{cm}^2$ per minute, the pressure drop shall be between 2 kPa and 10 kPa (20 mbar ~ 100 mbar).

E.1.4 Standard value of flue-gas's blackness

The flue-gas's blackness scale consists of a material which has a reflectance to light at $(85 \pm 2.5) \%$, with 10 color blocks regularly arranged from white to dark gray. The blackness value corresponds to the corresponding light attenuation factor, for example, the blackness value 6 indicates that the light attenuation rate is 60%. For each color block, the error of reflectivity shall not exceed 3%.

Appendix G

(Normative)

Conditions of type test

G.1 Requirements for test fuel

G.1.1 Fuel viscosity and nitrogen content

The liquid-fuel for testing shall meet the following requirements:

- a) It shall use the fuels which have a viscosity of $1.6 \text{ mm}^2/\text{s} \sim 6.0 \text{ mm}^2/\text{s}$ (at $20 \text{ }^\circ\text{C}$) at the burner's inlet and a nitrogen content of less than or equal to 200 mg/kg ;
- b) Liquid-fuel which meets the requirements of GB 25989 may be used as test fuel;
- c) Alcohol-based fuel which meets the requirements of GB 16663 may be used as test fuel;
- d) When using other liquid-fuels, it shall determine their viscosity and nitrogen content.

G.1.2 Gaseous-fuel

When testing gaseous-fuel burners, it shall use the gas that meets the requirements of GB/T 13611. In case of field test, it may also use other gaseous-fuels.

G.1.3 Analysis of fuel composition and its performance

Before testing the burner, the fuel shall be sampled, to analyze and test the followings by a testing laboratory with the test qualification:

- a) For gaseous-fuel, the analysis items are gas composition, relative density, net calorific value, Wobbe index;
- b) For liquid-fuel, analysis items are elemental analysis, viscosity ($20 \text{ }^\circ\text{C}$), density, net calorific value.

G.2 Requirements for test environmental conditions and system

G.2.1 The test environmental conditions shall meet the following requirements:

- a) The burner shall be installed in a well-ventilated space. The suitable indoor

ambient temperature is 5 °C ~ 35 °C, it also allows other ambient temperatures if they do not affect the test results;

b) A suitable atmospheric pressure is 97.272 kPa ~ 105.378 kPa;

c) A suitable air humidity is moisture content of 5 g/kg ~ 30 g/kg.

G.2.2 Test results (working diagram) shall be corrected according to the following reference conditions:

a) The ambient temperature is 20 °C;

b) The gas temperature is 0 °C;

c) The atmospheric pressure is 101.325 kPa;

d) The air humidity is moisture content of 10 g/kg.

G.2.3 The test system shall meet the following requirements:

a) The air quality in the test environment does not affect the validity of the test parameters;

b) The burner system's connection shall be safe, firm, and good in sealing performance. The construction shall be carried out strictly according to the wiring diagram and connection diagram of the valve block, piping, electrical components, as well as other technical documents which are provided by the burner's manufacturer. The connection of flanges and relevant components shall be carried out according to relevant standards, to ensure the safe and successful proceeding of test work;

c) The laboratory shall provide a stable power supply of rated voltage and rated frequency for the burner.

G.3 Requirements for test furnace

G.3.1 General requirements

The test can be carried out in a test furnace as specified in standard. In the absence of a specified test furnace, the test shall be carried out in a test furnace that meets the following requirements:

a) The test furnace which has an output heat output ≤ 7000 kW;

b) The test furnace which has an output heat output > 7000 kW.

G.3.2 Structure of test furnace which has an output heat output ≤ 7000 kW

The structure of the test furnace is as shown in Figure G.1. The design

G.3.4 Requirements for cooling medium

The cooling medium shall meet the following requirements:

- a) The temperature of the cooling medium shall be as low as possible and shall be kept between 15 °C and 60 °C under the following conditions:
 - 1) Start;
 - 2) Determination of flame stability and safe operating limits;
 - 3) Flame stability test.
- b) During the test of the following items, the temperature of the cooling medium shall be maintained between 40 °C and 80 °C, meanwhile the system shall maintain thermal equilibrium:
 - 1) Test of flame stability and safe operating range;
 - 2) Test of combustion characteristics;
 - 3) Test of heat output range.

G.3.5 Arrangement of measuring-point

The arrangement of measuring-points shall meet the following requirements, as shown in Figure G.5:

- a) Measurement points of flue-gas analysis are arranged in the flue, perpendicular to the flow direction of the flue-gas, having an insertion depth of 1/3 of the diameter of the flue. During the test, there shall be no air leakage;
- b) Measurement points of flue pressure are arranged at a distance of 0.15D from the measurement point of flue-gas analysis, the distance from the rear wall of the test furnace is 2D;
- c) Measurement points of flue-gas are arranged at 0.15D from the measurement points of flue pressure.

the requirements of 7.1.5 and 7.3.1.

I.10.2 Liquid-fuel burner

After ensuring each correct start and ignition test of the burner, in addition to the following conditions, it shall also meet the safety conditions as specified in the relevant standards:

- a) The temperature of the cooling medium shall be between 40 °C and 80 °C;
- b) The combustion air's temperature and laboratory temperature are between 5 °C and 35 °C.

In this state, verify whether it complies with the requirements of 7.3.4.

I.11 Measurement of safety time

The safe time is measured as follows:

- a) Measurement of ignition safety time: When the burner is started, use the safety time tester to measure the time interval from the time when the fuel enters the furnace and the ignition fails to the time when the fuel fast shut-off device starts action;
- b) Measurement of extinction safety time: When the burner is running, use the safety time tester to measure the time interval from the time when the flame detector device issues the flame extinction signal to the time when the safety shut-off valve starts closing;

The number of tests of the ignition safety time and the extinction safety time above shall each be not less than 3 times, the results of each test shall comply with the requirements of 7.1.4.

I.12 Test of ignition failure

After the burner is started, pull out the flame detector device from the burner, the test results shall meet the requirements of 7.1.8.2.

I.13 Test of flame stability

I.13.1 Test of flame stability shall be carried out when the burner is in the following operating conditions:

- a) The burner is in maximum heat output operation state;
- b) The burner is in the minimum heat output operation state;
- c) The operation state when the voltage changes (0.85 times ~ 1.1 times rated voltage).

- b) Heat-resistance test of gaseous-fuel burner: Supply the burner with 1.09 times the rated maximum heat output of the design gas. Meanwhile, adjust the combustion chamber's pressure to the pressure at the maximum heat output as provided by the manufacturer. Carry out test after the burner is operated for 10 minutes.

For the test results of the heat-resistance of the above-mentioned burner, it shall require that except for the inherent surface defects of all component materials, there shall be free from any deformation, cracking, overheating, etc.

I.16 Surface temperature test of burner's component

The surface temperature test of the component is carried out as follows:

- a) Measure the surface temperature of the control device and the safety device when the burner is not in operation;
- b) Under the rated voltage, adjust the heat output of the burner to the maximum value, adjust the internal pressure of the combustion chamber to the minimum value, adjust the excess air ratio (α) to the design value;
- c) After the burner runs for 30 min, measure the surface temperature of the control device and safety device of the burner.

The above test results of surface temperature of the burner's components shall comply with the requirements of 7.3.2.

I.17 Test of heat output range

I.17.1 Test of maximum heat output

The test of maximum heat output is performed as follows:

- a) Adjust the burner's heat output to the maximum value, adjust the supply voltage to the rated voltage, adjust the combustion chamber's pressure to the minimum value, adjust the excess air ratio (α) to less than or equal to 1.2;
- b) Detect the CO, NO_x content in the flue-gas, flue-gas's blackness (only for liquid-fuel burners) and excess air ratio (α), the test results shall comply with the requirements of 7.4.1.1 and 7.4.1.2;
- c) Record the fuel input in a real-time manner;
- d) The test duration is 20 min, the test data is recorded once every 5 min;
- e) According to I.9.2, calculate the maximum heat output of the burner.

I.17.2 Test of minimum heat output

For the measurement and correction of emissions, see Appendix D. The test results shall meet the requirements of 7.4.1.

I.19 Test of noise

The noise test is performed while the burner is in the nominal heat output operating state (i.e., the measuring-point 2 on the working diagram).

During the test, select 3 measuring-points at the front, left, right side 1 m in front of the burner, use the sound level meter to measure the noise along the forward, leftward, rightward directions of these three points, 3 measurement per point. Take the maximum average of all results as the test result, which shall comply with the requirements of 7.4.2.

I.20 Test of working diagram

I.20.1 Test duration

The test duration shall meet the following requirements:

- a) The test duration for each measuring-point of the positive-pressure running zone is 20 min;
- b) The test duration for the measuring-point of the negative-pressure running zone is 10 min;
- c) For each measuring-point, the measurement data is recorded once every 5 min.

I.20.2 Test requirements

I.20.2.1 General requirements

Test requirements shall meet the following requirements:

- a) In the test process of each measuring-point, it shall record in real-time the fuel input and combustion chamber's pressure;
- b) In the test process of each measuring-point, the excess air ratio (α) and combustion product's emissions shall meet the requirements of this standard.

I.20.2.2 Working diagram and measuring-point diagram of burner

The individual test points in the working diagram are carried out in accordance with Figure I.1 and Figure I.2.

I.20.2.3 Requirements of excess air ratio

I.20.3.1.3.1 The burner shall be adjusted to the following state:

- a) Heat output to the minimum value;
- b) Supply voltage to rated voltage;
- c) Combustion chamber's pressure to the maximum value;
- d) Excess air ratio, $\alpha \leq 1.5$.

I.20.3.1.3.2 The test items are as follows:

- a) CO and NO_x content in flue-gas, flue-gas's blackness, excess air ratio (α);
- b) Flame stability test.

I.20.3.1.4 Test of measuring-point 4

I.20.3.1.4.1 The burner shall be adjusted to the following state:

- a) Heat output to the minimum value;
- b) Supply voltage to the rated voltage;
- c) Combustion chamber's pressure to the minimum value (may be zero or negative);
- d) Excess air ratio, $\alpha \leq 1.5$.

I.20.3.1.4.2 Test items include: CO and NO_x content in flue-gas, flue-gas's blackness, excess air ratio (α).

I.20.3.1.5 Test of measuring-point 5

I.20.3.1.5.1 The burner shall be adjusted to the following state:

- a) Heat output to the maximum value;
- b) Supply voltage to the rated voltage;
- c) Combustion chamber's pressure to the minimum value (may be zero or negative);
- d) Excess air ratio, $\alpha \leq 1.2$.

I.20.3.1.5.2 Test items include: CO and NO_x content in flue-gas, flue-gas's blackness, excess air ratio (α).

I.20.3.1.6 Test of measuring-point 6

to the following state:

- a) Heat output to the declared value;
- b) Supply voltage to the rated voltage;
- c) Combustion chamber's pressure to the maximum value (positive-pressure for the measuring-point 2 and measuring-point 6; negative-pressure or zero for the measuring-point 5);
- d) Excess air ratio, $\alpha \leq 1.2$.

I.20.3.2.2.3 The test items are as follows:

- a) CO and NO_x content in flue-gas, excess air ratio (α), flue-gas's blackness, noise;
- b) Flame stability.

I.20.3.2.3 Test of measuring-point 3

I.20.3.2.3.1 The burner uses the standard gas of rated pressure and is adjusted to the following state:

- a) Heat output to the minimum value;
- b) Supply voltage to the rated voltage;
- c) Combustion chamber's pressure to the maximum value;
- d) Excess air ratio (α) is adjusted as specified in Table I.3.

I.20.3.2.3.2 The test items are as follows:

- a) CO and NO_x content in the flue-gas, excess air ratio (α);
- b) Flame stability.

I.20.3.2.4 Test of measuring-point 4

Adjust the burner according to the requirements of I.20.3.2.3.1, adjust the combustion chamber's pressure to the minimum value (zero or negative-pressure), then test the following items:

- a) CO and NO_x content in the flue-gas, excess air ratio (α);
- b) Flame stability.

I.21 Other test items

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