IEC PAS 63312

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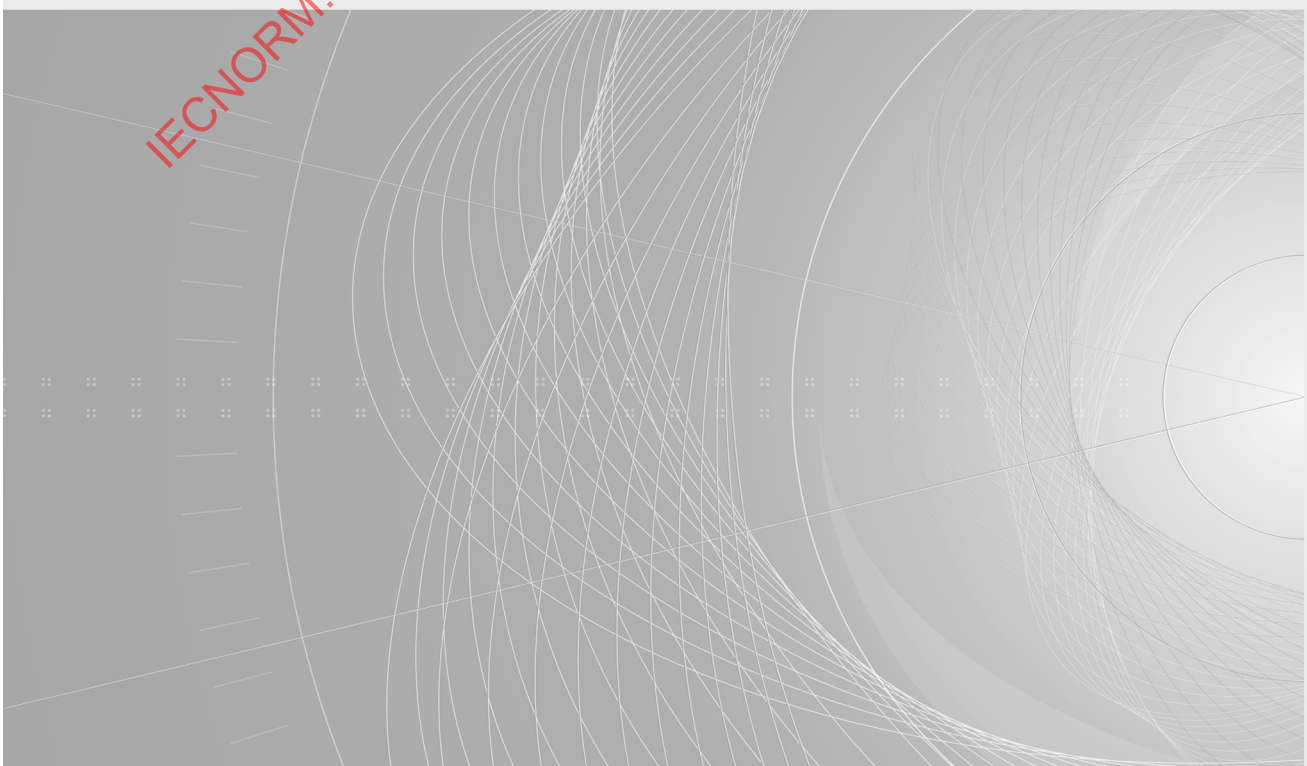
PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

colour inside

Technical specification for flame detector system of boiler



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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TECHNICAL SPECIFICATION FOR FLAME DETECTOR SYSTEM OF BOILER

FOREWORD

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IEC PAS 63312 has been processed by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
65B/1175/DPAS	65B/1180/RVDPAS

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned may transform it into an International Standard.

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INTRODUCTION

The flame detector is the key testing equipment for the boiler furnace safety protection and burner interlock control. In the whole combustion process of the boiler (especially in the variable operating condition), it detects the change of the combustion condition, and the corresponding control measures are taken through the connected terminal devices; so its reliability is related to the safety of the combustion system and the quality of the terminal products. Due to the difference in combustion conditions in the furnace, the reliability of the flame detector itself and the quality of the installation and maintenance, many problems are exposed during the operation, such as peeping of fire detection signals, missed detection, instability, false alarm information, fiber overheating loss, etc. All of these will bring safety hazards to the industrial production.

The purpose of this PAS is to develop comprehensive technical specifications for the functions and performance of industrial boiler flame detectors, as well as the technical requirements related to design, manufacture, installation, testing, operation, maintenance, etc., so as to provide the technical basis for flame detector system users.

TECHNICAL SPECIFICATION FOR FLAME DETECTOR SYSTEM OF BOILER

1 Scope

This PAS deals with the general requirements, classification and technical requirements, installation and commissioning requirements, inspection and maintenance requirements, test methods and requirements of radiant energy sensing flame detectors (including IR, UV, visible light, and imaging-based flame detectors).

This PAS is applicable to the type selection, design, installation, commissioning, inspection, maintenance and acceptance of the radiant energy sensing flame detectors, which monitor the flame status of burners.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-1, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61326-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61326-2-5, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-5: Particular requirements – Test configurations, operational conditions and performance criteria for field devices with field bus interfaces according to IEC 61784-1*

NFPA 85, *Boiler and Combustion Systems Hazards Code*

ANSI/TIA/EIA-232-F, *Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*

ANSI/TIA/EIA-422-B, *Electrical Characteristics of Balance Voltage Digital Interface Circuits*

ANSI/TIA/EIA-644-A, *Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
flame detector
device in the furnace safety supervisory system that detects the combustion status in real time according to the flame characteristics of the fuel, and which, when the flame status fails to meet the preset conditions, considers the target flame abnormal or disappeared and sends a signal in a certain manner to stop the corresponding fuel supply

3.2
infrared signal
radiant energy signals falling within the infrared spectrum, emitted from the flames of burning fuel such as coal and oil

3.3
ultraviolet signal
radiant energy signals falling within the ultraviolet spectrum, emitted from the flames of burning fuel such as natural gas and light oil

3.4
visible light signal
radiant energy signals falling within the visible light spectrum, emitted from the flames of burning fuel such as lean coal and mixed fuels

3.5
flame on
presence of flame in the furnace, as computed by the flame detector system

3.6
flame off
absence of flame in the furnace, as computed by the flame detector system

3.7
target flame
predefined flame to be detected, rather than the extended background radiation or the adjacent and opposing flames

3.8
flame intensity
value computed by flame detector according to the received radiant energy intensity of flame, representing the radiant energy intensity of the flame

3.9
flicker frequency
pulsation frequency of flame radiant energy, representing the change rate of the target flame's radiant energy intensity

3.10
AC amplitude
pulsation amplitude of radiant energy from flame, representing the peak-to-peak value of the radiant energy intensity pulsation of target flame

3.11
flame quality
extent away from the flame-off status, computed from the detected flame intensity and flicker frequency, representing the degree of flame stability

3.12
flame threshold
minimum value set for the flame detector to determine the presence of flame (i.e. flame-on threshold) or the maximum value to determine the absence of flame (i.e. flame-off threshold)

3.13
flame relay
on/off control switch that switches on when the flame logic judges that flame is present and switches off when it judges that flame is absent

3.14
fault relay
on/off control switch that switches on when no fault is detected and switches off when any fault is detected

3.15
flame detector probe
device installed locally, capable of flame information sensing, photoelectric conversion and signal amplification

3.16
analysis and processing unit
device that receives the signals transmitted from one or more flame detector probes, and, after analysing and processing by the corresponding processor, outputs the digital and analog signals of each flame signal

Note 1 to entry: The relevant parameters of each flame can be set independently.

3.17
one-to-one detection
detection mode in which each target flame has a separate, fixed flame detector

3.18
flame detector peeping
situation that exists when the flame detector cannot distinguish between a target flame and a non-target flame, and considers a non-target flame as the target flame

3.19
static commissioning
commissioning of flame detector system using simulative light sources before the boiler is started up

3.20
dynamic commissioning
commissioning of flame detector system after the boiler is started up, during which the flame detection data throughout the period from the startup to the full load operation of the boiler under typical operating conditions is analyzed and compared and the parameters setting is completed to meet the actual operating requirements of the boiler

3.21
light signal-based flame detector
flame detector that detects flames relying on the intensity, pulsation and other signals of the radiant light emitted by target flame, including infrared, visible light, ultraviolet, dual-spectrum, and full-spectrum types

3.22
imaging-based flame detector
flame detector that detects the flame by acquiring the real-time video images of the target flame

3.23
Class A unit overhaul
thorough inspection and repair on the generator unit, intended to maintain, restore or improve the performance of the unit equipment

Note 1 to entry: Class A is the highest level overhaul among regular unit overhauls.

3.24
Class B overhaul
inspection and repair on the faulty or defective equipment within the unit, which may include some targeted Class A overhaul items or rotational maintenance items depending on the evaluation outcome of the unit

3.25
Class C overhaul
targeted inspection, evaluation and repair carried out on the unit according to the wearing and aging trends of equipment, which may include the replacement of a small number of parts, the defect elimination, adjustment, preventive tests and other operations on the equipment, as well as some Class A overhaul items or rotational maintenance items

3.26
troubleshooting
activities performed on faulty equipment for the purpose of restoring it to such a status that it can execute its intended functions

Note 1 to entry: Troubleshooting includes diagnosis, repair, and replacement.

3.27
mean time between operating failures
MTBF
expectation of the duration of the operating time between failures

[SOURCE: IEC 60050-192:2015, 192-05-13]

3.28
reliability
ability to perform as required, without failure, for a given time interval, under given conditions

Note 1 to entry: The time interval duration may be expressed in units appropriate to the item concerned, e.g. calendar time, operating cycles, distance run, etc., and the units should always be clearly stated.

Note 2 to entry: Given conditions include aspects that affect reliability, such as: mode of operation, stress levels, environmental conditions, and maintenance.

[SOURCE: IEC 60050-192:2015, 192-01-24]

4 General

4.1 General requirements

The flame detector system mainly consists of flame detectors, signal transmission components and cables, junction boxes, flame detection cabinets, the analysis and processing unit, engineer tools, power supplies, installation accessories and the cooling system (if necessary). For the use purpose of each component, see Annex A.

The flame detectors should be marked with QR codes. The outer surfaces and nameplates shall be smooth, intact, scratch-free, and contamination-free. The film over the surface shall have no peeling and scratching. The characters in panels and nameplates shall be legible. There shall be no loose connections or junctions.

4.2 Power supply

The flame detector cabinet shall be provided with duplicate power supplies, which back up each other. It shall have a built-in power switching module, which balances the two power supplies via the automatic power distribution circuit.

Any failure of either power supply shall be alarmed, without affecting the normal operation of the equipment and missending signals. Switching between the two power supplies shall generate no disturbance and shall not enable the flame detector to send the "flame off" signal.

Each power supply circuit of the flame detector amplifier/flame detector shall be provided with a separate fuse or other separate protective measures.

The power supply to the fans in the flame detector cabinet shall be independent of the power supply to the flame detector system, or appropriate isolation measures shall be taken between them.

4.3 Functions and performance of flame detector

The functions and performance of flame detectors shall meet the requirements of NFPA 85 Boiler and Combustion Systems Hazards Code. Flame detectors shall be able to correctly identify the flames of fuel (coal, oil and gas) for the corresponding burners. They shall be continuously adjustable within the full frequency spectrum under monitoring (or the corresponding frequency spectrum), so that the flames can be detected throughout the whole range of working conditions.

The flame detectors should allow selection among multiple parameters, so that appropriate parameter groups can be selected for the specific fuel and combustion condition, and that the flame parameters can be switched according to the current background conditions.

The flame detectors shall correctly reflect the various flame statuses (such as flame frequency and intensity). They shall be able to mitigate the interference from the adjacent, opposite, furnace-reflected non-target flames or the interference from the adjacent main flame to the minimal level.

The flame detectors shall have the self-test function, which allows them, in a timely manner, to reflect their own conditions, make self-diagnosis of faults, and give alarms at the specified interval.

4.4 Signal output

The flame detector of each burner shall provide analog signal (4 mA to 20 mA or 0 to 10 V) outputs or communication means to indicate the intensity of flame output signal.

The flame detector of each burner shall have at least two passive dry contacts to output flame status signals (flame on/flame off) and flame detector fault signals.

For digital outputs of flame detector, single relay mode or double relay mode may be used.

a) Single relay mode: The deenergized/energized status of flame relay (contact open/closed) is used to indicate the flame on/flame off status, and the deenergized/energized status of fault relay (contact open/closed) is used to indicate the faulty/normal status.

b) Double relay mode: Two relays are used to indicate the flame on and flame off statuses respectively. When the flame-on relay is closed and the flame-off relay is open, it indicates the presence of flame. When the flame-on relay is open and the flame-off relay is closed, it indicates the absence of flame. When both relays are closed/open, it indicates a faulty status.

4.5 Interchangeability

Parts of the same type shall be interchangeable. The measurements of the same target flame indicated by different flame detection devices shall be substantially consistent and meet the overall accuracy and linearity requirements.

4.6 Installation

Flame detectors from different manufacturers may have different probe installation methods and requirements. They shall be installed in accordance with 6.1 and the manufacturer's instructions, so that the probe detection point aligns with the sensitive area for flame detection.

4.7 Commissioning

The commissioning of flame detectors consists of two stages: the static commissioning before startup of the boiler and the dynamic commissioning after startup of the boiler. The two-stage commissioning shall be so conducted that the internal parameters of each flame detector are optimized and the flame status in the boiler is correctly indicated throughout the period from boiler startup to full load operation.

4.8 Inspection and maintenance

The probe of flame detector is usually exposed to a harsh working environment. So proper inspection and maintenance is necessary for keeping stable and reliable operation of the flame detector system. In addition to the inspection and maintenance of the flame detector system during unit overhauls, the maintenance personnel shall also carry out routine maintenance and regular maintenance to identify and eliminate problems in a timely manner and improve the reliability of the flame detector system.

4.9 Tests

The purpose of tests is to verify the performance of flame detectors and the effectiveness of their maintenance activities. In order to ensure reliable operation of flame detectors, targeted tests shall be carried out during manufacture, delivery and maintenance.

5 Classification and requirements (design)

5.1 Classification of flame detectors

5.1.1 Classification principle

Flame detectors can be classified according to the detection principle, device structure, installation method, and safety level.

5.1.2 Classification according to detection principle

5.1.2.1 Overview

The flames of coal, oil or gas in the furnace of boiler are characterized by the continuous infrared, visible light and ultraviolet spectrums of radiation and the flame pulsation or flicker phenomenon. The intensity and spectrum distribution of flames vary with the type of fuel. And the spectral frequency and intensity of flame radiation constantly change with the combustion zone. Generally, the flame combustion zones can be divided into the initial combustion zone, the high temperature zone and the burn-out zone. The flame in the initial combustion zone features the most intensive flicker frequency. Appropriate flame detectors shall be used according to the specific characteristics of the target flame. The flame detector converts light signal to pulsation electrical signal (current or voltage signal) and distinguishes the target flame from background flame by detecting the frequency ranges, realizing effective detection of flame signals. According to the detection principle, flame detectors can also be classified into the light signal-based flame detectors and imaging-based flame detectors.

5.1.2.2 Light signal-based flame detector

Light signal-based flame detectors include the infrared, visible light, ultraviolet, dual-spectrum, and full-spectrum types. They detect the target flame by analysing and processing the intensity and spectral characteristics of flame radiation light. Electrical signals are pre-processed in a printed circuit board in the shell of flame detector probe. After logarithmic amplification and being converted into current signals by voltage/current conversion, the signals are transmitted through a shielded cable to the analysis and processing unit (flame amplifier) in the remote signal processing cabinet for processing. After various processes including frequency detection, intensity detection, and circuit detection, standard signals including the quality conditions of flame detector (flame intensity analog signal) and the presence/absence of flame (digital signals and flame detector fault signals) are output for display, alarming and boiler trip logic judgment.

5.1.2.3 Imaging-based flame detector

Real-time video images of flames are collected and the target flames are detected by using the image processing technology. The flame image contains the position, brightness, and pulsation information of target flame and background flame. By properly determining the position of detection area, the target flame can be distinguished from most background flames. Reasonably setting the parameters for judging the target flame could further improve the identification of background flame. Generally, the imaging-based flame detector collects the real-time video images of the target flame via the camera in burner's secondary air duct, and transmits signals to its signal processing unit via a video coaxial cable for processing. After the video analog-to-digital conversion, the built-in image processing algorithm is used to identify the target flame, and the signals such as flame intensity, flame status, and faults are output for display, alarming, and logic judgment.

5.1.3 Classification according to the structure of flame detector

5.1.3.1 Overview

According to detector structure, flame detectors can be classified into the integrated flame detector and split flame detector.

5.1.3.2 Integrated flame detector

The integrated flame detector is usually composed of a probe assembly and a flame signal analysis and processing unit, of which all the electronic devices are integrated and installed at the same local detection position.

5.1.3.3 Split flame detector

The split flame detector is also composed of a probe assembly and a flame signal analysis and processing unit, which, however, are independent of each other. The probe assembly is installed at the local detection position, while the flame signal analysis and processing unit is installed at another place in a favorable environment (such as an electronics room).

5.1.4 Classification according to installation method

5.1.4.1 Internally sighting flame detector

In the "internally sighting" installation mode of flame detector, the optical signals of flame radiation are transmitted to the flame sensor outside the boiler via the optical fibers or light guide tubes installed inside the boiler for flame detection.

5.1.4.2 Externally sighting flame detector

In the "externally sighting" installation mode of flame detector, the flame detector is installed outside the boiler and directly receives the light signals of the target flame in boiler for flame detection.

5.1.5 Classification according to safety level

5.1.5.1 Explosion-proof flame detector

The explosion-proof flame detectors, capable of explosion resistance, are used in explosive environments. Generally, the flame detectors for gas-fired boilers or gas-reacting boilers are exposed to an explosive environment. The common explosive installation environments for flame detectors mainly include gas-fired boiler, coal-fired boiler cofiring combustible gases, waste gas-fired boiler, gas synthesis boiler (such as HCL synthesis boiler), and gas-reacting boiler.

5.1.5.2 Non-explosion-proof flame detector

The non-explosion-proof flame detectors, incapable of explosion resistance, are used in non-explosive environments. The common non-explosive installation environments for flame detectors mainly include oil-fired boiler and coal-fired boiler.

5.2 Technical requirements of flame detectors

5.2.1 Basic functional requirements

5.2.1.1 Self-test function

Flame detectors shall be able to reflect their working conditions in real time by conducting continuous self-test and shall ensure the continuity of their self-test. Under the specified working conditions and when the flame input signal is valid, if the flame detector detects a fault, it shall automatically give an alarm signal via the relay or communication devices.

5.2.1.2 Flame threshold setting function

Under the specified working conditions, the flame-on and flame-off thresholds shall be adjustable. For the imaging-based flame detectors, both the position of each flame judgment zone and the flame recognition threshold shall be adjustable.

5.2.1.3 Flame intensity display

Under the specified working conditions and when the flame input signal is valid, the flame detector shall display the intensity of the flame input signal in real time. For the imaging-based flame detector, the flame signal intensity at the flame zone corresponding to the real-time image shall be provided in the control software.

5.2.1.4 Flame-on delay setting

Under the specified working conditions, the period from the time the flame input signal changes from flame-off to flame-on to the time the flame detector outputs flame-on signal is referred to as the flame-on delay. The delay shall allow appropriate presetting.

5.2.1.5 Flame-off delay setting

Under the specified working conditions, the period from the time the flame input signal changes from flame-on to flame-off to the time the flame detector outputs flame-off signal is referred to as the flame-off delay. The delay may be provided by the boiler manufacturer or preset by professionals.

5.2.1.6 Analog output signal

The analog output signal of flame detector is used for remote monitoring and shall meet the following conditions.

a) When the intensity of flame input signal is less than the lower limit of measuring range of flame detector, the output is DC 4 mA.

b) When the intensity of flame input signal is within the measuring range of flame detector, the output is DC (4 to 20) mA.

c) When the intensity of flame input signal is greater than the upper limit of measuring range of flame detector (overflow), the output is DC 20 mA.

5.2.1.7 Remote communication function of flame detector

The flame detectors shall be capable of remote communication and shall meet the following conditions.

a) The flame detectors shall have the remote communication function and should support common serial communication or fieldbus protocol.

b) The electrical performance of communication interfaces shall meet the requirements of ANSI/TIA/EIA-232-F or ANSI/TIA/EIA-422-B or ANSI/TIA/EIA-644-A.

5.2.1.8 Flame video image management function

The imaging-based flame detector system shall be capable of managing the flame video images, which allows display of flame images of multiple burners at the same time and provides convenience for users to understand the combustion status in the boiler. In addition, the system shall also record the videos of each burner to facilitate review and analysis of boiler combustion.

5.2.1.9 Over-temperature alarm function

The flame detectors should be capable of temperature detection, alarm thresholds setting, and over-temperature alarming. When the detected surface temperature exceeds the preset value, an alarm signal will be sent via the signal processing unit.

5.2.1.10 Functions of flame detector software

The software of flame detectors shall be able to monitor and control the multiple flame detectors or sensor modules distant from the central computer work station. The software shall also allow simple configuration by maintenance personnel to realize software parameters configuration, remote regulation and control, faults analysis, data archiving, and trends recording.

5.2.1.11 Access protection function

The flame detector software running at the central computer work station shall have the access protection function to prevent unauthorized users from modifying the configuration parameters. All working personnel are allowed to view the flame detection data, but only the authorized users are allowed to modify the parameters.

5.2.1.12 Data archiving and playback

The flame detector software shall have the functions of data archiving and playback. The parameter setting files and parameter trend curves can be archived. The parameter information, trend curves and other data recorded by the software can be played back.

5.2.1.13 Flame video image display

The software of imaging-based flame detector shall realize display and switching of flame video images, allowing users to view the flame video images of a single burner or multiple burners. Meanwhile, the flame detector software shall also be able to display the output images of video recorder, allowing users to operate the video recorder and play back the video.

5.2.1.14 Remote configuration mode

Remote configuration can be realized by serial communication or fieldbus communication and the flame browser software based on common computer operating system and the corresponding Chinese/English version.

5.2.2 Basic performance requirements

5.2.2.1 Technical parameter requirements

The technical parameters of flame detector shall meet the following requirements.

a) Working voltage: 5 V DC, 12 V DC, 24 V DC, 220 V AC from local utility power system (−15 %, +10 %).

b) Power consumption: ≤ 5 W.

c) Relay output: passive dry contact.

d) Relay capacity (resistive load): ≥ 1 A, 240 V AC; ≥ 1 A, 24 V DC; minimum load: 10 mA, 5 V DC; mechanical life ≥ 100 000 times.

e) Response peak wavelength: infrared (IR) sensor: 780 nm to 3 000 nm.

   Visible light (VL) sensor: 380 nm to 780 nm.

   Ultraviolet (UV) sensor: 10 nm to 380 nm.

f) Time delay: flame-on delay is adjustable from 1 s to 6 s; flame-off delay is adjustable from 1 s to 4 s.

g) Analog output: DC (4 to 20) mA, with current isolation; accuracy: ±5 % of full measuring range; maximum connected load: 750 Ω.

h) Remote communication port: RS-485 serial channel, which can be configured via Profibus or Modbus protocol.

   1) Profibus: Maximum speed is 12 Mbit/s.

   2) Modbus: Maximum speed is 115,200 kbit/s.

i) The self-test interval of flame detectors shall not be more than 2 minutes, and the self-test duration shall not be more than 0,1 seconds.

5.2.2.2 Environmental adaptability requirements

Under normal working conditions, the flame detectors shall meet the following requirements:

a) Operating temperature range without explosion-proof requirements: integrated flame detector: −40 °C to +70 °C; split flame detector probe: −40 °C to +80 °C; analysis and processing unit: 0 °C to 60 °C. (The low temperatures are according to IEC 60654-1.)

b) Relative humidity: 0 % to 95 %, non-condensing.

c) Explosion-proof operating temperature: integrated flame detector: −20 °C to +70 °C; split flame detector probe: −40 °C to +70 °C; analysis and processing unit: 0 °C to 60 °C.

d) The maximum working temperature of optical fibers shall not be lower than 380 °C. When the cooling air is lost, the optical fiber type flame detectors shall be able to run safely for at least 20 min.

e) The cooling air supply to imaging-based flame detectors shall be always kept normal.

f) The working atmospheric pressure shall range from 86 kPa to 106 kPa.

The storage environment shall meet the following requirements.

1) Ambient temperature: −40 °C to +85 °C.

2) Ambient relative humidity: 0 % to 95 %, non-condensing.

3) Atmospheric pressure: 86 kPa to 106 kPa.

5.2.3 Reliability requirements

5.2.3.1 Requirements on electrical characteristics

The electrical characteristics shall meet the following requirements:

a) The terminals shall be screw terminals.

b) Allowable cross-sectional area of cables:

   0,2 mm^2 to 2,5 mm^2 (J1 connector) for AWG24 to AWG12 relay contacts.

   All other terminals: AWG28 to AWG16, 0,8 mm^2 to 1,5 mm^2.

c) Insulation resistance: The insulation resistance between each output end and the housing of flame detector shall be ≥ 20 M.

d) Insulation intensity: The insulation intensity between each output end and the housing of flame detector shall be able to withstand the voltage of AC 750 V (50 Hz) for 1 min without breakdown or flashover.

5.2.3.2 Protection rating requirements

The protection ratings of the local flame detector cabinets and the flame detector probes shall not be lower than IP52 and IP65, respectively, and shall also meet the requirements of IEC 60529, IEC 61010-1 and ANSI/TIA/EIA-232-F. In addition to the above, the exploration-proof flame detectors shall also meet the following requirements.

a) Explosion-proof rating: According to the requirements of explosion protection zones, the explosion-proof performance of flame detectors shall meet the requirements of IEC 60079-0 and IEC 60079-1. And they shall have obtained the explosion-proof certificates from the national recognized explosion-proof performance test agencies and shall have an explosion-proof rating of not lower than Ex d II C T4.

b) When partial modifications are made to the appearance or mechanical structure of flame detectors involving their explosion-proof performance, the modified flame detectors must be sent to the original explosion-proof test agency for retesting or necessary filing.

c) The manufacturer shall ensure that the production of flame detectors is in accordance with this PAS and the drawings approved by the explosion-proof test agency.

5.2.3.3 Requirements on anti-interference performance

The anti-interference performance of flame detectors shall meet the following requirements.

a) Immunity to electrostatic discharge: It shall meet the electrostatic discharge immunity requirements of IEC 61326-1 on the contact discharge test at severity level III and the air discharge test at severity level III.

b) Immunity to radio frequency electromagnetic field radiation: It shall meet the requirements of IEC 61326-1 on the radio frequency electromagnetic field radiation immunity at severity level III within the frequency range of 80 MHz to 1 000 MHz.

c) Immunity to electrical fast transient pulses: It shall meet the requirements of IEC 61326-1 on the electrical fast transient pulses immunity of power supply of flame detector at severity level III.

d) Immunity to conducted disturbances induced by radio frequency fields: It shall meet the requirements of IEC 61326-1 on the immunity to the conducted disturbances induced by radio frequency fields at severity level III within the frequency range of 150 kHz to 80 MHz.

5.2.3.4 Requirements on mechanical characteristics

The mechanical characteristics of flame detectors shall meet the following requirements:

a) Sine curves of running vibration: frequency range: 5 Hz to 200 Hz; maximum acceleration: 20 m/s^2 (2G); maximum displacement: 0,15 mm.

b) After the vibration test is carried out in accordance with 8.1.4.9, the mechanical structure and components of the flame detectors shall not become loose, and the product performance and electrical characteristics of the flame detectors shall remain unchanged (according to energization test).

c) After the impact test is carried out in accordance with 8.1.4.10, the mechanical structure and components of the flame detectors shall not become damaged or loose, and the product performance and electrical characteristics of the flame detectors shall remain unchanged (according to energization test).

d) After the collision test is carried out in accordance with 8.1.4.11, the mechanical structure and components of the flame detectors shall not become damaged or loose, and the product performance and electrical characteristics of the flame detectors shall remain unchanged (according to energization test).

e) After the drop test is carried out in accordance with 8.1.4.12, the mechanical structure and components of the flame detectors shall not become damaged or loose, and the product performance and electrical characteristics of the flame detectors shall remain unchanged (according to energization test).

5.2.3.5 Continuous running time

In normal operating environment, the mean time between failures (MTBF) of flame detectors shall not be less than 70 000 h.

5.2.3.6 Flame detector cables

The categories of cables connected to flame detectors shall meet the following requirements:

a) The connecting cables from local flame detectors to the flame detector cabinet shall be the heat-resistant, flame-retardant, shielded cables. The cores of the cables shall be distinguished by colors to ensure the accuracy and reliability of signals and facilitate future maintenance or modifications.

b) The communication cables between the flame detector cabinet and the distributed control system (DCS) cabinet shall be the shielded twisted pair cables.

c) The shield of connecting cables shall be reliably grounded.

5.3 Technical requirements of cooling system (optional, depending upon the actual requirements of flame detectors)

5.3.1 Functional requirements of cooling air system

5.3.1.1 Basic requirements

The flame detectors work near the boiler, exposed to high temperature and heavy fly ash. The flame detectors shall be kept within their rated working temperature range to ensure reliable operation and prolong their service lives. The basic requirements on cooling air system are as follows.

a) The cooling air system of flame detectors is used to prevent the flame detectors from being damaged by over-temperature and to keep them clean.

b) The cooling air system shall consist of two mutually-standby fans, switching baffle (or check valve), inlet filter, fan control cabinet, pressure switch and other components.

c) The two cooling fans shall work in parallel in a redundant configuration (one working and one standby), and each cooling fan shall at least reach 130 % of the system capacity.

d) The fan control cabinet shall be provided with two independent AC power supplies.

5.3.1.2 Local control cabinet for cooling fans

The local control cabinet for flame detector cooling fans shall be provided with a remote/local selector switch, a local start/stop control button switch, and the fan running status indicators.

5.3.1.3 Instruments configuration requirements

The local instruments required for the monitoring and interlock protection of the cooling air system may be configured as listed in Table 1.

Table 1 – Configuration of monitoring and interlocking instruments of flame detector cooling air system

Name	Purpose	Qty.
Pressure switch or pressure transmitter	Two-out-of-three boiler shutdown logic according to the low-low pressure of cooling air header hose	3
Pressure switch or pressure transmitter	Alarm of low pressure	1
Pressure switch or pressure transmitter	Fan interlocking	1
Pressure transmitter	Remote indication of cooling air header hose pressure	1
Pressure indicator	Indication of cooling air header hose pressure	1
Differential pressure transmitter (optical, depending upon actual requirements)	Alarm of high differential pressure at fan inlet filter	1 or 2

5.3.1.4 Air source switching baffle

The outlet baffles of the two flame detector cooling fans (or other cooling air sources) shall be able to switch automatically without affecting the normal operation of the flame detector cooling fans.

5.3.1.5 Supply air to other equipment

The flame detector cooling fans should not supply air to the equipment other than flame detectors. If they have to do so, a sufficient air supply margin shall be reserved, so that the normal operation of flame detectors cannot be affected.

5.3.2 Performance requirements of cooling air system

5.3.2.1 Air source requirements of cooling air system

Both insufficient cooling air pressure and unclean cooling air may result in slagging and even damage of the flame detector probe. Therefore, unless otherwise specified by the flame detector manufacturer, the air source of purge system shall meet the following requirements.

a) Purge air source: Use clean, dry and cool air. The inlet air temperature of the fans shall be < 45 °C.

b) The minimum purge air flow and pressure shall be determined according to the number of flame detectors and the diameters of the inner and outer air hoses of flame detectors. The minimum purge air flow of each flame detector probe shall be as follows.

   1) Externally sighting flame detector: not less than 113 L/min; not less than 400 L/min in case of severe environmental contamination.

   2) Internally sighting flame detector: not less than 400 L/min.

   3) Imaging-based flame detector: not less than 2 500 L/min for single-protection type; not less than 4 300 L/min for double-protection type.

c) Minimum purge pressure.

   1) Externally sighting flame detector: The air pressure measured at the inlet of Y-shaped connecting duct shall be more than 20 mm H_2O (1" water column) above the bellows pressure.

   2) Internally sighting flame detector: The air pressure measured at the inlet of Y-shaped connecting duct shall be more than 400 mm H_2O (12" water column) above the bellows pressure.

5.3.2.2 Characteristic curves of cooling air fans and motors

The cooling air fans shall keep their pressure head basically unchanged within a certain air flow range, and their motors shall meet the following requirements.

a) Insulation rating: F.

b) Temperature rise rating: B.

c) Protection rating: IP55.

d) Use the local utility power (380 V AC ± 10 %, 50 Hz ± 1 Hz in China for example), 3-phase 3-wire system or 3-phase 4-wire system.

e) The motors shall be energy-saving, small/medium-sized, three-phase asynchronous motors and shall at least meet the IE2 energy efficiency requirements in IEC 60034-30-1.

f) Fan noise level: the noise at 1 m from fan shell shall be lower than 85 dB.

g) Efficiency of high-pressure centrifugal ventilating fans: ≥ 70 %.

6 Installation and commissioning requirements

6.1 System installation requirements

6.1.1 Installation preparations

6.1.1.1 Technical preparations

The inspection, confirmation and other technical preparations before installation shall be performed in accordance with the following requirements.

a) Obtain the construction drawings from design institute and the system manual and installation diagrams from the manufacturer and conduct joint review of the drawings. Prepare the relevant technical documents such as work instructions or construction plan, commencement report, safety and technical disclosure, welding process disclosure, hazards lists, and work risk control plan, and review and approve them in accordance with the required approval procedures.

b) Give technical disclosure to the relevant management and construction personnel. Check the models, sizes and lengths of the components and ensure that they fully meet the design requirements and actual needs.

c) Check the interface between the flame detector system and the external systems and equipment according to the manufacturer's drawings and other materials. The introduction of power supply and instrument air shall meet the requirements of the equipment manufacturer. The connection of signal cables and control cables shall meet the design requirements. Be familiar with the technical materials form the manufacturer and understand the precautions in the installation of the system.

6.1.1.2 Confirmation of construction conditions

Prior to installation, check and confirm that the following construction conditions are met.

a) The required construction personnel arrive at the installation site, are aware of the technical, safety and quality requirements of their tasks, and are familiar with the precautions and key points in the installation of flame detectors. Special operation workers such as welders shall be certified to work.

b) The installation of the boiler's water walls, stairs, aisles, platforms, and railings have been completed. The positions of the holes reserved for installing flame detectors meet the design requirements, while all influence factors have been considered in the design of such positions, including the positions of flame detectors observing the target flames, boiler's thermal expansion, and the impacts of aisles or other equipment on the convenience of dismantlement, installation and maintenance of flame detectors. If the reserved holes have to be opened on site, site guidance from the manufacturer's personnel is necessary. The boiler has already met the conditions for installing the flame detector system.

c) Check that the models, sizes, and quantities of the equipment and accessories required for installing the flame detectors are consistent with the design, and their appearance is undamaged, complete and intact. They have been properly stored after requisition.

d) All installation materials, such as tee joints, mounting flanges, guide conducts, stainless steel hoses (cooling air lines), angle guide plates, and fixing brackets are prepared in place. The tools and apparatuses required for construction have been properly prepared: electric welding machines and other equipment have been arranged in place, the power supply required for installation has been connected properly, and the site has met the conditions for use. The temporary lighting required on site has been installed and meets the site construction requirements.

e) Scaffolding of suitable height has been erected at the installation place in the appropriate orientation. The width and height of the scaffolding shall meet the construction requirements. The scaffolding shall be provided with ladders for the construction staff to go up and down. The scaffolding can be used only after passing the acceptance inspection.

6.1.1.3 Installation precautions

In order to protect personal safety during installation and ensure that the installation position meets the operation and maintenance requirements, the following precautions shall be taken during installation.

a) Before entering the boiler for installation, the corresponding work permits shall be obtained in accordance with the relevant procedures. The entire installation process shall be kept under firm tutelage of the designated personnel. The width and height of the scaffolding in the boiler shall meet the construction requirements. The site lighting shall meet the construction requirements (for example, in the burners, the voltage rating of mobile lamps shall be lower than 36 V, and the welding belts pulled into containers shall be well insulated to prevent electric shock). During operations, safety belts shall be fastened properly in accordance with the relevant work procedures, and the hand-held tools shall be equipped with safety ropes.

b) Before the scaffolding in the furnace is removed, the welding and installation of the flame detector brackets in the burners and in the furnace shall be completed. The installation positions of flame detectors shall be determined taking into account the influence of furnace thermal expansion and the space required for protruding the flame detector probe.

c) The lengths of prefabricated cables shall be determined according to the length of the flame detector probe. If the manufacturer provides the prefabricated cables of reasonable lengths, ensure that there are no intermediate joints in the prefabricated cable between each flame detector probe and its junction box. Before laying the prefabricated cables, temporary protection measures shall be taken on their joints. During connection, care shall be taken to ensure that the joints are correctly connected.

6.1.2 Installation of flame detectors

6.1.2.1 Installation of internally sighting flame detectors

The installation process consists of the determination of installation position, brackets welding, and the installation of flame detector. The installation shall be performed according to the following steps and requirements.

a) Determination of installation position

   1) According to the drawings and the flame detector installation openings reserved in the burners, check that the installation openings are through holes with the dimensions not less than those indicated in design drawings and the positions meeting the design requirements.

   2) Determine the installation point of the bracket in combination with the installation method of flame detector.

   3) In case where the installation opening for flame detector needs to be expanded for the purpose of modifying the plasma ignition device, the opening expansion work shall be carried out under the guidance of the manufacturer's personnel.

b) Welding of flame detector front bracket

   1) Seal-weld the front bracket of flame detector onto the burner in line with the drawings or the manufacturer's requirements. The front bracket of flame detector is generally welded on the manufacturer-supplied angle guide plate.

   2) Weld the angle guide plate on the inner side of the burner near the furnace. Perform spot welding after the mounting angle of the bracket is adjusted via the angle guide plate. After the trial installation of flame detector succeeds and it is confirmed that the installation angle meets the manufacturer's requirements, weld the front bracket.

   3) Make sure the welding is firm.

c) Installation of flange type flame detector mounting bracket

   1) Weld the fixing flange of flame detector on the outer side of the reserved opening in the burner in line with design drawings. The bracket shall be perpendicular to the lateral side of the burner without inclining and shall be installed firmly.

2) The fixing flange of flame detector is generally welded with a short tube to facilitate connection. The length of such short tube shall be determined according to the site conditions or the installation instructions. The welding materials shall be reasonably determined according to the welding base material. During installation, pay attention to the orientation of the flange fastening screws.

3) In the installation of bracket, perform electric spot welding first, and, after the trial installation of flame detector succeeds, perform formal welding.

4) The very front end of flame detector is generally made of porcelain or glass. When installing, the flame detector shall be carefully introduced from the fixing flange to the front bracket and fix it as required.

d) Installation of flame detector flange sleeve and internally sighting flame detector

1) Weld the fixing flange of flame detector on the outer side of the reserved hole in the burner in line with the drawings. The bracket shall be perpendicular to the lateral side of the burner without inclining. Perform spot welding, and then carry out trial installation of the flame detector. After confirming that the installation position is appropriate, seal-weld the periphery of the flange sleeve.

2) After welding, remove the welding slags and promptly apply anti-rust paint. If the flame detector cannot be installed temporarily, wrap the flange with plastic cloth or color strip to prevent rain and debris from entering. After the trial installation, promptly return the flame detector components to the warehouse for proper storage.

3) After the bracket is welded, the mechanical work around the installation point is basically completed, and the site installation conditions of flame detector are met, the internally sighting flame detector can be installed.

4) Since the internally sighting flame detectors are precision instruments, they shall be carefully transferred to the site. The very front end of the flame detector is generally made of porcelain or glass, so the flame detector shall be carefully and slowly inserted into the sleeve. Then lead the detector to the front bracket and fix and tighten it according to the manufacturer's requirements. Avoid sudden or violent vibration of flame detector and excessive distortion of the optical fiber part of flame detector.

6.1.2.2 Installation of externally sighting flame detector

Depending on whether an opening needs to be made in the burner panel on site or the type of the opening that has been made in the burner panel, the installation requirements of the externally sighting flame detectors are different.

a) Where an opening needs to be made in the burner panel on site, the opening shall be made in accordance with the drawings and the opening diameter shall be consistent with the design. The universal joint shall be directly fixed on the burner panel or the embedded tube. Adjust the angle of the universal joint so that the flame detector probe points to the flame, and then fasten the universal joint.

b) Where a round opening has been made in the burner panel, with the opening diameter matching the universal joint, the universal joint can be directly welded. If the opening diameter is less than the requirement of universal joint, enlarge the opening. If the opening diameter is larger than the requirement of the universal joint, fabricate a flange with an appropriate size for the transitional welding between the universal joint and the opening. After the flange is welded firmly, adjust the angle of the universal joint and fasten it.

c) In case where a tube is embedded in the burner panel and the embedded tube is neither threaded nor flanged, if the size of the embedded tube matches the universal joint, the embedded tube may be directly welded to the universal joint. If the embedded tube does not match the universal joint, fabricate a flange with an appropriate size for the transitional welding between the universal joint and the embedded tube. After the flange is welded firmly, adjust the angle of the universal joint and fasten it.

d) If a tube is embedded in the burner panel and the embedded tube is threaded, fabricate the accessories for connecting the universal joint and the embedded tube according to the size of the existing thread. When carrying out the installation on site, properly screw in the universal joint, adjust its angle and then fasten it.

e) If a tube is embedded in the burner panel and the embedded tube is flanged, fabricate a mounting flange according to size of the existing flange to allow connection of the universal joint and the embedded tube. When carrying out the installation on site, properly connect the universal joint by the flange, adjust its angle and then fasten it.

The installation of the cooling air hoses, prefabricated cables, and local junction boxes for externally sighting flame detectors is the same as that for internally sighting flame detectors.

6.1.2.3 Installation of imaging-based flame detector probe

The determination of installation position of the probe, the opening, the welding of the bracket, the installation of flame detector and the connection of the cooling air hoses shall be performed in accordance with the following steps and requirements.

a) Determine the installation position according to the structure and dimensions of the burners and air ducts in boiler. For the direct-flow burner, the probe should be installed in the square hole of the secondary air duct above the burner nozzle, and for the cyclone burner, the probe should be installed in an opening made at the appropriate position in the secondary air nozzle. The installation position shall allow sight of the unburned zone, burning zone and burnout zone of the flame. The flame detector probe should be retracted backward as far as possible on the condition that the field of view of the probe is not obscured.

b) Make an opening at an appropriate position near the burner of the boiler. The opening shall keep away from baffles and tension rods. Check whether the inner sleeve of the flame detector probe can be pulled out smoothly. In the area directly behind the flame detector probe, there shall be no obstacles blocking the protruding of flame detector probe before and after boiler expansion. Within about 400 mm below the protruded flame detector probe, there is no obstacle that does not expand with the boiler, avoiding damages due to collision with cables and obstacles.

c) Firmly weld the eccentric bracket of flame detector probe to the secondary air duct at the predetermined installation position by using double-sided stainless steel. If the intermediate space among secondary air ducts is insufficient, the probe may be installed without eccentric bracket and the front protection tube of the probe may be directly welded to the secondary air duct.

d) The outlet of the cooling air hose of the flame detector should point downward or upward. The metallic cooling air hose shall reserve a certain margin in length to ensure that the cooling air hose stretches freely and smoothly and provides unobstructed cooling air in both the cold status and thermal expansion status of the boiler.

e) For swing-type burners, when installing the flexible-sleeve flame detector probe, the nozzle shall be adjusted to the horizontal position before installation.

6.1.2.4 Installation of ancillary equipment

The ancillary equipment includes the cooling air hose, the flame detector control cabinet and the local control box, which shall be installed in accordance with the following requirements.

a) Connect the cooling air hose of the flame detector according to requirements. The flame detectors shall use stainless steel cooling air hoses to eliminate the thermal expansion of boiler.

b) The flame detector cabinet is generally arranged in the electronics room, and it shall be installed together with other panels and cabinets in the electronics room that have already been delivered. The cabinet shall be grounded according to the design requirements. The installation position of the local junction box shall be determined according to the length of the pre-fabricated cables of flame detector. Generally, it is installed at the middle point in the same row of flame detectors, far away from heat sources.

c) Inspect the power system configuration and ensure that it meets the requirements of 4.2.

6.1.2.5 Installation of cables

The connection, laying and wiring of prefabricated cables shall meet the following requirements.

a) The lengths of prefabricated cables shall be determined according to the distance of flame detector. In case the manufacturer provides the prefabricated cables, there shall be no intermediate joints in the prefabricated cable from each flame detector to the junction box. The cables entering the junction box shall be introduced from the bottom, and measures shall be taken to prevent moisture and dust. The connection between the prefabricated cables and the flame detector shall be made taking into account the thermal expansion of the boiler and shall be kept as far away from heat sources as is practical.

b) The cables shall be laid in accordance with the design drawings and the requirements of the applicable cable laying codes. Since the flame detection signal is one of the important signals in the furnace safeguard supervisory system (FSSS), the cables from the flame detector junction box to the control cabinet shall be high-temperature shielded cables. The cables connected with DCS system may use ordinary computer cables or shielded control cables. For the safety precautions in cable laying, please refer to the applicable cable laying codes.

c) The cable terminals shall be connected properly and firmly and marked by correct and clear number labels. Connect the shielded cables according to the design. The shielded cables shall be reliably connected in the intermediate junction boxes. The circuit numbers of cable terminals in the flame detector shall correspond to those in cabinets.

6.1.2.6 Protection of the installed flame detectors

In view of the harsh environment and complicated cross-construction works on site, appropriate protective measures shall be taken to prevent damage to the installed flame detectors.

a) If possible, the flame detectors should be installed after the application of boiler thermal insulation is completed.

b) After installation, protective measures shall be taken and warning signs shall be provided to prevent collision, stamping and damage to the connected cables.

6.1.3 Acceptance of installation

Table 2 provides the quality criteria for installation acceptance of flame detector system.

Table 2 – Installation acceptance criteria of flame detector system

Process	Inspection item	Nature	Unit	Quality criteria	Method and tools
Inspection on flame detector probe	Model and size			In line with design	Check
	Appearance			Undamaged	Observe
	Accessories			Complete and intact	
	Insulating resistance		MΩ	≥ 1	500 V insulating resistance meter
Installation of flame detector probe	Position			In line with design	Check
	Ambient temperature		°C	≤ 60	Thermometer
	Installation of bracket			Firm	Attempt to move it and observe
	Fixing angle	Key item		In line with the manufacturer's requirements	Attempt to move it and observe
	Serial numbers of probes	Key item		In line with those in cabinets	Observe

Process	Inspection item		Nature	Unit	Quality criteria	Method and tools
Flame detector system	Connection of signal cables of flame detector probe				Firm, without loose connections; no impact on the access to the monitoring and control equipment during maintenance.	Attempt to move it and observe
	Cooling air system				Intact air hoses without folding and bending, reliably connected with flame detector probes, with firm hose clamps.	Attempt to move it and observe
	Junction box of flame detector probe				Complete and fastened screws, with reliable rain-proof measures.	Attempt to move it and observe
	Protective measures				Complete, intact	Check
	Wiring	Connection of cable terminals			Correct, firm	Check using the cable check tools
		Cable number labels			Correct, legible, indelible	Observe
	Signs				In line with the design, firmly attached, with indelible characters	Check

6.2 Commissioning requirements after installation

6.2.1 Static commissioning

6.2.1.1 Technical preparations for static commissioning

The technical preparations for the static commissioning of flame detector after installation shall at least meet the following requirements:

a) Check and confirm that the flame detector probe has been installed properly, and the circuit connections are correct, tight, and in good contact.

b) Check the grounding of shielded cables, confirm its connection and grounding methods, and measure its grounding resistance, which shall meet the relevant technical requirements.

c) Confirm that the arrangement sequence and identification of flame detector processing units meet the requirements of the manufacturer.

d) Check that the initial parameters of all flame detector processing units and communication modules have been set and meet the relevant requirements.

e) Check that the status of flame output contact meets the actual requirements for the operation of the unit.

f) Check that the power supply redundancy meets the design requirements.

6.2.1.2 Contents and methods of static commissioning

Energize the system and perform the fundamental static commissioning. The inspection and test items and methods include the following.

a) Check that the system has no faults indicated (if there are faults indicated, first eliminate them).

b) Conduct tests and check that the redundant power supply system and the communication system work reliably. Measure the voltage of the two power supplies, which shall be within the allowable deviation range.

c) Check that the default settings of all flame detector processing units at the workstation are consistent, and that the default settings of all flame detectors preset at the workstation are consistent with those of the flame detector processing units. Inspect the real-time parameters of all flame detector processing units in the flame-off furnace status, and confirm that they are within the allowable range.

d) Test the fault signal, power failure signal, and flame-on signal of flame detectors and confirm that the responses are correct.

e) Check that the working noises of the fans (if any) and components in cabinets are normal.

f) Conduct tests and check that the indication of flame analog signals corresponds to the site conditions and that the indication of measuring range is correct.

g) Input circuit correctness test: Disconnect and then reconnect the flame detector cable plugs, and check that the corresponding channels of the system display correctly. The plugs shall be tested one by one. If incorrect wiring is found, correct it in a timely manner.

h) Simulate the “flame-on signal”, “fault signal” and “analog output signal”, check the status display of flame detectors. The signals received by DCS or independent workstation should be correct, the flame-off delay should be set correctly, and the output current measured at analog output terminal should be within ±5 % of the measuring range.

i) Power module failure alarm test: Switch on and off each power module, and check that the flame detector power failure alarms at the DCS are correct.

j) Power redundancy switching test: Switch on and off power modules A and B respectively. Observe and confirm that the flame detector processing unit is free of abnormal phenomena and the power interruption alarm is triggered properly.

k) Digital output test: Energize the flame detector, and enable the flame detector to output the flame-on/off and fault/free-of-fault signals by conducting forced functions or simulation experiment. Check that the signals received by DCS or the independent workstations are correct. Otherwise, reconfigure the signal output status according to the procedures specified by the manufacturer, and repeat the above tests.

l) Power-off status test: Disconnect the power switches of all power modules, check the DCS side or measure with a multimeter to confirm that the signal output status of flame detector is consistent with the requirements of DCS. If they are not consistent, reconfigure the signal output status according to the procedures specified by the manufacturer, and reinspect the consistency between the signal output status of flame detector and the requirements of DCS.

6.2.1.3 Pre-adjustment test

Complete the pre-adjustment test on flame detectors before ignition, and conduct the flame illumination simulation test at the flame detector probes (together with the flame-off delay test).

a) Provide good coordination and safety supervision. One person enters the furnace via access door wearing safety protection equipment, carrying a flashlight or lamp and cleaning cloth. One person stays outside the access door carrying an intercom, responsible for communication and response. And another person stays on the side of the flame detector cabinet carrying an intercom, responsible for observing, responding to, and recording the flame signals detected by the corresponding flame detectors.

b) Carry out the flame illumination simulation test using a flashlight or lamp and cleaning cloth at each flame detector one by one in sequence in the furnace. Wipe the lenses clean with a cleaning cloth before illumination.

c) Enable the DCS's memory function for flame intensity and flame-on signal, and check both the real-time trend graph and historical trend graph of the two parameters.

d) At the start and the end of the flame illumination simulation test, use the intercom to inform the monitoring personnel at the flame detector processing unit or the DCS to record the time when the flame signal is detected and the time when the flame signal disappears.

e) Check the flame signal display through the DCS's historical trend graph, and calculate the time delay for the flame signal to disappear.

6.2.2 Dynamic commissioning

6.2.2.1 Work preparations and technical requirements for dynamic commissioning

The technical preparations for the dynamic commissioning of flame detectors after installation shall at least meet the following requirements.

a) Identify the combustion characteristics of each burner, and give the parameters (including intensity, frequency threshold, etc.) for determining the presence of flame in the furnace. For imaging-based flame detectors, confirm the burning position of the target flame, and correctly set the position of each judgment zone and the flame-on/off threshold or jitter threshold corresponding to the relevant zones.

b) Adjust the internal parameters of each flame detector to reach the best detection effect and the optimal balance between the detectability and reliability of the individual flames, so that the flame detectors would act correctly in case of flame failure of the whole furnace during the operation of the boiler and no malfunctions would occur under normal operating conditions.

c) The type and display of the flame signals output to DCS should be correct.

6.2.2.2 Basic principles of dynamic commissioning

The "peeping" or "overlooking" phenomena may occur during boiler operation. In addition to hardware capabilities, they are usually associated with the dynamic commissioning methods.

a) The flame detectors commissioned under a low operation load of the boiler may be excessively sensitive. When a burner shuts down under a high load, the peeping phenomenon may easily occur, affecting the normal running of control logic.

b) The flame detectors that have been commissioned under a high operation load of the boiler may be sluggish. During cold status ignition or low load operation period, even when the burner has been ignited, the flame detector may still have no output at all, i.e. the overlooking phenomenon, which is likely to cause the misoperation of flame protection.

c) According to a) and b) above, the high and low loads during commissioning should be determined at about 70 % and 20 % of the full load, respectively, and repeated pre-adjustments are required to reach the optimal status.

If repeated adjustments do not work, the commissioning personnel may make adjustments according to the following principles:

a) For oil flame detectors, prefer overlooking over peeping, that is, reduce the sensitivity and improve the stability of oil flame detectors appropriately, so as to prevent the unfired oil from being injected into the furnace.

b) For coal flame detectors, prefer peeping over overlooking, that is, increase the sensitivity of coal flame detector appropriately.

6.2.3 Contents of system dynamic commissioning

6.2.3.1 Confirmation of cooling air system

After the cooling fans (if any) are put into operation, check and confirm that the cooling fan system meets the following requirements.

a) Check that there is no low pressure alarm from the cooling air system of flame detectors, there is no air leakage from the cooling air hoses, there is no air leakage from the connections between cooling air hoses and flame detector probes, and that the pressure indicated by the pressure gauge at the end of air hose is greater than the minimum cooling air pressure requirement of the flame detector probe.

b) When the outlet pressure of header hose is lower than the preset alarm threshold, an alarm should be given at the monitoring interface.

c) When the outlet pressure of header hose is lower than the preset interlock threshold, the standby cooling fans should be started by interlocking.

d) When the outlet pressure of header hose is lower than the preset protection threshold, the "two-out-of-three" logic computation will be performed via three "flame detector cooling air pressure low low" switches, and then the "flame detector loses cooling air" signal should be issued to trigger master fuel trip (MFT).

6.2.3.2 Adjustment after ignition

The adjustment to light signal-based flame detectors after ignition shall be made in accordance with the following requirements.

a) Set the parameters and record all internal parameters and thresholds according to the stability of real-time data and the site experience.

b) After the burners operate for a few minutes, observe and record the real-time data changes over a period of time, observe the fluctuation range of the data (verify whether the boiler has been actually put into operation by observation via the furnace poke hole or flame television), and make the record. Adjust the internal parameters according to the data fluctuation.

c) Conduct the ignition flame detection test on the burners:

   1) Switch off the target burner, and ignite the adjacent and diagonal (opposite) burners (the maximum background radiation light impact). The "flame-on" indicator of the flame detector processing unit should not light up.

   2) Ignite the target burner, and switch off the adjacent and diagonal (opposite) burners (the minimum impact of background radiation light). In this case, the flame-on indicator of the flame detector processing unit should light up; otherwise repeat step b).

d) Adjust other internal parameters in the startup of flame detector processing unit according to the above steps and methods.

e) After the main burner is started, adjust the settings of the flame detector processing unit for the main burner following steps b) and c).

f) Conduct flame detection test on the main burner: Switch off the adjacent and diagonal burners, start the target main burner (the minimum background radiation light impact), and the flame-on indicator of the flame detector processing unit should light up.

g) Describe the characteristics of the output flame analog signal according to the recorded real-time data and the real-time data change rules observed on site.

The adjustment to imaging-based flame detectors after ignition shall be made in accordance with the following requirements.

a) When starting a burner, check the burning status of the target flame from the corresponding real-time flame image. If the burner is started successfully, firstly set the positions of flame judgment zones. The black dragon zone, the burning zone, and the jitter zone shall be arranged in the correct positions of the target flame. Meanwhile, preliminarily set the judgment thresholds to avoid missending the flame-off signal. For cyclone burners or burners with inconspicuous black dragon zone, the black dragon zone may be arranged in the dark area on the edge of the image and its size may be reduced to prevent affecting the normal flame judgment.

b) After the burner runs stably, further adjust the positions and sizes of the flame judgment zones. After waiting for 10 minutes, use the history curve function of the flame detector software to view the range of change of each judgment parameter within the 10 minutes, and adjust each judgment threshold accordingly.

   1) The lower limit of brightness of burning zone shall be set at approximately 20 % below the lower limit of brightness fluctuation range of the burning zone.

   2) The upper limit of brightness of the black dragon zone shall be set approximately 20 % above the upper limit of brightness fluctuation range of the black dragon zone.

   3) The lower limit of the jitter amplitude shall be adjusted according to the lower limit of jitter amplitude range of the jitter zone.

c) When the target burner is switched off and the diagonal or adjacent burner is started, observe whether the flame detector has the "peeping" phenomenon. If there is the "peeping" phenomenon, it may be solved by adjusting the flame judgment zones and the judgment thresholds. However, the parameters adjustment shall not affect the judgment of the target flame. After adjustment, the accuracy of the target flame judgment shall be tested.

d) For flame detectors that have incorporated the “start-up mode” signal, the adjustment of judgment parameters shall be based on the normal burning phase. When the “start-up mode” signal is valid during the boiler startup phase, the flame detector will automatically modify the judgment parameters to ensure accurate and steady judgment of flame-on status.

e) Adjust the flame detector of each burner according to the startup sequence of the boiler using the above methods.

6.2.3.3 Commissioning for improving the detectability of individual flames

The commissioning for improving the detectability of individual flames may be conducted according to the following steps.

a) First identify the background flame: Make sure the target flame is off, and ignite all other burners and adjust them to the maximum burning intensity. Observe and record the maximum intensity and frequency of the target flame.

b) Identify the target flame: Adjust the target burner to a low flame intensity, and adjust other burners to reach the minimal background flame impact. Observe and record the minimum intensity and frequency of the target flame.

c) Optimize the internal parameters according to the recorded parameters, and verify the identification effect by conducting the ignition flame detection test on the burner.

d) If the identification effect is unsatisfactory, the sight line of the flame detector probe shall be adjusted appropriately.

6.2.3.4 Full-process optimization of parameters

Collect the real-time data under the critical operating conditions, low-load conditions and dangerous operating conditions during the period from the start-up to full-load operation of the boiler. Identify the combustion characteristics of each burner by data statistics, calculation and processing. Fine-tune the setting values for the burning intensity and frequency under the flame-on/off condition. Determine the optimal balance between the detectability and reliability of the individual flames. Adjust the internal parameters of each flame detector to the best detection effect, so that the flame detectors work normally during the operation of the boiler.

When the power is lost or the main control module fails (initialization or restart), the status of the contacts sent to the protection system shall meet the actual operation requirements.

6.2.4 Acceptance of system commissioning

6.2.4.1 Commissioning acceptance items

The commissioning acceptance items of flame detector system are as shown in Table 3.

Table 3 – Commissioning acceptance items of flame detector system

Process	Acceptance item		Nature	Unit	Quality criteria	Method and tools	Result
-	Cables	Nature	-	-	High-temperature shielded cable	Inspection	
		Grounding of shield	-	-	Single point grounding on the side of control system	Measurement	
		Insulation resistance	-	-	Greater than 2 MΩ	Measurement by megohmmeter	
-	Parameters setting	Frequency	-	-	Criteria specified by the manufacturer	Check	
		Intensity	-	-	Criteria specified by the manufacturer	Check	
Adjustment	Power supply redundancy switching test				No interference, no missending of signals	Perform power switching on site	
	Self-test function of flame indication signal circuit		-	-	Criteria specified by the manufacturer	Create faults intentionally	
	Flame detection sensitivity		Key item	-	Flame status Analog indicators indicate correctly	Use the method specified by the manufacturer, or conduct the lamp/flame light simulation test	

6.2.4.2 Acceptance tests

The acceptance test shall be performed as follows.

a) System self-test: Intentionally create a hardware failure, and check the self-test results and the displayed information, which should be consistent with the setting.

b) Burner flame detection: Stop and start the burners, and directly observe and record the displayed information.

c) Self-test of flame detector probe: During operation, short-circuit the wiring of any flame detector probe and then open it, and observe and record its self-test, alarm and display results.

7 Requirements on inspection, operation and maintenance

7.1 System inspection and maintenance requirements

7.1.1 Preparations

Preparations for system inspection and maintenance shall be made following the specified standard procedures and shall meet the following requirements.

a) Before removing and reinstalling the flame detector probe, confirm that the boiler has been out of operation. If the boiler is in operation, the maintenance personnel shall apply for the work permit following the relevant standard procedures before work.

b) Before work, force the target flame detector probe to generate a "flame-on" digital output to prevent tripping of the monitoring and control equipment and the boiler. In order to ensure the normal operation of the monitoring and control equipment and the boiler, only one forced output can be generated at a time (that is to say, only when one flame detector probe is removed and reinstalled and the forced signal has been released, can the next flame detector probe be treated).

c) Before removing and reinstalling the flame detector probe, the flame detector probe to be operated shall be powered off.

d) Before removing and reinstalling the flame detector probe, the maintenance personnel shall be familiar with the operation procedures.

e) When the maintenance personnel do operations in the furnace, there shall be guardians outside the furnace.

7.1.2 Power supply inspection

Use a 500 V megohmmeter to measure the ground insulation of power supply system. The insulation resistance shall be greater than 20 MΩ.

Check the rated current of power switches and fuses, as well as the blowing current of the fuses. They shall meet the requirements of the equipment and systems they serve, and their capacity and purposes shall be clearly indicated by labels.

Each flame detector shall have an independent fuse. The power supply to the fans of the flame detector cabinet shall be independent of that to flame detectors or there shall be reliable isolation measures between them.

7.1.3 Installation inspection of flame detectors

During the maintenance of the unit, the installation of flame detectors shall be inspected and shall meet the following requirements.

a) The lenses of the flame detector probes should be clean and free of breakage, and their external protective sleeves should be free of high temperature corrosion and damages.

b) Check that the flame detectors are secured and cannot be shaken and the detection angles of the flame detectors are fixed. After reinstallation, confirm that the joint between the flame detector and the sampling sleeve is reliably sealed.

c) For external-sighting flame detector probes, the universal joint in the mounting assembly should align with the furnace. (The universal joint may become loose due to collisions during inspection and maintenance, resulting in changes in the detection angle and misalignment with the furnace.)

d) The flame detector holes in the mounting assemblies of externally sighting flame detectors should be unobstructed, clean, and free of deposits and slags.

e) For the rigid external sleeves of optical fiber type flame detectors, pull out the optical fibers, and the sleeve should be unobstructed, clean, and free of deposits and slags.

f) For the flexible external sleeves of optical fiber type flame detectors, find a flexible corrugated pipe or a deslagging tool for other external sleeves that is longer than the optical fiber, extend it into the external sleeve of the optical fibers, and do deslagging operations. There should be no slags inside.

g) For the flexible external sleeves of optical fiber type flame detectors, their bending may be changed due to the vibration of the boiler or unintentional touch by the construction personnel during maintenance. Nevertheless, the external sleeve assembly should be kept in its natural status.

7.1.4 Dismantlement and inspection of optical fibers

When replacing the lens assembly and the optical fibers of the flame detector probe, the maintenance personnel shall wear fireproof glasses to prevent dust from entering eyes and prevent high temperature from injuring face. The following provisions apply.

a) When removing the optical fibers while the boiler is running, the purging/cooling air supply should be kept. For swing-type burners, the swing angle of the burner should be set to 0° (that is, in the horizontal position) before removing the optical fibers.

b) When removing the inner core of the flame detector probe assembly, do not look directly into the flame hole of the flame detector probe assembly, and be careful of the high temperature of optical fibers. The instrument and control (I&C) maintenance personnel shall wear protective gloves to prevent burns. The optical fibers should be pulled out slowly to facilitate the cooling of the fibers.

c) After pulling out the optical fibers, inspect the hot end surface of the fibers. If there is any contamination (deposit), wipe the hot end surface with absorbent cotton and absolute ethanol.

d) Measure the length of the optical fibers and check that the optical fibers have not excessively prolonged due to unsmooth operations and violent pulling in dismantlement. When the prolongation exceeds 30 mm, the optical fibers shall be replaced.

e) Make the hot end of the optical fibers point towards light sources such as a flashlight, observe the optical fibers at the cold end, and there should be no broken fibers. If large dark points are found at the cold end of the optical fibers (suggesting a large number of broken fibers), the fibers shall be replaced. The broken fibers shall be brought back to repair room and tested as follows by a professional engineer using a standard light source simulator:

   1) Assemble the tested optical fibers to the flame detector probe and energize them. Install the front end of the optical fibers on a standard light source simulator. Regulate the light source simulator to a fixed illumination intensity (brightness), and observe the flame detector probe or the illumination intensity indicated by the flame detector analysis and processing unit.

   2) If the illumination intensity of the tested optical fibers is less than 85 % of the preset value of the simulator, the optical fibers are unacceptable. For example: If the preset standard illumination intensity of the light source simulator is 60, the minimum allowable illumination intensity equals to 60 × 85 % = 51. If the illumination intensity of the optical fibers is lower than 51, the optical fibers are unacceptable. If the illumination intensity of the optical fibers is higher than 51, the optical fibers are acceptable.

   3) After confirming that the optical fibers are acceptable and can continue to be used, store them reliably for future use.

f) If the standard light source simulator is unavailable, remove the plate inside the detector probe, and shake a flashlight at the front of the sensor. There should be flame signals indicated at the corresponding channel in the flame detector processing unit.

7.1.5 Inspection and maintenance of analysis and processing unit

During each Class A overhaul, the analysis and processing unit shall be inspected and maintained as follows.

a) Power off and clean up the detection signal analysis and processing unit, and check that the wires are connected tightly and arranged neatly.

b) Clean up the cooling fans and check that they rotate properly with normal air flow.

c) Check that the measured voltage of the two independent power supplies of the analysis and processing unit is normal. Check that the output voltage value of the configured 220 V AC/24 V DC power redundancy module is within the allowable deviation range.

d) Check that the indicated thresholds, flame intensity and frequency of each processing unit as well as the preset time delay of flame protection signals are within the normal range and consistent with the actual conditions.

e) After the analysis and processing unit is energized, check that no fault code appears and the self-test function runs normally.

7.1.6 Inspection and maintenance of cables

During each Class A overhaul, the flame detector cables shall be inspected in accordance with the following.

a) Inspect the power cables. In case of duplicated power supplies, use a multimeter to perform measurement at the flame detector probe junction box or the analysis and processing unit. Both of the power supplies should be normal.

b) Inspect the signal cables, connect the standard light source simulator to the flame detector probe, and simulate the various light source signals. The DCS should receive the corresponding flame detection signals.

c) Along the route of signal transmission cables, there should be no hidden safety hazards, and the waterproof and dustproof measures should be effective. If there are transitional junction boxes or cabinets, the cable shields should be connected via the box or cabinet terminals. Inspect ground wires of each flame detector analysis and processing unit in the cabinets one by one, and make sure they are well grounded. In addition to the ground copper bars in the cabinets, make sure that the cabinet bodies are also reliably grounded.

d) When laying signal cables or laying other cables in cable tray, the cables may be damaged by friction with cable tray, making the cable shield contact with the cable tray. For this reason, the cable shield is grounded at the cable tray and loses its shielding effect. During inspection and maintenance, disconnect the grounding of cable shield, and the insulation resistance measured between the shield and the ground should be greater than the nominal value. Restore the grounding of cable shield, and the resistance between the shield and the ground measured at the cable end should be less than the nominal value.

e) Repair the junction boxes as necessary.

7.1.7 Inspection and maintenance of cooling air system

The inspection and maintenance of cooling fan system shall be conducted in accordance with the following.

a) Clean all pressure switches, pressure gauges, and pressure transmitters, and repair the waterproof, dustproof and other protection measures as necessary.

b) After the inspection and maintenance, the start and switch between the cooling fans, and the cooling fans should run normally. The vibration of the fans should meet the relevant requirements.

c) Inspect the instruments of the cooling air system. Start the fans, and the pressure indication should be normal. Observe at the DCS operator station, and the pressure switch signals before and after the startup of the fans should be transmitted to the DCS operator station. Check that the signals of pressure transmitters are transmitted to the DCS operator station, and that the signals of filter differential pressure switches are transmitted to the DCS operator station.

d) Inspect the cooling air control cabinet, switch to local operation mode, and test each function one by one. All functions and all indicators should be normal. Switch to remote control mode, test each function at the DCS operator station, and observe the feedback signals of the cooling air control cabinet at the DCS operator station. All the signals should be normal.

e) Check that the manual butterfly valve at the fan outlet can open and close normally.

f) Check that the manual ball valve at the cooling air hose for the flame detector probe can open and close normally. After the inspection, make sure that the manual ball valve is fully opened.

g) Check that all bolts and nuts have not loosened due to vibration. If the fans have belts, check that the tension of the belts has not changed due to vibration.

h) Inspect the lubrication of the bearings and add lubricating oil according to the user manual of the fans.

i) The fan filters shall be cleaned on a regular basis. The cleaning cycle depends on the cleanliness on site.

j) Before each ignition of the combustion chamber, check that the cooling fans of the flame detector operate normally, there is no leakage in the cooling air hose and all its components, the pressure at the end of the cooling air hose is greater than 5 kPa, and the cooling air hose is reliably connected with the probe.

7.2 System test requirements

7.2.1 Power system test

Measure the power supplies to the system equipment, logic controllers and I/O module. The measured values shall reach the nominal values.

Disconnect any of the power supplies, the corresponding audible and visual alarm signals should be displayed normally.

Power interruption test: Cut off the currently working power supply, and the flame detector analysis and processing unit should continue working normally without power interruption and the black screen phenomenon. Restore the original working power supply, cut off the current working power supply, and the flame detector protection system should work normally without disturbance.

Voltage drop test: Reduce the voltage of the working power supply to the lower limit of the allowable voltage, the working power supply should be automatically switched to the standby power supply, and the flame detector should work normally without disturbance.

7.2.2 Inspection on the analysis and processing unit

After the maintenance, carry out the following inspections on the performance of the analysis and processing unit and check the correctness of the parameter settings.

a) After the analysis and processing unit is energized, check that no fault code appears and the self-test function is normal.

b) In case of the analysis and processing unit that has been put into operation (connected with the signal of the flame detector probe), check that the output signals displayed by DCS are consistent with the actual conditions.

c) In case of the analysis and processing unit that has not been put into operation, use a multimeter to check that the output signals of the flame detector analysis and processing unit are normal.

7.2.3 Inspection and tests on flame detector probes

7.2.3.1 Illumination response performance test

As long as the actual condition permits, during each Class A overhaul, the illumination response performance test should be carried out on the flame detector probes in accordance with the illumination response range provided by the manufacturer.

a) Install the flame detector probe on a standard light source simulator, and adjust the light source under reference conditions so that the light source simulator gives out light of the standard level, with fixed flame brightness, fixed flicker frequency, and fixed AC amplitude. Check that the feedback parameters of the flame detector probe match with the standard light source simulator (refer to the user manual of the standard light source simulator for the specific operations), and the response errors comply with the user manual.

b) Change the output frequency of the light source within the specified range. The flame detector should respond accordingly. The error of flame pulsation response frequency should comply with the product specifications.

c) Set the flame frequency, illuminance and light source frequency to their setting values, connect the output contact of flame detector with the timing stoppage end of electric stopwatch, and conduct the flame-on response time test. When the flame detector is working, switch on the light source and turn on the electric stopwatch to start timekeeping until the output contact of flame detector acts. The flame response time observed at the end of the timekeeping should comply with the product specifications.

d) For the flame detector probes, when the simulated light source emits light in various states, use a multimeter to check that the output signals of the flame detector probe meet the nominal value requirements.

7.2.3.2 Visible light test with pulsation frequency

If the tests in 7.2.3.1 are carried out unconditionally, the flame detection performance of the whole furnace may also be tested using the visible light with pulsation frequency. Observe and record the capability of flame detector probe to discriminate flare light and constant light as well as its sensitivity to changes in light intensity. The test result should meet the relevant requirements.

7.2.3.3 Test on imaging-based fire detector probe

Align the imaging-based fire detector probe with a bright point and observe the video images collected by the fire detector probe. The video images should be clear, stable and smooth, without obvious disturbance, mismatch, deformation, color shift and other faults.

7.2.4 Basic functional tests

In addition to the tests mentioned in 7.2.3, the basic functional tests mentioned in 5.2.1 shall be carried out, and the test results shall meet the basic functional requirements in 5.2.1.

7.2.5 Parameter adjustment test

Whenever the flame detector probe is maintained, its installation position is changed, or its fixing sleeve is replaced, the flame detector shall be readjusted.

The analysis and processing unit should correctly reflect the flame-off furnace parameters when the intensity and frequency settings of each analysis and processing unit are changed, and their ranges should meet the actual operation requirements of combustion chamber.

7.2.6 Check of parameter settings

Check the internal parameter settings. If they are inconsistent with the historical records, analyze the reasons and make sure that they meet the actual requirements for normal operation and accurate flame detection.

7.2.7 Tests on cooling fans

7.2.7.1 Calibration of instruments

During unit overhauls, the instruments in the cooling air system shall be calibrated to ensure that the action errors of pressure switches in relation to their setting values and the indication accuracy of pressure instruments meet the specified requirements.

7.2.7.2 Functional test on cooling air system

Startup permit functional test on cooling fans.

a) When the manual control baffle at the inlet of cooling fan is opened, start the cooling fan.

b) Check that the cooling fans start normally, the status display is correct, and the fan vibration meets the specified requirements.

When any of the following conditions is met, the standby cooling fan should start automatically. Confirm that the standby cooling fan starts automatically, and the status and alarm display are correct.

a) One fan is running, the differential pressure between the outlet header hose and the furnace is low, and the time delay is greater than the set value.

b) The working fan has electrical failures or has been stopped.

c) The differential pressure between the cooling air header hose and the furnace is low and the air temperature in the secondary air windbox is higher than (or the header hose pressure is lower than) the set value.

When any of the following conditions is met, the cooling fan should be tripped. Check whether the cooling air fan trip status and the alarm display are correct.

a) The differential pressure between the cooling air header hose and the furnace is high and the air temperature in the secondary air windbox is lower than (or the header hose pressure is higher than) the set value.

b) Electrical fault signals are sent from the fans.

When the cooling fans are running, check that the pressure of the cooling air distributes evenly among the four corners of the furnace, and the pressure at the hose end is greater than 5 kPa.

7.3 System operation

7.3.1 Restart

Perform the following operations after confirming that the original working circuit has been restored, the cable inlets and outlets in the cabinet have been sealed, the number plates of cable connection circuits are clear, intact and correct, the wire connections are tight and elegant, and the power supply voltage is normal.

a) Switch on the devices and all the power switches, and the devices should work normally. Check that the self-test of each device in the system is free of faults, and the display is consistent with the actual status of the device and meets the unit startup requirements. For the imaging-based flame detector system, adjust the brightness regulating knob, contrast regulating knob and frame frequency trimming knob to reach suitable image brightness.

b) The flame detector cooling air system should work normally, with the pressure at the end of cooling air hose greater than 5 kPa. The differential pressure between the cooling air in each flame detector probe and the furnace as well as the cooling air flow passing through each flame detector probe shall meet the specified requirements (from the manufacturer).

7.3.2 Maintenance during operation

Reliable operation of the flame detector system necessitates performing the following maintenance during operation.

a) When observing the combustion condition in the furnace through the poke hole, keep a distance from the poke hole and avoid direct viewing.

b) During operation, use a handheld thermometer to check the ambient temperature of the flame detector probe, which should be lower than the range required by the manufacturer. Check that the indicators on each flame detector module panel in the flame detector cabinet indicate normally.

c) Check that the fans run normally and the cabinet temperature is lower than the allowable value.

d) Check that the flame intensity and frequency indicated by each channel are in the normal range and consistent with the actual conditions.

e) The flame detector cooling air system should meet the requirements of 7.3.1 b).

f) When it is found that depositing or slagging of the probe hinders the sighting or imaging of flame, clean the foreign objects in a timely manner, and inspect and adjust the cooling air system as appropriate so that the air pressure is sufficient to clean the lens.

g) If the image in the monitor is too bright or saturated, adjust the "Aperture" button in the camera controller or install an additional color filter on the lens to obtain a clear and stable image. Then adjust the system to reach the optimal image effect.

7.3.3 Inspections before boiler shutdown

Carry out the following inspections before the boiler is shut down. Make a record of any abnormal conditions, which would be handled after the boiler is shut down.

a) Carry out inspections and make the records in accordance with 7.3.2.

b) During the boiler shutdown, observe the signals of each device, which should be consistent with the actual operation of the device.

c) Inspect the communication of the flame detector running software, verify the parameters and back up the system data as appropriate. Repair or replace the flame detector probes that have failed the remote tests.

d) Intentionally create a hardware fault, and start the self-test procedure. The self-test results and displayed information should be consistent with the actual situation.

7.4 System maintenance requirements

7.4.1 Routine maintenance

Any hidden danger in the components of the flame detector system, if not detected and eliminated in a timely manner, is likely to result in local or global failure or fault of the flame detector system and affect the stable operation of the unit. Therefore, routine maintenance is the foundation for ensuring the stable and efficient operation of the flame detector system.

a) Check that the dynamic display of intensity and frequency at each processing module is consistent with the actual conditions. When any defects are found, such as dust depositing of the flame detector probe, burnout of optical fibers or system halt, they should be eliminated promptly.

b) Inspect the operation status display of the system devices and the communication with other systems. In case of any abnormality, promptly identify the reason and eliminate it.

c) When any device trips, record or print the occurrence time of the fault, the first fault signal and the relevant parameters.

d) In each shift, check that the cooling air system of flame detectors has no leakage, and the pressure at the end of cooling air hose meets the specified requirements.

e) Check that the signals and protection actions of flame detectors can be reliably put into operation to prevent the forced signals of flame detectors affecting the operation of the main equipment.

f) The cooling air system of the flame detectors should work normally to ensure that there is no leakage in the components of the cooling air hoses. The pressure at the end of cooling air hose should be greater than 5 kPa.

g) Check that the fans in the flame detector cabinet run properly without abnormal noise, and the status indication of the analysis and processing unit, the power module, and the communication module is normal.

7.4.2 Regular maintenance

Regular maintenance is a supplement to routine maintenance. In addition to eliminating the defects that are inconvenient to treat in routine maintenance, in the regular maintenance, preventive maintenance should be carried out based on status assessment. According to the maintenance category and the routine maintenance outcome, the regular maintenance shall include the following tasks.

a) Make periodic switchovers between the power supplies of the flame detector to confirm that the analysis and processing unit and the probe amplifier work normally.

b) Clean the filter screens of the flame detector cooling fans, and clean the cooling air fan control cabinet, the components in the cabinet and the filtering devices.

c) The maintenance personnel shall periodically check and clean the hot end surface of the optical fibers. The inspection cycle depends on the cleanliness of the site. Periodically calibrate the pressure gauge and the pressure switch, fasten the wire connections in the cabinet, and repair the cabinet locks, the identification labels of various components, and the rainproof and dustproof measures as necessary. Periodically perform maintenance, startup and switching tests on the cooling fans to keep them in good working condition.

d) Periodically clean the flame detector probes, inspect the lenses, optical fibers, sensitive elements, probe amplifiers, sockets, etc., and replace the aging and burned parts. Prevent the components of the flame detector probe from aging, contamination and burnout due to high temperature.

e) Periodically carry out self-test test on the flame detector probe (e.g. short-circuit and disconnect the wiring of any flame detector probe during operation), and the system fault alarms should be displayed correctly.

f) When the flame detector installation position is changed, the fixing sleeve is replaced, or the probe is reinstalled, it shall be confirmed that the requirements of 7.1.2 are met, the seal with the sampling sleeve is intact, and the connection with the cooling air hose is reliable. After readjustment, the flame detector shall meet the requirements in 7.1.3, 7.2.3 and 7.2.5.

g) Replace the damaged cables, fasten the wire connections (the connections should not loosen when they are gently pulled), and repair the waterproof and dustproof measures of the junction boxes.

h) Periodically carry out static and dynamic tests on the performance and functions of flame detectors.

i) Periodically run the cooling fans in parallel to reduce the contamination or slagging of the lenses of the flame detector probes.

j) Periodically check that the displayed flame intensity and frequency of each channel are within the normal range and consistent with the actual conditions.

k) Periodically check that the historical trend records of the flame analog and digital signals are displayed correctly.

7.5 Archives

Establish complete, effective technical data archives of the routine and regular maintenance, faults handling and parameters setting of the flame detector system, including the following.

a) The installation, maintenance, calibration and periodic test records of the flame detector system shall be complete and standardized, and the data in them shall be correct. At least two maintenance or calibration cycles can be traced.

b) The setting records of the flame intensity and frequency, the flame signal action thresholds and the relevant internal parameters shall be correct and complete.

c) When flame detector signals lead to tripping of the operating equipment, the occurrence time of the fault, the first fault signal and the relevant parameters shall be recorded or stored in a timely manner to provide basic data for subsequent optimization of the flame detectors and logic performance.

d) The relevant system drawings, the user manuals of the equipment and special instruments, and the software backup.

8 Test methods and requirements

8.1 Test methods

8.1.1 General

In the delivery acceptance and replacement of components in the flame detector system, the user should understand the relevant test items and verify the compliance of the tests conducted on the products. Clause 8 lists the test items, methods and technical requirements relating to product performance.

8.1.2 Test reference conditions

The working environment of the test reference spare parts shall meet the following requirements:

a) ambient temperature: 15 °C to 35 °C;

b) relative humidity: 45 % to 75 %;

c) atmospheric pressure: 86 kPa to 106 kPa.

8.1.3 Test instruments and equipment

The test instruments and equipment shall meet the requirements in Table 4.

Table 4 – Test instruments and equipment

S/N	Item	Requirements	Qty.
1	DC stabilized power supply	(0 to 2) A/(0 to 30) V	1
2	Light source	The type of light source is determined according to the type of the sensors. The light intensity is determined according to the characteristics of the sensors and the sensing distance.	1
3	Air pressure test chamber	According to the requirements of Annex B.	1
4	Climatic environment test chamber	Comply with the requirements of IEC 60068-2-78.	1
5	Vibration tester	Comply with the requirements of IEC 60068-2-6.	1
6	Impact tester	Comply with the requirements of IEC 60068-2-27.	1
7	Rain drop tester	Comply with the requirements of IEC 60529.	1
8	Dust test chamber	Comply with the requirements of IEC 60529.	1
9	Insulation resistance tester	The DC voltage of the megohmmeter (or insulation resistance meter) measuring insulation resistance shall comply with the requirement of Table 5, and its accuracy level shall not be lower than 10.	1
10	Withstand voltage tester	Comply with the requirements of IEC 61010-1.	1
11	Electrostatic discharge generator	Comply with the requirements of IEC 61326-1.	1
12	RF signal generator	Comply with the requirements of IEC 61326-1.	1
13	Rapid transient pulse train generator	Comply with the requirements of IEC 61326-1.	1
14	Disturbance generator	Comply with the requirements of IEC 61326-1.	1