Mitsubishi Infrared Type
Flame Detector IR-S
Operation Manual
Notes

1 Please be aware that due to product improvements and modifications, the product description in this manual may differ in certain respects from the actual product.

2 This manual may not be distributed or reproduced in whole or in part without permission.

3 The contents covered in this manual are subject to change without prior notice.

4 Please be aware that no liability whatsoever will be accepted for consequences arising from the use of this manual.

5 Although every effort has been made to ensure the clarity, correctness and accuracy of the contents, in case you require clarification on any point, or notice any error or discrepancy, please do not hesitate to contact us.
# Contents

1. PREFACE ...................................................................................................................... 1
2. OVERVIEW .................................................................................................................... 2
   2.1 Principle of Detection .............................................................................................. 2
   2.2 Features .................................................................................................................. 2
   2.3 Combination with Automatic Burner Control Unit ................................................. 3
   2.4 Configuration of Infrared Type Flame Detector IR-S ................................................. 3
3. DETECTION ASSEMBLY ............................................................................................... 4
   3.1 Structure of Detection Assembly ............................................................................. 4
   3.2 Specifications of Cooling Air ................................................................................... 6
      3.2.1 Specifications of Cooling Air ............................................................................ 6
      3.2.2 Cooling Air Precautions ................................................................................. 6
   3.3 Installing the Detector Assembly ............................................................................. 7
4. DETECTOR PANEL ......................................................................................................... 8
   4.1 Detector Panel Configuration ................................................................................... 8
   4.2 Wiring between Detector Assembly and Detector Panel ....................................... 8
5. DETECTOR UNIT ............................................................................................................ 9
   5.1 Description of Panel Control (With no luminance gain, mounted module: MFD-CH01) 10
   5.2 Description of Panel Control (With luminance gain, mounted module: MFD-CH02) ... 13
   5.3 Meter Module (Option: Meter module is supplied) ................................................. 16
   5.4 Simulation Switch Unit (Option: Simulation switch unit is supplied) ...................... 17
6. POWER UNIT ................................................................................................................ 18
   6.1 Description of the Panel's Front ............................................................................. 18
7. TERMINAL UNIT ........................................................................................................... 19
8. DETECTOR MODULE'S CIRCUITRY ............................................................................ 20
   8.1 Arithmetic Circuit for the Frequency Component .................................................... 20
   8.2 Arithmetic Circuit for the Luminance Component (Without luminance gain: MFD-CH01 is the module mounted) .......................................................... 22
   8.3 Arithmetic Circuit for the Luminance Component (With luminance gain: MFD-CH02 is the module mounted) ............................................................... 24
   8.4 Checking Circuit ..................................................................................................... 28
      8.4.1 Sensor Check .................................................................................................. 28
      8.4.2 Detector Module Check ............................................................................... 30
   8.5 Power Monitoring ................................................................................................... 32
9. FLAME DETECTOR MAIN POWER SUPPLY CIRCUIT ............................................... 35
10. FLAME DETECTOR POWER SUPPLY MONITOR CIRCUIT .................................... 36
11. EXTERNAL CONNECTION TERMINAL ....................................................................... 37
12. ADJUSTMENT AND MAINTENANCE FOR THE FLAME DETECTOR ......................... 38
   12.1 Sensitivity Adjustment (Without luminance gain; with the MFD-CH01 module mounted) .............................................................................................................. 38
   12.2 Sensitivity Adjustment (With luminance gain: with the MFD-CH02 is the module mounted) .............................................................................................................. 39
   12.3 Maintenance and Inspection for the Detection Assembly ....................................... 40
   12.4 Maintenance and Inspection for the Electric Circuit ............................................. 42
13. STANDARD SPARE PARTS .......................................................................................... 46

INDEX
Appendix 1 Flame Detection Concept of Frequency Component and Luminance Component
Appendix 2 Flame Detection Concept of "Flame Failure"
Appendix 3 Burner Control Concept of "Individual Flame Failure"
Appendix 4 LED Indications inside Flame Detector Panel and Operator Console Indication
Appendix 5 Sight Angle of Flame Detector Sensor
This manual explains how to operate two models of the IR-S Type: the IR-S equipped with a checking function and the IR-S equipped with both a checking function and a luminance level amplification function. Please contact us if you are interested in how to operate the IR-S equipped with a flame detection function alone and the Rack Mounted type IR-S.
2 OVERVIEW

As a manufacturer of thermal electric power plants, Mitsubishi Heavy Industries (MHI) provides systems ranging from boilers to automatic control unit for burners. Our burner flame detectors, which play a key role as a protective device for boilers, come in three basic models: the ultraviolet type ("UV" type), the infrared type ("IR" type), and the image-processing ("OPTIS") type. When we deliver boilers, we select the optimal type of flame detector, depending on the kind of fuel you use and other factors. The Infrared Type Flame Detector IR-S has been commercialized by inheriting the technology of its predecessor, the IR Type infrared ray flame detector, which has been already highly evaluated by a large number of applications. The IR-S Type provides a broad set of features that can meet a wide range of requirements in boiler operation.

2.1 Principle of Detection

Similar to the previous infrared ray flame detector, the target of detection in the IR-S Type is infrared rays which are hardly affected by a furnace’s environment. It detects the intensity of infrared rays in the ignition part of the burner flame and the inherent frequency components that are selectively removed.

2.2 Features

1. High sensitivity to luminance

In addition to having a wide dynamic range for sensitivity, the sensor uses a spherical lens at the end of the flame detector assembly to provide powerful observational capabilities. For these reasons, the IR-S Type's sensitivity is roughly 100 times as high as that of any previous infrared ray flame detector, so that it is flexible enough to handle a variety of fuels. It also fully meets the requirement for low-NOx operation for boilers taking place in recent years.

2. Infrequent contamination of surface lens

Because a spherical lens is used at the flame detector assembly's end. The cooling air for the flame detector flows over the outer periphery of the spherical lens, constantly removing dirt and dust. The result is an anti-fouling design and that eliminates the need for constant maintenance.

3. Easy maintenance and inspection

The circuits are structured as blocks using printed circuit board modules. The compatibility among individual units assures easy maintenance and inspection. All systems are divided into "unit blocks," which are connected by multi-conductor cables. The resulting simple system configuration is easy to maintain and inspect.

2.3 Combination with Automatic Burner Control Unit

As part of an automatic burner control unit, the Infrared Type Flame Detector IR-S provides the burner control unit with combustion information about its burner. Specifically, the flame detector identifies whether or not the burner flame currently has proper combustion. The judgment is sent to the automatic burner control unit, which identifies one of the three modes: on, off, and extinction.
2.4 Configuration of Infrared Type Flame Detector IR-S

The flame detector consists of three major parts: the detector section, which is located in the boiler section and converts readings of the burner flames into electrical signals; the detector panel, which houses the electrical circuitry; and the signal wiring, which connects the components.

(1) Detector Assembly

The detector assembly functions as a sensor for the flame detector. It consists of the protective pipe (guide pipe), which is fixed in the burner wind box, and the detector section, which is contained within a protective pipe.

(2) Detector Panel

The detector panel consists of the following: the storage rack for detector modules, which will amplify flame signals detected by the detector section; the dual power unit, which supplies the system with electric power; and the terminal unit, which connects the I/O cables that handle elements such as flame detection signals.
3 DETECTION ASSEMBLY

3.1 Structure of Detection Assembly

(1) Protective Pipe

The protective pipe consists of the guide pipe I (movable part), flexible pipe, guide pipe II (fixed pipe), cooling-air T pipe, and adapter II. The purpose of the protective pipe is two-fold. It serves as a guide to place the detector assembly in position and it serves as a path for the detector cooling air to protect the detector head from high temperatures. With the flame detector for a rotary combustion boiler, the protective pipe's guide pipe I is connected with the guide pipe II through the flexible pipe and connected to the air nozzle. Therefore, the protective pipe moves vertically together with the burner nozzle.

(2) Detector Assembly

The detector assembly consists of the following elements: detector head, flexible hose, connection pipe, sensor unit, and sensor case. The detector head conducts the light from the burner flames to the sensor unit through the optical fiber. Through the spherical lens, which is used to protect the optical fiber, the burner flame light enters the optical fiber and is converted by the sensor unit into an electrical signal.

Lens set

The lens set consists of a spherical lens and its container. Besides protecting the optical fiber from the furnace's radiation, heat, and dirt, it functions to provide optical signals for the burner flame.

Optical fiber

The optical fiber (light guide) is an optical signal cable that transmits infrared rays from the burner flame to the sensor unit. It is a reliable design having roughly 20,000 fiber strands.

Sensor unit

The sensor unit converts optical signals, which are transmitted by the optical fiber in the sensor section, into electrical signals. Within the sensor unit are a photoelectric transfer element and a preamplifier circuit.
Sensor case

The sensor case houses the sensor unit, to which optical signals are sent after they have been transmitted via the optical fiber from the light transmitting window of the sensor unit case flange.

The sensor unit case flanges are connected by the protective pipe's adapter II and four allen bolts (M6). The sensor case meets the Edx II BT4 standards for a pressure-resisting, explosion-proof structure.
3.2 Specifications of Cooling Air

Detector cooling air protects the detector section from the wind box air and the furnace high temperature. This requires a reliable and clean air source. Detector cooling air is supplied from the outside through the PT1 1/2 flexible hose connected to the T pipe. Cooling air enters the furnace by way of the protective pipe. It also helps prevent entry of dust or dirt from the furnace.

3.2.1 Specifications of Cooling Air

- Air consumption per detector: 1.5 Nm³/min
- Detector inlet air pressure: 150 mm Aq or more (furnace pressure)
- Cooling air temperature: Not higher than 60°C
- Allowable detector head temperature: Not higher than 200°C
- Allowable sensor amplifier temperature: Not higher than 60°C

3.2.2 Cooling Air Precautions

1. Immediately after removing the sensor case from the adapter II, immediately pull out the detector section. After removal, immediately replace the attached cover plate so that there will be no effect on the other detectors.

2. Be sure that the ambient temperature for the detector head does not exceed the specified value. Otherwise, there may be a negative effect on the equipment life, such as deterioration of the optical fiber.

3. Take care not to use a stop valve or similar in the cooling-air piping.

4. It is recommended that a backup for the separate cooling-air system should be provided.
3.3 Installing the Detector Assembly

(1) Installing the Protective Pipe

The protective pipe holds the flame detector assembly in proper position and protects the flame detector assembly against high temperatures due to heat radiation from the furnace. To get the maximum performance from the flame detector, therefore, you should install the protective pipe following the instructions of the flame detector installation diagram.

For a rotary combustion burner, installing the protective pipe should be followed by inspection to make sure that the protective pipe is not subject to undue force and it does not contact any parts in the wind box.

(2) Cooling-Air Piping

The cooling-air piping is branched from its main pipe to individual flame detectors. PT1-1/2 threads are used for connection to the protective pipe's T pipe.

(3) Installing the Detector Assembly

The detector assembly should be handled with extra care because of the installed glass lens and light guide. Usually, the detector assembly is about 1 cm longer than the protective pipe. After fully inserting the detector assembly until it end contacts the protective pipe's stopper, use four tightening bolts and uniformly clamp them to the attaching flange. If the detector assembly gets caught in something during insertion or removal, you should turn it clockwise and counterclockwise. If there is a footing in the furnace, how the detector head is inserted should be inspected from within the furnace.

(4) Wiring

The wiring to the detector assembly terminal box uses a PF conduit connection. The wiring uses four-conductor, shielded, heat-resisting, vinyl-coated control cables. When using flexible conduits, perform wiring with care so that there will be no need to remove the wiring when conducting maintenance or inspection. The detector assembly is provided with pressure-resistant packing glands, which should be used between the detector section and the flexible conduit.
4 DETECTOR PANEL

4.1 Detector Panel Configuration

The standard configuration of the detector panel includes the following devices.

(1) Detector Unit
(2) Dual Power Supply Unit
(3) Terminal Unit
(4) Main Power Supply Circuit

4.2 Wiring between Detector Assembly and Detector Panel

The wiring between the detector assembly and the detector panel normally uses the cable specified below.

- Cable type: Shielded, heat-resistant vinyl-coated control cable
- Code: JIS.HCVVS four-conductor shielded
- Nominal cross-sectional area: approximately 2 sq. mm
- Pressure resistance: 2000V or more
- Ambient temperature: 105°C or less

The wiring should be directly connected to the detector panel without using any junction cable. The wiring shield must always be grounded at the transmission circuit side (the detector panel's external connection terminal); that is, it must not be grounded at the detector section's terminal box.

The cables may be laid in the same tray where the other control cables are located, provided that it is separated from any control cable with 30A (or 480V) or more.
The standard configuration of the detector unit consists of detector modules, which process and amplify detection signals, and a motherboard, which functions as an interface to the modules.

The detector unit is capable of mounting up to 10 detector modules. Each module has an arithmetic circuit handling two burners so that each detector unit can have up to 20 burners (equivalent to five stages).

For the sensitivity switching function added to a combined oil/gas burner, an arithmetic circuit handling two burners per module is used for both the oil and gas applications. In this case, each detector unit can house up to 10 burners.
Outline of Detector Module Front Panel (MFD-CHO1)

1 Sensor power monitor lamp
The GREEN lamp lights when the power supply is normal.

2 Low luminance level lamp, Flame detected lamp
The GREEN lamp lights when the luminance level is low.
The RED lamp lights when the flame is detected.

3 Flame frequency level adjuster (1)
This is a gain regulator for the flame flicker signal.

4 Flame frequency level adjuster (2)
This is a gain regulator for the DC voltage that is proportional to the flame flicker signal.

5 Flame frequency level adjuster (3)
This is a switch that finally determines the level of the flame flicker signal.

6 Luminance level threshold switch
This is a DIP switch for setting the voltage that determines the luminance level.

7 Module input signal test pin (Input signal from sensor)

8 Test pin for amplified flame frequency level signal

9 Test pin for DC signal proportional to flame frequency level signal.

10 Power monitor lamp of detector module
(The GREEN lamp lights if the power supply is normal.)

11 Sensor abnormal lamp
(The RED lamp lights if the sensor is abnormal.)

12 Flame detector abnormal lamp
(The RED lamp lights if the sensor or module is abnormal.)

13 Module check exclusion switch
(This refers to an exception regarding sensor or module check.)

14 Abnormal reset switch

15 Manual switch to start a module check

The same as 1-9 above
Description of the Panel Operation

(1) Sensor power monitoring lamp (S.PWR1+/−)
This is a monitoring lamp for the on-site sensor unit power supply (±12V) coming from the module. The GREEN lamp lights when the power supply is normal; otherwise (when the fuse is blown), the lamp goes out. As seen from the front, the left side is for +12V monitoring and the right side is for -12V monitoring.

(2) Low luminance level lamp, Flame detected lamp (FLAME1)

Low luminance level lamp (Green)
The lamp turns on while the luminance level of the flame is low, and shows the contact used for “All Flame Off”, the condition of furnace purge, is closed. With all of these lamps lighting, one of the furnace purge condition “All Flame Off” condition will be established.

Flame detected lamp (Red)
This lamp is used to show whether or not the flame is detected. The lamp turns on when the flame is detected, and turns off when no-detected.

(3) Flame frequency component level adjuster (1) (AC.GAIN1)
This is a gain adjuster that adjusts the magnitude of a flicker signal that is selectively taken out from measurements of the burner flame.

(4) Flame frequency component level adjuster (2) (DC.GAIN1)
The flicker signal of a flame amplified by AC.GAIN is converted into a DC voltage by the frequency-voltage (F/V) converter circuit. This is a gain regulator for the DC voltage that is proportional to the flame's flicker signal.

(5) Flame frequency component level adjuster (3) (AC.SET1)
This is a switch that finally determines the level of the flame's flicker signal amplified by AC.GAIN.

(6) Luminance level threshold switch (DC.SET1)
This is a switch that determines the threshold value of the comparator circuit in the arithmetic circuit for the burner flame's luminance level.

(7) Flame detection signal certification test pin

TP1-1
This is a test jack for checking the detector module's input. It also checks the sensor circuit's output. The DC component of this signal indicates the radiation intensity (luminance) of the burner flame's infrared rays.

TP1-2
This is a test jack for checking the amplified signal from the burner flame's flicker component.

TP1-3
This is a test jack for checking the DC voltage signal that is proportional to the burner flame's flicker frequency.
(8) Power monitor lamp of detector module

This is a monitoring lamp for the main circuit power (±12V) for the module's circuit. The GREEN lamp lights if the power supply is normal; otherwise, the lamp goes off. As seen from the front, the left side is for +12V monitoring and the right side is for -12V monitoring.

(9) Sensor abnormal lamp (S.ABN.1/2)

The RED lamp lights if the sensor is found to be abnormal from the result of a sensor check. As seen from the front, the left side is for Channel 1 and the right side is for Channel 2.

(10) Flame detector abnormal lamp (FD.ABN.1/2)

The RED lamp lights if the sensor or module is found to be abnormal from the result of a sensor check or a module check. As seen from the front, the left side is for Channel 1 and the right side is for Channel 2.

(11) Module check exclusion switch (CHK/STOP)

This is used when no module check is required. The check function is excluded when the switch is set to the right position.

(12) Abnormal reset switch (ABN.RST)

This switch is for resetting the alarm for a sensor or module abnormal.

(13) Manual switch to start a module check (CHK.START)

This is the start switch for manually-performed module check. Pressing this switch starts a module check. It also functions as a time setting switch for the Automatic Module Check Start, which takes place every 24 hours. Pressing the switch resets the timer circuit that automatically starts a module check. With the switch turned on, a module check will automatically be started at an interval of roughly 24 hours.
Outline of Detector Module Front Panel (MFD-CHO2)

1 Sensor power monitor lamp
   The GREEN lamp lights when the power supply is normal.

2 Low luminance level lamp, Flame detected lamp
   The GREEN lamp lights when the luminance level is low.
   The RED lamp lights when the flame is detected.

3 Flame frequency level adjuster (1)
   This is a gain regulator for the flame flicker signal.

4 Flame frequency level adjuster (2)
   This is a gain regulator for the DC voltage that is proportional to the flame flicker signal.

5 Flame frequency level adjuster (3)
   This is a switch that finally determines the level of the flame flicker signal.

6 Luminance level adjuster
   This is a gain regulator for the luminance level.

7 Module input signal test pin (Input signal from sensor)

8 Test pin for amplified flame frequency level signal

9 Test pin for DC signal proportional to flame frequency level signal

10 Test pin for amplified flame luminance level

11 Power monitor lamp of detector module
   (The GREEN lamp lights if the power supply is normal.)

12 Sensor abnormal lamp
   (The RED lamp lights if the sensor is abnormal.)

13 Flame detector abnormal lamp
   (The RED lamp lights if the sensor or module is abnormal.)

14 Module check exclusion switch
   (This refers to an exception regarding sensor or module check.)

15 Abnormal reset switch

16 Manual switch to start a module check

The same as 1-10 above
Description of the Panel Operation

(1) Sensor power monitoring lamp (S.PWR1+/−)

This is a monitoring lamp for the on-site sensor unit's power supply (±12V) coming from the module. The GREEN lamp lights when the power supply is normal; otherwise (when the fuse is blown), the lamp goes out. As seen from the front, the left side is for +12V monitoring and the right side is for -12V monitoring.

(2) Low luminance level lamp, Flame detected lamp (FLAME1)

Low luminance level lamp (Green)
The lamp turns on while the luminance level of the flame is low, and shows the contact used for “All Flame Off”, the condition of furnace purge, is closed. With all of these lamps lighting, one of the furnace purge condition “All Flame Off” condition will be established.

Flame detected lamp (Red)
This lamp is used to show whether or not the flame is detected. The lamp turns on when the flame is detected, and turns off when no-detected.

This lamp is used to show whether or not there is a burner flame. When the GREEN lamp is on, it means that a contact signal indicating "Flame OFF" is being issued. But when the RED lamp is on, it means that a contact signal indicating "Flame ON" is being issued.

(3) Flame frequency component level adjuster (1) (AC.GAIN1)

This is a gain adjuster that adjusts the magnitude of a flicker signal that is selectively taken out of the measurements of burner flame.

(4) Flame frequency component level adjuster (2) (DC.GAIN1)

The flicker signal of a flame amplified by AC.GAIN is converted into a DC voltage by the frequency-voltage (F/V) converter circuit. This is a gain adjuster for the DC voltage that is proportional to the flame's flicker signal.

(5) Flame frequency component level adjuster (3) (AC.SET1)

This is a switch that finally determines the level of the flame's flicker signal amplified by AC GAIN.

(6) Luminance level threshold switch (DC.SET1)

This is a switch that determines the threshold value of the comparator circuit in the arithmetic circuit for the burner flame's luminance level.

(7) Flame detection signal certification test pin

TP1-1

This is a test jack for checking the detector module's input. It also checks the sensor circuit's output.

The DC component of this signal indicates the radiation intensity (luminance) of the burner flame's infrared rays.
TP2-1
This is a test jack for checking the amplified signal from the burner flame's flicker component.

TP3-1
This is a test jack for checking the DC voltage signal that is proportional to the burner flame's flicker frequency.

TP4-1
This is a test jack for checking the amplified signal from the burner flame's luminance level.

(8) Power monitor lamp of detector module
This is a monitoring lamp for the main circuit power (±12V) for the module's circuit. The GREEN lamp lights if the power supply is normal; otherwise, the lamp goes off. As seen from the front, the left side is for +12V monitoring and the right side is for -12V monitoring.

(9) Sensor abnormal lamp (S.ABN.1/2)
The RED lamp lights if the sensor is found to be abnormal from the result of a sensor check. As seen from the front, the left side is for Channel 1 and the right side is for Channel 2.

(10) Flame detector abnormal lamp (FD.ABN.1/2)
The RED lamp lights if the sensor or module is found to be abnormal from the result of a sensor check or a module check. As seen from the front, the left side is for Channel 1 and the right side is for Channel 2.

(11) Module check exclusion switch (CHK/STOP)
This is a switch that is used when no module check needs to be conducted. The check function is excluded when the switch is set to the right position.

(12) Abnormal reset switch (ABN.RST)
This is a switch for resetting the alarm for a sensor or module abnormal.

(13) Manual switch to start a module check (CHK.START)
This is the start switch for manually performing a module check. Pressing this switch starts a module check.

(14) Luminance level threshold switch (DIP switch inside the board)
This is a switch that determines the threshold value of the comparator circuit in the arithmetic circuit for the burner flame's luminance level. The threshold value can be set at eight steps at a 0.5V interval starting with the minimum of 0.5V. The detector module must be removed before setting the threshold value. When the setting is to be performed during operation, it is necessary to take measures to prevent interfering with burner operation.
5.3 **Meter Module (Option: Meter module is supplied)**

1. **OUT LEVEL Voltage Indicator**
   
   This is a voltmeter that indicates an output signal from the sensor unit. Its reading is the same as the TP1 voltage at the module's front panel. With a maximum value of approximately 9V, it is a 15V full-scale moving-coil voltmeter.

2. **Sensor Select Switch**
   
   Each detector module has an arithmetic circuit for two burners, which is selected by the rotary switch. Selecting the value of 1 determines the upper burner, while selecting the value of 2 determines the lower burner.

3. **Module Select Switch**
   
   The detector unit contains up to 10 detector modules. (The number of detector modules differs depending on the number of burners used.) This is a rotary switch for selecting a detector module for which you want to indicate the voltage. (For slot selection) The numbers 1 to 10 printed on this switch correspond to the slot numbers shown on the upper part of the detector module.
5.4 Simulation Switch Unit (Option: Simulation switch unit is supplied)

This switch is for maintenance of the flame detector. It is to prevent interference with burner operation when it is necessary to remove an on-site sensor while the burner is in operation. There is a similar switch at every corner. Turing on the switch simulates "Flame detected". This switch is located at the rear of the detector unit.
6 POWER UNIT

The power unit consists of two elements. One is a duplicated power circuit for redundancy using diode comparison from a switching power supply. The other is a monitoring/displaying circuit that monitors the output voltage.

6.1 Description of the Panel Front

(1) Power Supply Indicating Lamp

This lamp is used to monitor the ±15V power supply for systems A and B. The GREEN lamp lights when the voltage is normal.

(2) "OUT PUT.VCHECK"

This test jack f is used to check the power unit's output voltage. It is used to measure the voltage between the +15V and COM points and between the -15V and COM points.
This unit connects the external cable to the panel equipment. It consists of an external terminal block and a connector for connecting the panel cable.
8 DETECTOR MODULE’S CIRCUITRY

After receiving signals, which have been converted from optical to electrical ones in the sensor unit, the detector module performs arithmetic operations on two components (frequency and luminance) of the burner flame and provides contact signals, which show where there is or is not a burner flame. Contact signals at the final output will be issued only when the module's power supply is normal. Another consideration are measures taken when the power supply is off. See Figure 1 for the detector module's circuit configuration and Figure 8-1 for the operation waveforms of each circuit block.

8.1 Arithmetic Circuit for the Frequency Component

(1) High-Pass Filter

This is a circuit that selectively separates burner flame signals, which have been converted into electricity at the sensor unit. It is a high-pass filter circuit that has an active filter for selectively separating only the flicker components unique to burner flames by regarding the furnace's radiation as the low-frequency component and the signal from the burner ignition region as the high-frequency component.

(2) AC Amplifier

The burner flame selected by the high-pass filter is a very weak signal. This signal needs amplification by switching the fixed resistors in order to make it easy to process the signal in the subsequent processes. The design is such that it is possible to set the degree of amplification at "AC GAIN" from the front of the panel. This setting can be made in four levels using the rotary switch.

(3) Rectifying Amplifier

This is a two-wave rectifying circuit intended to emphasize the flicker component of the burner flame.

(4) F/V Converter

This is an F/V converter circuit for converting a frequency signal that has been emphasized by the rectifying amplifier circuit to a DC voltage that is proportional to the signal.

(5) DC Amplifier

The analog signal for the DC voltage obtained by the F/V converter is amplified by the amplifier circuit. The design is such that it is possible to set the degree of amplification at "DC GAIN" from the front of the panel. This setting can be made in four levels using the rotary switch.
(6) Comparator 2

The analog signal amplified by the DC amplifier circuit is converted into a digital signal. As an output, the result of the decision is sent to the decision logic circuit. The threshold value of the comparator is approximately 4.5V; the ON level is used as a standard.
8.2 Arithmetic Circuit for the Luminance Component
(Without luminance gain: MFD-CH01 is the module mounted)

1) Buffer Amplifier

This is an interface circuit in which the burner flame signal converted photoelectrically in the sensor unit is used to send the infrared intensity (luminance level) to the detector unit.

2) Comparator 1

The analog signal at the luminance level in the burner flame signal entered through the buffer amplifier is converted into a digital signal. As an output, the result of the decision is sent to the decision logic circuit. The threshold value of the comparator can be set by the DC SET switch on the front of the panel. There are two standard levels for the setting: LOW, setting the OFF level at approximately 1 V, and HIGH, setting the OFF level at approximately 3.5 V.

Major portions of the analog arithmetic circuit are made up of hybrid ICs, which reduce complexity and enhance reliability.

3) Decision Logic Circuit

The decision logic circuit consists of a logic circuit, which is made up of logic ICs (PLD), and a relay output circuit. The circuit block shown below is for this logic circuit.

---

<table>
<thead>
<tr>
<th>Frequency component ON</th>
<th>Approx. 2 seconds</th>
<th>Luminance component ON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burner valve closed</td>
<td></td>
<td>Normal logic power supply</td>
</tr>
</tbody>
</table>

Extracting one burner

---

R
FD1
Flame

G
FD2
No flame
The timer circuit, which consists of the circuits shown above, is intended to restrict the response of burner flame detection resulting from transient changes in the burner flame or burner condition. The purpose of this design is to create a burner control system. The delay time is approximately 2 seconds. The contact ratings of the output relay for the flame detection signal are as follows.

- Contact rating power: 30W/62.5VA
- Contact rating voltage: 48V AC/DC
- Contact rating current: 1.25A
8.3 Arithmetic Circuit for the Luminance Component (With luminance gain: MFD-CH02 is the module mounted)

(1) Luminance Amplifier

This is an interface circuit in which the burner flame signal converted photoelectrically in the sensor unit is used to send the infrared intensity (luminance level) into the detector unit.

(2) Comparator 1

The analog signal at the luminance level in the burner flame signal entered through the buffer amplifier is converted into a digital signal. As an output, the result of the decision is sent to the decision logic circuit. The threshold value of the comparator can be set by the DC SET switch inside the module. The value can be set at eight levels at a 0.5V interval starting with the minimum of approximately 0.5V. (You must remove the module to make a setting.) Major portions of the analog arithmetic circuit are made up of hybrid ICs, which reduce the complexity and enhance reliability.

(3) Decision Logic Circuit

The decision logic circuit consists of a logic circuit, which is made up of logic ICs (PLD), and a relay output circuit. The circuit block shown below is for this logic circuit.

The timer circuit, which consists of the circuits shown above, is intended to restrict the response regarding burner flame detection resulting from transient changes in the burner flame or burner condition. The purpose of this design is to create burner control system. The delay time is approximately 2 seconds.
The contact ratings of the output relay for the flame detection signal are as follows.

- Contact rating power: 30W62.5VA
- Contact rating voltage: 48V AC/DC
- Contact rating current: 1.25A
This drawing shows MFD-CH01. Some circuits of Buffer amplifier and Comparator 1 are different for MFD-CH02.

1. The block diagram is for single corner. Each detector module can house two corners.
2. For details about the alarm circuit, refer to SH#FD041, which shows a system diagram for the flame detection panel power supply and alarm system.
<table>
<thead>
<tr>
<th>Circuit block</th>
<th>Output waveform</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor unit</td>
<td>![Sensor unit waveform]</td>
<td>Raw signal obtained by converting the burner flame signal photoelectrically (TP1)</td>
</tr>
<tr>
<td>Bypass filter</td>
<td>![Bypass filter waveform]</td>
<td>Selectively taking out the flicker component of the burner flame</td>
</tr>
<tr>
<td>AC amplifier</td>
<td>![AC amplifier waveform]</td>
<td>Amplifying the flicker component of the burner flame (AC GAIN)</td>
</tr>
<tr>
<td>Rectifier amplifier</td>
<td>![Rectifier amplifier waveform]</td>
<td>Emphasizing the flicker component of the burner flame (TP2)</td>
</tr>
<tr>
<td>F/V converter</td>
<td>![F/V converter waveform]</td>
<td>Converting it to a DC voltage proportional to the flame's frequency signal</td>
</tr>
<tr>
<td>DC amplifier</td>
<td>![DC amplifier waveform]</td>
<td>Amplifying the DC voltage (DC GAIN)</td>
</tr>
<tr>
<td>Comparator 2</td>
<td>![Comparator 2 waveform]</td>
<td>Converting it into a digital signal</td>
</tr>
<tr>
<td>Buffer amplifier</td>
<td>![Buffer amplifier waveform]</td>
<td>Sending the flame's raw signal as through output to comparator 1</td>
</tr>
<tr>
<td>Comparator 1</td>
<td>![Comparator 1 waveform]</td>
<td>Digitizing the raw signal obtained by converting the burner flame signal photoelectrically</td>
</tr>
<tr>
<td>Decision logic circuit</td>
<td>![Decision logic circuit waveform]</td>
<td>Making a decision as to whether or not there is a flame; adding the time element</td>
</tr>
<tr>
<td>Output relay circuit</td>
<td>![Output relay circuit waveform]</td>
<td>Driving the signal output relay</td>
</tr>
</tbody>
</table>

Figure 8-2  Output Waveforms for Blocks
8.4 Checking Circuit

The flame detector is required to perform stable flame detection and dependable extinction detection. For these functions to positively work, the IR-S conducts the following self-monitoring processes and, if a problem is found, issues an alarm depending on the problem.

(1) Sensor Check

This process monitors any problem in the sensor and pre-amplifier.

(2) Detector Unit Check

This process checks to see if the detector module's circuit works normally.

(3) Power monitor

This process monitors each section's power supply and, if any problem is found, issues an alarm.

8.4.1 Sensor Check

This function checks the sensor and pre-amplifier. A block diagram for an outline of this function is shown in Figure 8-3.

Figure 8-3 Sensor Check Block Diagram
Light from the flame is guided by the light guide and then converted into an electrical signal by the photodiode. This signal is amplified by the preamplifier before it goes to the detector module.

To check the signal, the instantaneous log amplifier should be shorted every 60 seconds so that the log amplifier's output is forcibly reduced to -12V. The output from a normal amplifier will always become -12V when the input is shorted. If a pulse signal occurs on this negative side, the log amplifier circuit is considered to be normal. Checking to see if there is a pulse signal at regular times makes it possible to check that the preamplifier is working normally and that the preamplifier and the detector module are connected with a cable.

If such a signal does not come within 128 seconds, the system considers the situation to be abnormal. The check starts immediately after the detector module's power supply is normally started. Refer to Figure 8-4 for a sensor check timing chart.

The signal changes to the extinction level temporarily (for 550 msec). However, there will be no incorrect output regarding the “Flame detected” OFF because the “flame detected” OFF has an "on-delay" lasting for 1.5 to 2 seconds.
8.4.2 Detector Module Check

This function checks that the detector module's flame detection function is normally working. A block diagram for the detector module's checking circuit is shown in Figure 8-5.

![Checking Circuit Block Diagram](image)

The check of the detector module is automatically repeated every 24 hours. It is also possible to start the check anytime by using the manual start switch at the module front. (However, you can stop the check operation if you use the exception switch.) See Figure 8-6, which shows a timing chart for Channel 1 applicable after the checking circuit is started.

Once the checking circuit is started, a dummy signal is issued to set the external output to be passed to the burner control panel at “ON”. One second later, the multiplexer (MPX) is switched to put the sensor input to the off check signal (0V). If, therefore, the flame identification circuit is normal, the result of decision shows the "Flame detected" is OFF. This is checked five seconds later. If "Flame detected" is "ON", the circuit is considered abnormal and the detector module is also considered abnormal. For normal operation, the input is switched to the sensor signal one second after the check is completed. Two seconds later, the dummy signal is turned off. This is the end of one check sequence. If the automatic check function is used, a similar check takes place every 24 hours.

As mentioned earlier, each detector module can receive two sensor signals. For the detector module, Channel 1 is first checked. Checking Channel 2 follows eight seconds after the start of the Channel 1 check.
For A to H, refer to the block diagram.

**Figure 8-6  Checking Circuit Timing Chart**
* (With the Checking Circuit Started under the “Flame ON” Condition)*

The module is considered abnormal if "Fire" is determined in spite of the 0V input.

Channel 2 starts checking.

1 sec. 5 sec. 1 sec. 2 sec.

- A Start (Automatic/manual)
- B Check command
- C Dummy signal
- D "Flame" signal
  * "Flame" external output
- E Off check signal selected
- F Sensor signal selected
- G Off check timing
- H Detector module abnormal

The module is considered abnormal if "Fire" is determined in spite of the 0V input.
8.5 Power Monitoring

In the flame detector, the dual power unit produces ±15VDC. Each detector module produces +5VDC required for the logic circuit and ±12V supplied to the sensor unit. Each power supply is equipped with a monitor relay for monitoring.

The following explains how the system detects abnormalities of the power supply using the self-monitoring function, as well as what the display is like.

(1) Alarm Output

The IR-S can output three external alarms and an interlock signal as shown below:

(a) Flame detector power supply normal
(b) Flame detector power supply abnormal
(c) Flame detector abnormal

(2) Flame Detector Power Supply Normal/Abnormal

This is an alarm output obtained by monitoring the power supply equipment. "Power Normal" (NOT a major fault) indicates that as before at least one of the duplicated power units operates normally and that the flame detector's function is functioning. "Power Abnormal" (ABNORMAL) indicates that one of the duplicated power units is faulty or that the 5V or ±12V voltage produced on the detector module has a problem.

See Figure 8-7, which shows the power supply's monitoring system.
Figure 8-7  Power Monitoring System
(3) Flame Detector Abnormal

This alarm is issued when there is something wrong with a non-power element. This may be attributed to the following problems.

· Detector module abnormal (Sensor abnormal, off check abnormal)
· Clock normal (Monitoring the clock on the detector's module)
· Monitoring the detector module for removal

See Figure 8-8, which shows the system monitoring diagram.

Figure 8-8  System Monitoring Diagram
For details about the power system for the flame detector panel, refer to the power supply division circuit in the list of flame detector drawings. The main power is supplied to the power unit through the noise filter and non-fuse breaker. After the power is converted to a DC voltage by the power unit, it is duplicated and supplied to the detector unit. The rating for the power unit is shown below.

- Input voltage range: 85V AC to 132VAC; 90VDC to 165VDC
- Input frequency range: 47Hz to 440Hz
- Output voltage: ±15V
- Output current: +15V/8.0A, -15V/4.0A
10 FLAME DETECTOR POWER SUPPLY MONITOR CIRCUIT

This circuit monitors the power supply from the power unit and the power supply for each detector module; a contact output is thus transferred to the burner control panel.
11 EXTERNAL WIRING TERMINAL

External wiring terminals are installed on the terminal unit and the panel's side chassis. Field wiring should be performed as per the external wiring diagram included within the flame detector connection diagram.
12 ADJUSTMENT AND MAINTENANCE FOR THE FLAME DETECTOR

12.1 Sensitivity Adjustment (Without luminance gain; with the MFD-CH01 module mounted)

Adjusting the sensitivity of the detector is complex in that the combustion mode of a burner flame to be detected will change according to the boiler load. To optimally set the sensitivity, it is important to identify detector characteristics from starting the boiler to its maximum load. We recommend that you leave basic settings to the manufacturer's adjuster. The adjustment procedures needed after sensitivity setting are as follows.

You can change the detector sensitivity using AC GAIN and DC GAIN found on the detector module's front panel. The basic functions of these two regulators are explained below.

(1) AC GAIN

This is a gain regulator that adjusts the magnitude of a flicker signal that is selectively taken out from measurement of a burner flame.

(2) DC GAIN

This is a gain regulator for the output voltage that is proportional to the burner flame's flicker frequency.

When adjusting the detector's sensitivity, you can increase the detector's output voltage by turning the AC GAIN or DC GAIN adjuster. If compensating for the sensitivity with AC GAIN fails to increase the detector's output voltage, you need to use DC GAIN to adjust it.

These adjustments should be made while reading the voltage values of test terminals TP.1, TP.2, and TP.3 on the detector module panel. In adjusting the flame detector, care should be taken for the boiler operating system as well, because the flame detector is part of the burner control system.
12.2 Sensitivity Adjustment (With luminance gain: with the MFD-CH02 is the module mounted)

Adjusting the sensitivity of the detector is complex in that the combustion mode of a burner flame to be detected will change according to the boiler load. To optimally set the sensitivity, it is important to identify detector properties from stating the boiler to its maximum load. We recommend that you leave basic settings to the manufacturer's adjuster. The adjustment procedures needed after sensitivity setting are as follows.

The detector sensitivity can be changed by AC GAIN and DC GAIN installed at the detector module's front panel. The basic functions of these regulators are explained below.

(1) AC GAIN

This is a gain regulator that adjusts the magnitude of a flicker signal that is selectively taken from measurement of a burner flame.

(2) DC GAIN

This is a gain regulator for the output voltage that is proportional to the burner flame's flicker frequency.

(3) Luminance amplifier (VR1,2)

This is a gain regulator for regulating the burner flame's luminance level voltage.

Adjusting the detector's sensitivity is thus conducted by adjusting AC GAIN, DC GAIN, and the luminance amplifier (VR1,2). If compensating for the sensitivity with AC GAIN fails to increase the detector's output voltage, you need to use DC GAIN to adjust it.

These adjustments should be made while reading the voltage values of test terminals TP.1, TP.2, and TP.3 on the detector module panel. In adjusting the flame detector, care should be taken for the boiler operating system as well, because the flame detector is part of the burner control system.
12.3 Maintenance and Inspection for the Detection Assembly

The detection assembly may be sufficiently inspected at the same time you perform regular boiler checking. At the beginning of a plant construction, however, use the following procedures to perform inspection and cleaning because the detector’s cooling air contains a lot of dust and dirt, which will significantly soil the lens and the like in a short period of time.

Procedures for disassembling the detector assembly for cleaning (see Figure 12-1)

1. Remove the four allen bolts (M6) from the adapter II.
2. Pull out the detector assembly from the guide pipe section.
3. After removing the detector assembly, attach the blind plate to the adapter II.
4. Clean the detector head section’s lens and the light guide’s light receiving part.
5. To install, reverse the above procedures.

If this work is performed during boiler operation, the system issues an alarm of burner extinction. You can prevent this alarm from being issued by, for example, removing the wiring at the burner’s external terminal connector for the “No Flame” output. Because this action is different depending on the burner logic, you need to carry it out through careful planning.
Assembly Drawing for the Detector Head (Figure 12-1)
12.4 Maintenance and Inspection for the Electric Circuit

One of the major items of maintenance and inspection for the electric circuit in the detection assembly is inspecting how the flame detector unit operates. Therefore, the checking circuit provides a daily inspection.
### States Shown at IR-S Problem (Fault) and Corrective Action

<table>
<thead>
<tr>
<th>No.</th>
<th>Position</th>
<th>Fault mode</th>
<th>Flame decision output</th>
<th>Lamps at the front of detector module</th>
<th>Lamps at the front of duplicated power unit</th>
<th>Alarm</th>
<th>Power abnormal</th>
<th>Detector abnormal</th>
<th>Corrective action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Light guide</td>
<td>Broken cable</td>
<td>OFF ON ON Green ON ON OFF OFF</td>
<td>ON ON ON ON</td>
<td>OFF OFF ON</td>
<td>* An extinction is detected when ENR = ON. * Remove the on-site sensor and disassemble it for inspection. * Replace the part (light guide).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Photodiode</td>
<td>Open</td>
<td>OFF ON ON Green ON ON OFF OFF</td>
<td>ON ON ON ON</td>
<td>OFF OFF ON</td>
<td>* An extinction is detected when ENR = ON. * Remove the on-site sensor and disassemble it for inspection. * Replace the part (sensor unit).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shorted</td>
<td>OFF ON ON Green ON ON OFF OFF</td>
<td>ON ON ON ON</td>
<td>OFF OFF ON</td>
<td>* An alarm is issued when the sensor is faulty. * Replace the part (sensor unit).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Log amplifier</td>
<td>Meter pointer exceeding upper limit</td>
<td>ON ON ON Red ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An alarm is issued when the sensor is faulty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0V</td>
<td>OFF ON ON Green ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An alarm is issued when the sensor is faulty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meter pointer exceeding upper limit</td>
<td>OFF ON ON Green ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An alarm is issued when the sensor is faulty.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sensor cable</td>
<td>Signal cable broken</td>
<td>OFF ON ON Green ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An alarm is issued when the sensor is faulty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+12V cable broken</td>
<td>OFF ON ON Green ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An alarm is issued when the sensor is faulty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0V cable broken</td>
<td>(Note) ON ON (Note) ON ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* Check the voltage on the on-site sensor's terminal block. * Repair the on-site sensor cable.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-12V cable broken</td>
<td>ON ON ON Red ON ON ON ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An alarm is issued when the module is faulty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>HPF AC AMP rectifier circuit</td>
<td>Meter pointer exceeding upper limit</td>
<td>ON ON ON Red ON ON OFF ON</td>
<td>ON ON ON ON</td>
<td>OFF ON ON</td>
<td>* An extinction is detected when ENR = ON. * Replace the part (detector module-4).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0V</td>
<td>OFF ON ON Green ON ON OFF OFF</td>
<td>ON ON ON ON</td>
<td>OFF OFF ON</td>
<td>* An extinction is detected when ENR = ON. * Replace the part (detector module-4).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Position</td>
<td>Fault mode</td>
<td>Flame decision output</td>
<td>Lamps at the front of detector module</td>
<td>Lamps at the front of duplicated power unit</td>
<td>Alarm</td>
<td>Power abnormal</td>
<td>Detector abnormal</td>
<td>Corrective action</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>------------</td>
<td>------------------------</td>
<td>--------------------------------------</td>
<td>----------------------------------------------</td>
<td>----------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>-------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 6   | Frequency/voltage (F/V) converter | Meter pointer exceeding upper limit | ON | ON | ON | Red | ON | ON | OFF | ON | ON | ON | ON | OFF | ON | ON | ON | * An alarm is issued when the module is faulty.  
* Start the "manual module check" function to reconfirm the situation.  
* Replace the part. |
|     |              | 0V         | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part. |
|     |              | Meter pointer exceeding upper limit | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module 4). |
| 7   | DC AMP       | Meter pointer exceeding upper limit | ON | ON | ON | Red | ON | ON | OFF | ON | ON | ON | OFF | ON | ON | ON | * An alarm is issued when the module is faulty.  
* Start the "manual module check" function to reconfirm the situation.  
* Replace the part (detector module 4). |
|     |              | 0V         | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module 4). |
|     |              | Meter pointer exceeding upper limit | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module 4). |
| 8   | Output comparator 2 | Meter pointer exceeding upper limit | ON | ON | ON | Red | ON | ON | OFF | ON | ON | ON | OFF | ON | ON | ON | * An alarm is issued when the module is faulty.  
* Start the "manual module check" function to reconfirm the situation.  
* Replace the part (detector module 4). |
|     |              | 0V         | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module 4). |
|     |              | Meter pointer exceeding upper limit | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module 4). |
| 9   | Luminance amplifier | Meter pointer exceeding upper limit | ON | ON | ON | Red | ON | ON | OFF | ON | ON | ON | OFF | ON | ON | ON | * An alarm is issued when the module is faulty.  
* Start the "manual module check" function to reconfirm the situation.  
* Replace the part (detector module 4). |
|     |              | 0V         | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module). |
|     |              | Meter pointer exceeding upper limit | OFF | ON | ON | Green | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | ON | * An extinction is detected when ENR = ON.  
* Replace the part (detector module). |

Note: If the sensor cable is broken at 0V, the status of flame detection at that time is stored.  (If there is a broken cable under the "Fire" condition, the status of "Fire" is stored.)
<table>
<thead>
<tr>
<th>No.</th>
<th>Position</th>
<th>Fault mode</th>
<th>Flame decision output</th>
<th>Lamps at the front of detector module</th>
<th>Lamps at the front of duplicated power unit</th>
<th>Alarm</th>
<th>Power normal</th>
<th>Detector abnormal</th>
<th>Corrective action</th>
</tr>
</thead>
</table>
| 10  | Output comparator 1      | Meter pointer exceeding upper limit | ON                    | ON ON Red                              | On On Off                                  | On Off On Off On Off On Off On | * An alarm is issued when the module is faulty.  
* Start the "manual module check" function to reconfirm the situation.  
* Replace the part (detector module). |
|     |                          | System A +15V faulty                 | ON                    |                                          | On Off On Off                              | Off On Off Off On Off On Off On | * An extinction is detected when ENR = ON.  
* Replace the part (detector module). |
13 STANDARD SPARE PARTS

Table 13-1 lists the standard spare parts.

Table 13-1

<table>
<thead>
<tr>
<th>Standard spare parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector Module</td>
</tr>
<tr>
<td>Sensor Unit</td>
</tr>
<tr>
<td>Lens Set</td>
</tr>
<tr>
<td>Packing (for installing the detector section)</td>
</tr>
</tbody>
</table>

Table 13-2 lists the tools.

Table 13-2

<table>
<thead>
<tr>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen Wrench Set</td>
</tr>
<tr>
<td>Cover Plate</td>
</tr>
</tbody>
</table>
INDEX

A
Abnormal reset switch ..................... 13, 16
AC Amplifier .................................. 22
Alarm Output .................................. 35
Allowable detector head temperature ...... 6
Allowable sensor amplifier temperature ..... 6

B
Buffer Amplifier .............................. 24

C
Clock normal .................................. 37
Combination with Automatic Burner
   Control Unit .................................. 2, 3
Comparator ..................................... 23, 24, 26, 30
Configuration of Infrared Type Flame
   Detector IR-S .................................. 2, 3
   cooling-air piping .......................... 6, 7

D
DC Amplifier .................................. 22
DC amplifier circuit ........................ 23
Decision Logic Circuit ....................... 23, 24, 26
Detector Module Check ...................... 2, 33
Detector Unit .................................. 8, 31
dual power unit .............................. 3, 35

F
F/V Converter .................................. 22
Flame detection signal certification test pin11, 15
Flame detector abnormal lamp ........... 13, 16
flame detector assembly .................. 2, 7
Flame detector main power supply circuit2, 38
Flame detector power supply abnormal ...... 35
Flame detector power supply normal ...... 35
Flame Detector Power Supply
   Normal/Abnormal .......................... 35
Flame frequency component level adjust 11, 15
Flame indicating lamp ...................... 11, 15
frequency-voltage (F/V) converter circuit11, 15

H
High-Pass Filter .............................. 22

L
lens set ......................................... 4
Luminance Amplifier ......................... 26
Luminance level threshold switch ..11, 15, 17

M
Manual switch to start a module check 13, 16
Meter Module ................................. 2, 18
Module check exclusion switch ........... 13, 18
Monitoring the detector module for removal ................................................. 37

O
optical fiber .................................... 4, 5, 6

P
Power monitor lamp of detector module13, 16
Power unit ..................................... 2, 20
pressure-resisting, explosion-proof
   structure ...................................... 5
Principle of Detection ....................... 2
protective pipe ............................. 3, 4, 5, 6, 7

R
Rectifying Amplifier ......................... 22
S
Sensitivity Adjustment .....................2, 41, 42
Sensor abnormal lamp ......................13, 16
sensor case.......................................4, 5, 6
Sensor power monitoring lamp............ 11, 15
sensor unit..... 4, 5, 11, 15, 18, 22, 24, 26, 35
Simulation Switch Unit.......................2, 19
Specifications of Cooling Air............. 2, 6
spherical lens ...................................2, 4
T
Terminal Unit ..................................3, 8, 40
Appendix 1 Flame Detection Concept of Frequency Component and Luminance Component

The essential purpose of the flame monitoring is to ensure the detection of combustion failure, such as flame loss or the flame is peripheral. Also it should be to avoid inappropriate burner cut off by over-protection / miss-detecting.

In this point of view, the individual “Flame Failure” is under the condition of both not Frequency component ON and not Luminance component ON as Logic(A), so that be able to ensure the detection of flame abnormal. This logic is equivalent to Logic(B).

In order to ensure the detection of flame failure, both signals should be activated together.
Appendix 2  Flame Detection Concept of “Flame Failure”

For the safe and reliable furnace operation, the essential situations of “Flame Failure”, as shown in 2) and 3) below, should be monitored.

1) “Flame On”

<table>
<thead>
<tr>
<th>Burner valve</th>
<th>Flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opened</td>
<td>Detected</td>
</tr>
</tbody>
</table>

Normal combustion

2) “Flame Failure” or the flame is peripheral

<table>
<thead>
<tr>
<th>Burner valve</th>
<th>Flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opened</td>
<td>Not detected</td>
</tr>
</tbody>
</table>

Combustion failure

The “Black Skirt” zone occupies the flame detector sight and the flame is not detected.

3) “Flame Failure” or the flame is lost

<table>
<thead>
<tr>
<th>Burner valve</th>
<th>Flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opened</td>
<td>Not detected</td>
</tr>
</tbody>
</table>

Combustion failure

The flow of the spreading fuel occupies the flame detector sight and the flame is not detected.

4) “Burner Off” or burner valve is closed

<table>
<thead>
<tr>
<th>Burner valve</th>
<th>Flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed</td>
<td>Detected or Not detected</td>
</tr>
</tbody>
</table>

Normal

During the burner valve closed it is not critical whether the flame detected or not.
Appendix 3  Burner Control Concept of “Individual Flame Failure”

(1) Combustion monitoring for the Fire Vortex.

MHI’s flame monitor and burner management concept is based on tangential firing which configures the fire vortex and the combustion of burners is supported each other. So that after one or more elevations of firing is established the flame condition is monitored as the whole fire vortex.

In the fire vortex theory, each flame monitoring system is not used for individual burner combustion monitoring but used for detecting the whole boiler flame lost. The protection for flame loss is composed as “All Flame Loss” which is activated when all elevations are detected as flame off.

(2) Individual Flame Failure Protection

Besides that, the logic for “Individual Flame Failure” protection which causes the individual burner stop is active only during the boiler start-up period such as when the number of burners in service is less than three.
Appendix 4  LED Indications inside Flame Detector Panel and Operator Console Indication

In some version of the Flame Detector System, the LED light indications inside the Flame Detector Panel are the direct indication of the flame sensing. For the detection of “Flame Failure”, however, the flame signal should be acquired with burner valve status. And the reference indication related “Flame On”, or “Off” is indicated on the screen in the Operator Console.

When the burner valve is closed, it is not critical whether the flame is detected or not, because valve closed in itself means that the fuel is cut. However, this mention is only for the time when another burner is firing. Before the initial firing of the boiler, the non-existence of flame everywhere will be confirmed by the furnace safety purge period.
Appendix 5  Sight Angle of Flame Detector Sensor

MHI’s flame detector has 15 degree angle sight from the center line.

We recognize that other manufacture’s flame detector width is not so different.