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(JIFMA/JSA)

**General safety code for industrial
combustion furnaces—Part 2:
Combustion and fuel handling
systems**

ICS 13.100;25.180.01

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Foreword

This Japanese Industrial Standard has been established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard submitted by Japan Industrial Furnace Manufacturers Association (JIFMA)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act. This Standard partially replaces **JIS B 8415**:2008, which has been withdrawn.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, published patent application or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, published patent application or utility model rights.

JIS B 8415 series consists of the following 3 parts under the general title *General safety code for industrial combustion furnaces*—:

Part 1: General requirements

Part 2: Combustion and fuel handling systems

Part 3: Protective systems

General safety code for industrial combustion furnaces—Part 2: Combustion and fuel handling systems

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 13577-2:2014**, Edition 1, with some modifications of the technical contents to corresponding to the actual situations in Japan.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JB. Annex JA is unique to **JIS** and not given in the corresponding International Standard.

This Standard is a type-C standard as defined in **JIS B 9700**.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the scope of this Standard.

When requirements of this type-C standard are different from those which are stated in type-A or -B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

This Standard shall always be used and take precedence for industrial combustion furnaces and associated devices.

Industrial combustion furnaces and associated devices generally consist of the following components:

- combustion chambers (e.g. steel construction with lining and/or refractory-lined);
- combustion and fuel handling systems;
- protective system;
- control and instrumentation system.

This Standard specifies the safety requirements on combustion for industrial combustion furnaces and associated devices. If the provisions of this Standard conflict with those specified in **JIS B 8415-1**, the provisions of this Standard shall take precedence.

Industrial combustion furnaces and associated devices are assumed to be operated by trained furnace operators.

1 Scope

This Standard specifies the safety requirements for combustion and fuel handling systems that are part of industrial furnaces and associated devices (hereafter referred to as the combustion furnaces) to which **JIS B 8415-1** applies.

NOTE 1 The general requirements on combustion furnaces are specified in **JIS B 8415-1**.

This Standard deals with significant hazards, hazardous situations and events relevant to combustion and fuel handling systems as listed in Annex A, when used as intended and under the conditions foreseen by the manufacturer.

This Standard covers the following:

- fuel pipework downstream of and including the manual isolating valve;
- combustion air supply (including oxygen and oxygen enriched combustion air) and flue gas system;
- burner(s), burner system and ignition device;
- functional requirements (protective system) for safety related control system (protective system).

This Standard applies to any oxidation with air or other gases containing oxygen of gaseous and liquid fuels, or any combustion of them to release thermal energy.

For thermal or catalytic post combustion and waste incineration, this Standard applies only to auxiliary burners designed to start-up and/or support the process.

The conditions concerning the pressure hazard of piping and components covered by this Standard shall be as specified in Annex E.

This Standard gives the necessary requirements regarding information for use.

This Standard does not cover hazards from heating generated by electricity.

This Standard does not deal with the hazards created by the release of flammable substances from the products processed in the combustion furnaces.

This Standard is not applicable to the following fuel handling systems:

- welding machines;
- up-stream of manual isolating valve of furnace equipment.

This Standard is not applicable to electrical cabling and power cabling upstream of the furnace equipment control panel/protective system.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 13577-2:2014 *Industrial furnaces and associated processing equipment—Safety—Part 2: Combustion and fuel handling systems* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 0202 *Parallel pipe threads*

NOTE Corresponding International Standard: ISO 228-1 *Pipe threads where pressure-tight joints are not made on the threads—Part 1: Dimensions, tolerances and designation*

JIS B 0203 *Taper pipe threads*

NOTE Corresponding International Standard: ISO 7-1 *Pipe threads where pressure-tight joints are made on the threads—Part 1: Dimensions, tolerances and designation*

JIS B 2220 *Steel pipe flanges*

JIS B 2239 *Cast iron pipe flanges*

NOTE Corresponding International Standard: ISO 7005-2 *Metallic flanges—Part 2: Cast iron flanges*

JIS B 2240 *Copper alloy pipe flanges*

NOTE Corresponding International Standard: ISO 7005-3 *Metallic flanges—Part 3: Copper alloy and composite flanges*

JIS B 2301 *Screwed type malleable cast iron pipe fittings*

NOTE Corresponding International Standard: ISO 49 *Malleable cast iron fittings threaded to ISO 7-1*

JIS B 2312 *Steel butt-welding pipe fittings*

JIS B 2351-1 *Metallic tube connections for fluid power and general use—Part 1: 24 degree SIGN compression fittings*

NOTE Corresponding International Standard: ISO 8434-1 *Metallic tube connections for fluid power and general use—Part 1: 24° cone connectors*

JIS B 2351-5 *Metallic tube connections for fluid power and general use—Part 5: Test methods for threaded hydraulic fluid power connections*

NOTE Corresponding International Standard: ISO 19879 *Metallic tube connections for fluid power and general use—Test methods for hydraulic fluid power connections*

JIS B 8415-1 *General safety code for industrial combustion furnaces—Part 1: General requirements*

NOTE Corresponding International Standard: ISO 13577-1 *Industrial furnaces and associated processing equipment—Safety—Part 1: General requirements*

JIS B 8415-3 *General safety code for industrial combustion furnaces—Part 3: Protective systems*

NOTE Corresponding International Standard: ISO 13577-4 *Industrial furnace and associated processing equipment—Safety—Part 4: Protective systems*

JIS B 9700 *Safety of machinery—General principles for design—Risk assessment and risk reduction*

NOTE Corresponding International Standard: ISO 12100 *Safety of machinery—General principles for design—Risk assessment and risk reduction*

JIS B 9960-1 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements*

NOTE Corresponding International Standard: IEC 60204-1 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements*

JIS C 9730-2-5 *Automatic electrical controls for household and similar use—Part 2-5: Particular requirements for automatic electrical burner control systems*

NOTE Corresponding International Standard: IEC 60730-2-5 *Automatic electrical controls—Part 2-5: Particular requirements for automatic electrical burner control systems*

JIS C 9730-2-6 *Automatic electrical controls—Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

NOTE Corresponding International Standard: IEC 60730-2-6 *Automatic electrical controls—Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

JIS G 3452 *Carbon steel pipes for ordinary piping*

JIS G 3454 *Carbon steel pipes for pressure service*

JIS G 3455 *Carbon steel pipes for high pressure service*

JIS G 3456 *Carbon steel pipes for high temperature service*

JIS G 3457 *Arc welded carbon steel pipes*

JIS G 3458 *Alloy steel pipes*

JIS G 3459 *Stainless steel pipes*

JIS G 3460 *Steel pipes for low temperature service*

JIS G 3461 *Carbon steel tubes for boiler and heat exchanger*

JIS G 3462 *Alloy steel tubes for boiler and heat exchanger*

JIS G 3463 *Stainless steel tubes for boiler and heat exchanger*

JIS H 3300 *Copper and copper alloy seamless pipes and tubes*

JIS H 3401 *Pipe fittings of copper and copper alloys*

JIS K 6774 *Polyethylene pipes for the supply of gaseous fuels*

ISO 5817 *Welding—Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded)—Quality levels for imperfections*

ISO 8434-2 *Metallic tube connections for fluid power and general use—Part 2: 37 degree flared connectors*

ISO 8434-3 *Metallic tube connections for fluid power and general use—Part 3: O-ring face seal connectors*

ISO 23550 *Safety and control devices for gas and/or oil burners and appliances—General requirements*

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

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

- ISO 23551-3 *Safety and control devices for gas burners and gas-burning appliances—Particular requirements—Part 3: Gas/air ratio controls, pneumatic type*
- ISO 23552-1 *Safety and control devices for gas and/or oil burners and gas and/or oil appliances—Particular requirements—Part 1: Fuel/air ratio controls, electronic type*
- ISO 23553-1 *Safety and control devices for oil burners and oil-burning appliances—Particular requirements—Part 1: Automatic and semi-automatic valves*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS B 9700**, and the following apply.

3.1 Combustion and burner

3.1.1

burner

device(s) for the introduction of fuel, air, oxygen or oxygen-enriched air at the required velocities, mixing and concentrations to maintain ignition and combustion of fuel

NOTE See **2.10** of **ISO 13574**.

3.1.2

pilot burner

independently controlled burner designed to ignite the main burner

NOTE See **2.21** of **ISO 13574**.

3.1.3

permanent pilot burner

pilot burner that is intended to be left on permanently

NOTE See **2.20** of **ISO 13574**.

3.1.4

cross-ignited burner

group of burners designed and arranged such that, by means of their proximity and relative position, ignition of all burners can be ensured if one burner is ignited

Example A line burner

NOTE See **2.13** of **ISO 13574**.

3.1.5

forced draught burner

burner in which the main air for combustion is supplied by means of a fan

NOTE See **2.14** of **ISO 13574**.

3.1.6

induced draught burner

burner in which the combustion air is supplied by providing suction in the combustion chamber by mechanical means, usually a fan

NOTE See **2.16** of ISO 13574.

3.1.7

natural draught burner

burner in which the combustion air is entrained at atmospheric pressure, by the buoyancy of a chimney or the fuel velocity

NOTE See **2.18** of ISO 13574.

3.1.8

radiant tube burner

burner that heats up the furnace indirectly by means of firing into a radiant tube protruding into the furnace whereby the combustion remains wholly separated from the furnace

NOTE See **2.24** of ISO 13574.

3.1.9

combustion chamber

part of combustion furnace in which the combustion takes place

NOTE See **2.39** of ISO 13574.

3.1.10

flashback

flame propagation from the burner in upstream direction inside the piping

NOTE See **2.69** of ISO 13574.

3.1.11

high-temperature equipment

combustion furnace operating at 750 °C or above in the temperature inside the furnace

NOTE See **2.83** of ISO 13574.

3.1.12

lighting torch

hand-held burner that is used to ignite another burner

NOTE See **2.97** of ISO 13574.

3.1.13

LFL (lower flammability limit)

minimum concentration of vapour-to-air below which propagation of a flame will not occur in the presence of an ignition source

NOTE 1 Synonymy of LEL (lower explosion limit).

NOTE 2 See **2.104** of ISO 13574.

3.1.14

low-temperature equipment

combustion furnace operating at below 750 °C in the temperature inside the furnace

NOTE See **2.105** of **ISO 13574**.

3.1.15

multiple burner equipment

combustion furnace with several burners with a common air and fuel piping firing in a common combustion chamber

NOTE See **2.112** of **ISO 13574**.

3.1.16

single burner equipment

equipment operating with one burner

NOTE See **2.173** of **ISO 13574**.

3.1.17

regenerative burner

regenerative combustion type burner incorporating heat storage bodies such as ceramic balls and ceramic honeycomb as a heat exchanger in an air supply/exhaust channel

3.1.18

alternative regenerative burner

a regenerative burner which burns two units as a set while switching alternately in a short time

While one burner is burning, the other burner sucks a exhaust gas inside the furnace and stores heat, then when switched, the combustion air is passed through the heat storage body, pre-heated and used for combustion. Therefore, in this system, burning burners are the half of installed burners.

3.2 Fuel supply

3.2.1

wobbe index

calorific value of a gas, on a volumetric basis, at specified reference conditions, divided by the root square of its relative density, at the same specified metering reference conditions

NOTE 1 Wobbe index is gross or net depending on whether the calorific value used is the gross or net calorific value.

NOTE 2 See **2.206** of **ISO 13574**.

3.2.2

pressure

pressure relative to atmospheric pressure (gauge pressure)

NOTE 1 As a consequence, vacuum is designated by a negative value.

NOTE 2 See **2.128** of **ISO 13574**.

3.3 Burner operation

3.3.1

burner input rate

highest quantity of fuel energy used by a burner in unit time corresponding to the volumetric or mass flow rates, and the calorific value used being the net calorific value

NOTE See **2.11** of **ISO 13574**.

3.3.2

calorific value

quantity of heat produced by the combustion, at a pressure of 101.3 kPa of unit volume or mass of gas, the constituents of the combustible mixture being taken at reference conditions and the combustion products being brought back to the same conditions

NOTE 1 There are two types of calorific values.

- a) Superior caloric value including latent heat of water produced by combustion assumed to be condensed
- b) Inferior caloric value not including latent heat of water produced by combustion assumed to be condensed

NOTE 2 See **2.28** of **ISO 13574**.

3.3.3

start fuel flow rate

fuel flow rate during the start-up of the burner(s)

NOTE See **2.178** of **ISO 13574**.

3.3.4

air/fuel ratio

ratio between the mass flow rate of combustion air and the mass flow rate of fuel

NOTE See **2.2** of **ISO 13574**.

3.3.5

oxygen-enriched combustion air

combustion air used in a combustion furnace having an oxygen concentration (volume fraction) of 25 % or over, to which oxygen is added or nitrogen concentration is reduced

NOTE 1 In this Standard, oxygen-enriched combustion air is defined as the air with an oxygen concentration of 25 % based on the safety division.

NOTE 2 Requirements in **4.5** are specified regarding oxygen and oxygen-enriched combustion air as oxygen.

3.4 Fuel piping construction devices

3.4.1

condensate drain

pipe designed to collect and drain condensates from gas piping

NOTE See **2.40** of **ISO 13574**.

3.4.2

filter/strainer

device that enables foreign elements to be collected, which could otherwise cause failures in the system

NOTE See **2.63** of **ISO 13574**.

3.4.3

nominal size

alphanumeric designation of size for components of a pipework system, which is used for reference purposes, comprising a dimensionless whole number which is indirectly related to the physical size, followed by the letter A, of the bore or outside diameter (mm) of the end connections

NOTE See **2.115** of **ISO 13574**.

3.4.4

pipework

assembly of piping including devices such as valves and orifices by means of which fuel and combustion air or oxygen convey from the point(s) of supply to the burner(s)

NOTE See **2.123** of **ISO 13574**.

3.4.5

piping

components intended for the transport of fluids, when connected together for integration into a pressure system

NOTE See **2.124** of **ISO 13574**.

3.4.6

maximum allowable pressure

maximum pressure for which the equipment or piping system is designed, as specified by the manufacturer

NOTE 1 It is defined at a location specified by the manufacturer. This shall be the location of connection of protective and/or limiting devices or the top of equipment, or if not appropriate any point specified.

NOTE 2 See **2.132** of **ISO 13574**.

3.4.7

proof-of-closure switch

electrical switch that monitors the closed position of the valve closure member and which is used as an interlock

NOTE See **2.136** of **ISO 13574**.

3.4.8

test pressure

pressure to which pipework is submitted to a check for soundness

NOTE See **2.186** of **ISO 13574**.

3.4.9

automatic shut-off valve

valve that opens when energised and closes automatically when de-energized to shut off the fuel supply

NOTE See **2.194** of **ISO 13574**.

3.4.10

closing force

force available to close the valve, independent of any force provided by fuel gas pressure

NOTE See **2.195** of **ISO 13574**.

3.4.11

manual isolating valve

manually operated valve which is upstream of all other fuel controls to that combustion furnace and by means of which the fuel supply to the combustion furnace can be shut off

NOTE See **2.198** of **ISO 13574**.

3.4.12

manual shut-off valve

manually operated valve by means of which the fuel supply to an individual burner or to a group of burners can be shut off

NOTE See **2.199** of **ISO 13574**.

3.4.13

non-return valve

device to prevent the back-flow of air, fuel, oxygen etc.

NOTE See **2.200** of **ISO 13574**.

3.4.14

pressure relief valve

valve or regulator designed to relieve excessive pressure

NOTE See **2.201** of **ISO 13574**.

3.5 Adjustment, control and safety devices

3.5.1

air pressure detector

device for sensing the existence of air pressure

NOTE See **2.1** of **ISO 13574**.

3.5.2

automatic burner control system

protective system comprised of at least a programming unit and all the elements of a flame detector device

NOTE 1 The various functions of an automatic burner control system can be in one or more housings.

NOTE 2 See **2.5** of **ISO 13574**.

3.5.3

control system

system that responds to input signals from the process and/or the furnace operator and generates output signals which cause the process control to operate in the required way

NOTE See **2.41** of **ISO 13574**.

3.5.4

pressure relief

device containing a part which is designed to yield safely to an unsafe increase of internal pressure

NOTE See **2.61** of **ISO 13574**.

3.5.5

flame detector device

device by which the presence of a flame is detected and signalled, which consists of a flame sensor, a flame detector amplifier and a relay for signal transmission

NOTE See **2.65** of **ISO 13574**.

3.5.6

flame sensor

practical flame-sensing element, the output signal value of which is used as the input for flame detector amplifier

NOTE See **2.67** of **ISO 13574**.

3.5.7

flame arrestor, flame trap

device fitted to the pipework, and its intended function is to allow flow but prevent the transmission of flame

NOTE See **2.68** of **ISO 13574**.

3.5.8

gas pressure regulator

device that maintains the downstream pressure constant to within fixed limits, independent of variations, within a given range, of the upstream pressure and/or flow rate

NOTE See **2.74** of **ISO 13574**.

3.5.9

lock-out

safety shut-down by the protective system itself, such that a restart can only be accomplished by a manual reset

This refers to non-volatile lock-out.

NOTE See **2.101** of **ISO 13574**.

3.5.10

manual reset

action after a lock-out of a safety related device (e.g. automatic burner control) carried out manually by the supervising furnace operators

NOTE See **2.107** of **ISO 13574**.

3.5.11

protective system

instrumented system used to implement one or more safety related instrumented functions

A protective system is composed of any combination of sensor(s), logic solver(s) and final elements.

NOTE 1 This can include either safety related instrumented control functions and/or safety related instrumented protection functions.

NOTE 2 See **2.138** of **ISO 13574**.

3.5.12

purge

forced introduction of a fluid into a pre-determined area, in order to cleanse, by displacement, the existing fluid

NOTE See **2.141** of **ISO 13574**.

3.5.13

pre-purge

forced introduction of air or inert gas into the combustion chamber and flue passages, in order to displace any remaining fuel, air mixture and/or combustion products, and which takes place between the start signal and the energizing of the ignition device

NOTE See **2.142** of **ISO 13574**.

3.5.14

recycling

process by which, after a safety shut-down, a full start-up sequence is automatically repeated

NOTE See **2.154** of **ISO 13574**.

3.5.15

safe discharge area

zone which is safeguarded against the risk of combustion of discharged flammable gasses

NOTE See **2.162** of **ISO 13574**.

3.5.16

safety device

device used for implementation of protective functions, either by alone or as a part of protective system

NOTE For example, sensors, limiters, flame supervision devices, burner control systems, logic systems, operation terminals, automatic shut-off valves

3.5.17

safety shut-down

process that is effected immediately following the response of a safety device or the detection of a fault in the automatic burner control system and which puts the burner out of operation by immediately closing the automatic fuel shut-off valves and the ignition device

NOTE See **2.166** of **ISO 13574**.

3.5.18

valve proving system

system to check the effective closure of automatic shut-off valves by checking leak-tightness

It shall consist of a programming unit, a measuring device, valves and other functional assemblies.

NOTE See **2.193** of **ISO 13574**.

3.6 Sequence time

3.6.1

ignition

starting up the chemical reaction of combustion of a fuel/combustion air mixture by application of a much smaller energy source

NOTE See **2.87** of **ISO 13574**.

3.6.2

main flame

flame, other than the ignition flame, on the main burner

NOTE See **2.106** of **ISO 13574**.

3.6.3

safety time

interval between a fuel valve being energised and de-energised if the flame detector signals the absence of a flame

NOTE See **2.167** of **ISO 13574**.

3.6.4

safety time, first

interval between the pilot fuel valve, the start fuel valve or main fuel valve being energised and each being de-energised if the flame detector signals the absence of a flame

NOTE See **2.168** of **ISO 13574**.

3.6.5

safety time, second

interval between the main fuel valve being energised and being de-energised if the flame detector signals the absence of a flame

NOTE 1 Definition used only if there is a first safety time applicable to either a pilot or start gas flame.

NOTE 2 See **2.169** of **ISO 13574**.

3.6.6

total closing time

interval between the occurrence of an unsafe condition and the automatic shut-off valves being in fully closed position

NOTE See **2.192** of **ISO 13574**.

3.6.7

closing time

interval between de-energizing the valve and the closure member attaining the closed position

NOTE See **2.197** of **ISO 13574**.

4 Safety requirements and protective measures

4.1 General

To ensure the safety of the combustion and fuel handling system of combustion furnace, the following shall be satisfied:

- choice of materials such that the construction and operation of the system are not detrimentally affected. In particular, all the components of piping shall be capable of withstanding the mechanical, chemical and thermal loads to which they can be subjected during normal operation and foreseeable abnormal operation (e.g. identified during a safety assessment);
- reliable and correct time for ignition of the air/fuel-mixture at the burner(s);
- prevention of unintentional release of unburned fuels;
- shut-off fuel-supply in case of relevant fault;
- protection of pipeline to preclude the propagation of flame in reverse direction;
- prevent ignition when the evacuation of combustion products is not ensured;
- prevent ignition when the process conditions are not in the safe state.

A risk assessment in accordance with **JIS B 9700** shall be carried out.

Electrical circuits shall be designed in accordance with **JIS B 9960-1**. However, the requirements to meet **JIS B 9961** and/or **JIS B 9705** (all parts) described in **9.4.1** of **JIS B 9960-1** are not applicable where the requirements of the protective system specified in **JIS B 8415-3** apply. Annex F provides information for the determination of SIL or PL of safety-related functions covered in this Standard.

4.2 Gaseous fuels

4.2.1 Gaseous fuel pipework

4.2.1.1 General

The pipework design shall take into account the composition and properties (e.g. pressure, temperature, corrosiveness, specific gravity) of the fuel gas and the need for venting, purging and cleaning.

The pipework materials shall be in accordance with the relevant standards.

Oscillations which may cause damage to pipework, components or safety systems shall be prevented by a suitable means (e.g. firm anchoring and/or use of flexible couplings). The gaseous fuel piping shall be in accordance with **JIS G 3452**, **JIS G 3454**, **JIS G 3455**, **JIS G 3456**, **JIS G 3457**, **JIS G 3458**, **JIS G 3459**, **JIS G 3460**, **JIS G 3461**, **JIS G 3462**, **JIS G 3463**, **JIS H 3300** and **JIS K 6774**. **JIS G 3458** is applicable only to the piping of under 1.6 MPa in pressure, **JIS G 3452** of under 1.0 MPa in pressure, **JIS K 6774** of under 0.3 MPa for embedded part, and **JIS H 3300** of 0.1 MPa for exposed part.

The flexible piping and fittings shall be in accordance with **4.2.1.5**.

4.2.1.2 Connections

Gas pipework connections shall be metallic and shall be of threaded, compression, flanged, welded or brazed types. The number of connections shall be kept to a minimum.

Threaded connections shall be used only for the following pressure/nominal size combinations:

- nominal size up to 100 A, pressure 15 kPa or under
- nominal size up to 50 A, pressure 200 kPa or under
- nominal size up to 25 A, pressure 500 kPa or under
- nominal size up to 15 A, pressure 1 MPa or under

For fittings in accordance with **JIS B 2301**, the following limitations shall be observed:

- maximum allowable pressure is 50 kPa;
- for nominal size 25 A or under, the maximum allowable pressure is 500 kPa.

Where the equipment has a threaded connection, the threads shall be in accordance with **JIS B 0202** or **JIS B 0203** as appropriate. The threaded connection complying with **JIS B 0202** is limited to up to 50 A in nominal size. In the case of the threaded connection complying with **JIS B 0202**, the tightness shall be ensured by a ring gasket. In the case of the threaded connection complying with **JIS B 0203**, suitable sealants shall be used to ensure tightness.

Other threaded connections may only be used providing they ensure tight connections and are suitably identified.

The design of pipework shall be such as to avoid tensile loading of the connection parts.

For steel pipes of 20 A or under in nominal size and 0.1 MPa or under in maximum service pressure, bite type connections may be used.

For copper and copper alloy seamless pipes, the fittings shall be in accordance with **JIS H 3401**, and for pipes of 20 A or under in nominal size and used at 0.01 MPa or under in pressure, flared connections or bite type connections may be used.

Compression fittings shall comply with **JIS B 2351-1**, **JIS B 2351-5**, **ISO 8434-2** or **ISO 8434-3**. They shall only be used for pressures 500 kPa or under and pipe diameters 42 mm or under.

Any pipe passing through an unventilated space shall not have a connection except welded fittings.

Flanges shall comply with **JIS B 2220** and **JIS B 2239** as appropriate.

Arc welding shall comply with **ISO 5817**, quality level C.

When pipes of dissimilar metal materials are connected, bimetallic corrosion (galvanic corrosion) shall be avoided by selecting appropriate materials.

4.2.1.2A Installation place of fuel pipework, etc.

Fuel piping, air piping, oxygen piping, exhaust pipes and their accompanying devices shall be installed in such a place where there is no risk of overheating or breakage. The accompanying devices herein mean such devices contacting with the fluid in piping as valves, gas pressure regulators, mixers, pressure gauges, flowmeters and thermometers, excluding fans and pumps, in addition to the parts necessary for the connection of piping.

4.2.1.3 Unconnected pipework

Any unconnected pipework shall be plugged, capped or blank flanged by means of metallic parts.

4.2.1.4 (Missing number)

4.2.1.5 Flexible piping and fittings

The flexible piping shall satisfy the general requirements of **4.2.1.1**, together with the following:

- shall be as short as practicable;
- shall be suitable for the maximum and minimum operating temperatures (fuel and ambient);
- shall be suitable for a pressure 1.5 times the pressure at operation (with a minimum of 15 kPa), at the maximum and minimum operating temperatures;
- shall have a directly accessible, upstream manual shut-off valve;
- shall be mounted in such a way as to avoid distortion, whiplash and damage;
- shall be constructed from suitable material both metallic and/or non-metallic selected for the application duty and not be easily damaged.

Fittings for removable devices shall ensure a gastight connection with the equipment connected and disconnected.

4.2.1.6 Marking

The gas pipework shall be identified as gas pipework.

4.2.1.7 Soundness/tightness

The gas pipework shall be tight and designed to withstand the pressure 1.5 times the maximum service pressure. After assembly, the gas pipework shall be submitted to its test pressure and tested for leak-tightness. The test pressure shall be not less than 1.1 times the maximum service pressure at any point.

The external leakage rate shall not give rise to a dangerous condition, flammable and/or toxic, in the foreseen circumstances of the device installation. As an example of appropriate leakage test method, there are a spray bubble leak test, pressure decay monitoring and the like. The method and frequency of testing to determine the external leakage shall be specified in the instruction handbook (see **6.3.3**).

In addition to the pressure test on the pipework, all the pressure relief valves shall be tested to ensure their operation at the correct pressure.

4.2.1.8 Condensate drains

In cases where condensates can create a hazard, means shall be provided at the lowest points of the device for draining any condensate. Any condensate drains, siphons, etc. shall be in a position such that they can be easily checked. Flammable condensates shall be collected by an appropriate means (e.g. piped into a container).

Valves in condensate drains shall be suitably plugged, capped or blank flanged by metallic parts.

4.2.1.9 Purge points

Means shall be provided to facilitate purging of the gas piping during commissioning and maintenance to prevent the build-up of flammable substances.

4.2.1.10 Blow-off pipes, breather pipes or conduits

Where blow-off pipes, breather pipes or conduits are fitted on regulators or relief valves or vent valves, adequate means shall be provided to facilitate the venting of gas from the system to a safe discharge area.

In case breather pipes or blow-off pipes are gathered, the cross section of the collector shall be suitable to evacuate simultaneously total flow rates of the exhaust sources.

In case breather pipes are gathered with blow-off pipes, non-interaction of the collected lines, valves and instruments shall be verified.

4.2.1.11 Pressure relief devices and flame arrestors on pipework

For equipment designed for situations in which flashback can occur, flame arrestors and/or pressure relief devices shall be fitted.

Pressure relief devices shall be designed to yield at a pressure of the design pressure of the pipework or under, and shall be positioned such that the discharge fluid and the pressure relief device does not constitute a risk to the equipment, furnace operators or third parties.

Especially, concerning the fuel piping through which oxygen or oxygen-enriched combustion air is supplied to the combustion furnace, one or more back-flow preventing devices and flame arrestors respectively shall be installed in the place nearest to each burner.

NOTE Requirements regarding oxygen and oxygen-enriched combustion air are specified in **4.5**.

A flashback at least shall trigger an alarm. The required measures after a flashback shall be described in the instruction handbook.

4.2.1.12 Pressure oscillations

The gas pipework shall be designed so as to avoid the possibility of gas velocities and pressure fluctuations causing oscillations which could cause damage to pipework, components or safety systems (e.g. by designing the correct sizing of piping, using pressure regulator).

4.2.1.13 Equipment supplied with different fuel gases

Where a burner is intended for alternating use with more than one gaseous fuel, means shall be provided to ensure that the supply pipework of the gas not being fired is positively isolated.

4.2.1.14 By-passes

Mechanical and/or electric by-passes shall not be fitted in parallel with any item of safety device. This requirement shall not apply to valve proving systems (see **ISO 23551-4**) on automatic shut-off valves.

When a by-pass is required for the purpose of maintenance management such as leakage check, a by-pass for an automatic shut-off valve may be installed only when any of the following measures is taken:

- installation of interlock for preventing the equipment from operating when the by-pass is in operation;
- stand-by system or a starting circuit with an automatic shut-off valve equipped in the by-pass.

4.2.1.15 Isolation of required safety devices

Required safety devices (e.g. pressure switches, relief valves) shall not be isolated from the equipment they protect during start-up or operation of the burner. In case isolating valves cannot be avoided and are mounted between these required devices and the main piping, these isolating valves shall be locked in the open position during operation of the equipment by adequate means (e.g. manual lock).

4.2.1.15A Grounding

A pipework such as fuel piping and accompanying devices should be grounded for the purpose of preventing static electricity accidents.

4.2.1.15B Gas booster

A gas booster shall be constructed in such a way as to be free from gas leakage and air suction through the shaft part, etc. and installed according to the following:

- a) Lubrication oil, etc. shall not be contaminated into the discharge gas.

- b) The discharge gas pressure shall not increase up to 1.5 times or higher the design pressure of the piping, etc. installed downstream of the gas booster, and there shall be no pressure fluctuation affecting the combustion.
- c) There shall be no abnormal decrease in the suction pressure adversely affecting the supply pressure upstream of the gas booster.
- d) In case where there is a risk that the gas pressurized by the gas booster may back-flow to the upstream adversely affecting the supply pressure on the upstream side, some back-flow prevention measures shall be taken.
- e) The gas booster shall not give excessive vibrations to pipework.

4.2.2 Required safety devices

4.2.2.1 Manual isolating valve

A manually operated isolation valve shall be fitted upstream of the first control device in the gas pipework. Manual isolating valves shall be so designed or positioned as to prevent inadvertent operation but shall be easily accessible and capable of rapid operation when required.

They shall be so designed that the “Open” and “Close” positions are readily distinguishable (e.g. a 90° turn valve if applicable and available).

4.2.2.2 Filter/strainer

Special care should be taken to prevent the ingress of particles, either from the pipework or from the gas, which would be detrimental to the operation of the equipment by the incorporation of a suitable filter/strainer immediately downstream of the first manual isolating valve of the equipment. Additional filters/strainers may be required (e.g. immediately upstream of the automatic shut-off valve). The filter/strainer shall be positioned in such a way that periodic maintenance services can be carried out easily. The filtering capacity of filter/strainer has to be chosen according to the requirements of downstream device.

NOTE Normally safety and control devices for gas burners and gas-burning appliances require upstream filters with filtering capacity of 50 µm or under. Strainers with larger mesh size are only suitable for primary cleaning.

In case of the installation of a by-pass to the filter/strainer, an identical filtering device shall be installed on the by-pass line.

The intervals for checking the filter and/or the strainer shall be specified in the instruction handbook.

4.2.2.3 Gas pressure regulator

A gas pressure regulator shall be incorporated where this is necessary for control of the pressure and the flow rate.

Gas pressure regulators when fitted shall comply with **ISO 23551-2** as appropriate.

If the outlet side of the gas pressure regulator and/or the following pipework up to the burner is/are not designed for the maximum supply pressure (inlet pressure upstream to the gas pressure regulator under fault conditions) an over pressure cut-off device shall be installed upstream of the gas pressure regulator shutting off the gas supply before an excessively high pressure occurs.

The over pressure cut-off device shall be:

- a mechanical valve which measures the gas pressure downstream of the gas pressure regulator by means of an impulse line and closes by spring force in case the pressure exceeds the set response pressure, or
- an automatic shut-off valve complying with **ISO 23551-1** actuated by an overpressure detector installed downstream of the gas pressure regulator. The overpressure detector shall comply with **JIS C 9730-2-6** or be evaluated to ensure appropriate reaction time and accuracy. In this case, signal processing shall meet the requirements of the protective system specified in **JIS B 8415-3**.

A small capacity relief valve shall always be applied downstream of the gas pressure regulator, if an over pressure cut-off device is installed to vent small leakages of the high pressure cutoff.

Pressure adjustment on the gas pressure regulator shall only be possible with a special tool provided for the task.

Where the gas for the pilot burner is taken from upstream of the gas pressure regulator to the main burner(s), the pilot burner shall be equipped with a separate gas pressure regulator.

4.2.2.4 Low gas pressure protection

Low gas pressure protection measures shall be fitted. The low gas pressure protection device has to provide satisfactory and reliable proof of the pressure for all operation conditions.

The system shall prevent start-up or cause safety shut-down and lock-out in the event of pressure falling below a pre-determined value. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

Gas pressure detectors shall comply with **JIS C 9730-2-6** or shall be evaluated to ensure appropriate reaction time and accuracy.

4.2.2.5 High gas pressure protection

High gas pressure protection measures shall be fitted in all circumstances except when:

- the equipment supply pressure does not exceed 10 kPa, and
- regulator failure does not result in an unsafe start-gas flow rate being obtained.

Where high gas pressure protection is required, the system shall prevent start-up or cause safety shut-down and lock-out in the event of a pre-determined pressure being exceeded. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

Gas pressure detectors shall comply with **JIS C 9730-2-6** or shall be evaluated to ensure appropriate reaction time and accuracy.

4.2.2.6 Automatic shut-off valves

The gas supply to each burner or group of burners shall be under the control of two automatic shut-off valves in series in the gas pipework in accordance with the following subclauses of **ISO 23551-1**:

- for general requirements (see **7.1**);
- for leak tightness (see **7.2**);
- for durability (see **7.5**);
- for the closing function (see **7.6.101**);
- for the closing force (see **7.6.104**);
- for the closing time (see **7.6.106**).

The closing time shall satisfy the total closing time specified in **4.2.7.8**.

The automatic shut-off valves shall endure the intended number of cycles in the furnace equipment.

The construction and materials of automatic shut-off valves shall be suitable for the used gas composition.

Automatic shut-off valves shall be capable of withstanding all upstream pressures, backpressure and differential pressure under all process circumstances.

High cycling applications over 100 000 cycles/year, (e.g. pulse firing, regenerative burners) shall use only valves that are declared capable of the intended number of cycles and on/off cycling rate.

The instruction handbook shall specify the need to check automatic shut-off valves for correct operation, the procedure to be adopted and the intervals at which this should be carried out and the requirements for replacement. Means to permit the furnace operators to determine when automatic shut-off valves require replacement shall be supplied.

NOTE 1 It is commonly agreed that valves are to be tested annually unless longer testing intervals can be justified by the risk analysis.

In the durability test on the fuel switching valve of regenerative burner, the operation of the valve should be repeated 2×10^6 cycles (2 million cycles) or more. The durability test shall be carried out by the method specified in **ISO 23550**. Relays having mechanical durability against 10^7 cycles or more and electrical durability against 2×10^6 cycles or more should be used for switching valves.

All systems shall have the ability for manual leak testing of the automatic shut-off valve.

Control valves may be used as safety shut-off valves provided they are designed as both safety shut-off and modulation valves and tested for concurrent use.

The automatic shut-off valves shall not open or shall shut off the fuel to the burner when the limit of any safety condition is reached. In this case, the relevant automatic shut-off valves shall be de-energised by the protective system specified in **JIS B 8415-3**.

NOTE 2 Examples for safety related conditions to be considered are (but not limited to): minimum and/or maximum gas flow rate, minimum and/or maximum gas pressure, minimum and/or maximum airflow rate, minimum and/or maximum air pressure, failure of power supply and/or other utilities (e.g. compressed air, steam), failure of heat transfer fluid, fume extraction malfunction, minimum and/or maximum operating temperature, minimum and/or maximum combustion chamber pressure, flame failure,

failure of valve proving as referred in **4.2.2.7** and incorrect air gas ratio as referred in **4.2.3.3**.

It shall only be possible to manually reset (locally or remotely) the lock-out of a closed automatic shut-off valve.

Flame failure or process control shut down shall cause the closing of two automatic shut-off valves piped in series except in the following cases where closing a single individual burner shut-off valve is sufficient:

- in case of high-temperature operation;
- in case of low-temperature operation where the individual burner automatic shut-off valve is fitted with POC in accordance with **ISO 23551-1**, and the protective system closes an upstream automatic shut-off valve (header valve) if one of the individual burner valve is not proven closed by the POC switch.

Flame failure or process control shut down of radiant tube burner system shall cause the closing of two automatic shut-off valves piped in series except in the following cases where the closing of a single individual burner shut-off valve is sufficient:

- each radiant tube burner system is explosion resistance;
- the exhaust system dilutes the ignitable fuel-air-mixture from leaking gas valves inside the exhaust system of 25 % or under of the LFL.

Typical examples of piping and components are shown in Annex C.

4.2.2.7 Proof-of-closure of automatic shut-off valve (valve proving)

The closure of automatic shut-off valves controlling capacities higher than 1 200 kW shall be proved at each start-up of combustion furnace. In case where the closure of valve is not proved, the current start-up shall be stopped and the system shall go to lock-out.

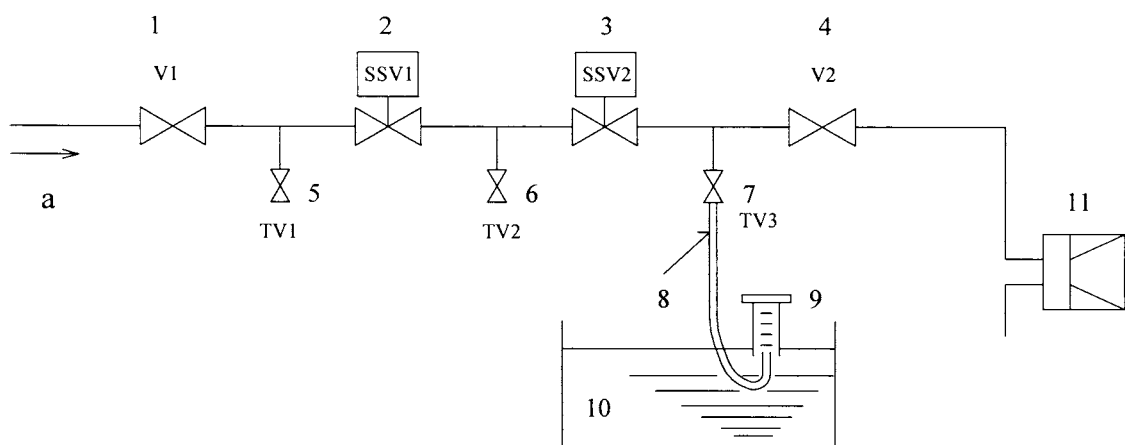
The proof-of-closure of valve shall be carried out at least once a year. The valve proving procedure and the action after such failure shall be specified in the instruction handbook (e.g. replacement of valve). An example of the procedure of proof-of-closure of valve is shown in the following and Figure 1.

- a) Apply a pressure to the interval between SSV2 and V2 to confirm that there is no pressure drop. Pay attention to the reverse withstand voltage of the automatic shut-off valve.
- b) Open V1 with SSV2 closed, and open SSV1 or apply a pressure to SSV2 upstream after having connected TV1 with TV2 using a rubber hose, etc.
- c) Under this condition, open V2 to make the pressure of SSV2 downstream equal to the atmospheric pressure, then close V2. Attach a rubber hose etc. to TV3, immerse other end of the hose in a water container such as a beaker by about 10 mm in depth to check if bubbles appear or not when TV3 is opened (passing through check). If bubbles continue to appear without stopping, the automatic shut-off valve is judged to be leaking. The leakage rate shall be measured and the valve shall be repaired or replaced. The leakage shall be calculated by measuring the amount of gas trapped in a measuring cylinder containing water and by measuring the time using a stopwatch or the like.

- d) Similarly, carry out the passing through check and the leakage rate measurement on SSV1 upstream.
- e) When there are three or more valves, the similar checks and measurements shall be carried out in sequence starting from the most downstream.

In the case of such piping as used in a low frequency application for which a gas pressure cannot be used for proof-of-closure of valve, supply a high-pressure gas from the upstream side of the automatic shut-off valve to be checked.

The leakage rate shall comply with **ISO 23550**.



Key

- 1 Burner manual shut-off valve 1 (V1)
- 2 Automatic shut-off valve 1 (SSV1)
- 3 Automatic shut-off valve 2 (SSV2)
- 4 Burner manual shut-off valve 2 (V2)
- 5 Test valve 1 (TV1)
- 6 Test valve 2 (TV2)

Key

- 7 Test valve 3 (TV3)
- 8 Flexible hose
- 9 Measuring cylinder
- 10 Water container
- 11 Burner
- a Fuel gas flow direction

Figure 1 Proof-of-closure method of automatic shut-off valve

It is generally agreed that a leak rate of the valve(s) of 0.1 % or under of the maximum gas flow rate into the combustion chamber during operation is considered as the proof-of-closure of valve. In case of preheated gas and/or oxygen or oxygen enriched combustion, this value has to be readjusted accordingly.

For the furnace equipment intended to be started up more than two times a year, the closure of automatic shut-off valve(s) shall be proved by an automatic system. Automatic valve proving shall meet the requirements of the protective system specified in **JIS B 8415-3**.

Simultaneous closure of three automatic shut-off valves in series for each burner may be used as an alternative means for proving of closure specified in this clause.

Ball valves equipped with a closing position indicator (CPI) specified in **ISO 23551-1** may be used as a part of an automatic system for the proof-of-closure of valve.

In multiple burner systems with two automatic shut-off valves for each burner, automatic testing does not have to prove each burner valve individually (see Figure C.2b).

The testing of the individual burner valves shall be specified in the instruction handbook.

4.2.2.8 Individual manual shut-off valves for burners

For burners which are independently ignited, each individual burner shall be fitted with a manual shut-off valve suitable for the type of gas.

However, if the installation of such a manual valve affects the mixing characteristics of mixing devices (e.g. venturi mixers), the shut-off valve shall be installed upstream of any such device.

For multiple burners in which cross-ignition from burner to burner occurs by design, the complete group of burners shall be fitted with at least one manual shut-off valve.

4.2.2.8A In-furnace overheat prevention device

An in-furnace overheat prevention device which detects abnormal in-furnace temperatures and shuts off the fuel supply shall be installed in preparation for the case where the in-furnace temperature rises abnormally exceeding the specified furnace temperature range. This in-furnace overheat prevention device shall not be used in conjunction with the temperature regulator and its temperature detector for the control purpose, except for a glass melting furnace or the like.

The overheat prevention device shall meet the requirements of the protective system specified in **JIS B 8415-3**.

4.2.2.8B Seismo-sensing device

A seismo-sensing device which detects vibration shocks and shuts off the fuel supply should be installed, as necessary, in preparation for the case where an excessive vibration shock (seismic intensity 6 or higher) is caused by an earthquake. The seismo-sensitive device may be installed on the furnace equipment itself or in the factory, or the vibration data may rely on the earthquake alert signals from Japan Meteorological Agency.

4.2.2.8C Gas leakage detector

When a gaseous fuel is used, a gas leakage detector should be installed in a place where the leaking gas is likely to stagnate.

4.2.3 Combustion air and air/fuel ratio

4.2.3.1 Combustion air system

The pipework design shall take into account the properties of combustion air (e.g. pressure, temperature).

All manual control devices (ventilator, valves, etc.) shall be set in their pre-determined positions and protected against inadvertent movement.

The location of the combustion air intake shall be such as to prevent entry of impurities (e.g. dust) and combustion products, unless provided for by the design (e.g. for reduction of emission of nitrogen oxides NO_x).

The ventilation of furnace equipment shall be such as to allow an adequate supply of process air and combustion air to reach the burner(s) under all conditions.

Attention should be paid to sufficient air supply to the furnace equipment. For many applications, it is recommended to install an air inlet filter with filter monitoring to achieve reliable operation of the installation.

The combustion air system shall be designed in a manner that prevents the back-flow of furnace atmosphere through a burner.

The piping for combustion air shall be designed so as to avoid oscillations that may lead to hazards.

4.2.3.2 Airflow rate and pressure detectors

The furnace equipment fitted with forced or induced draught burner(s) shall be fitted with devices for proving adequate airflow during ignition and operation of the burner.

Airflow failure at any time during the pre-purge, ignition and operation of the burner shall cause safety shut-down and shall cause a lock-out. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

The air-proving device shall be checked in the “no flow” state prior to start-up [e.g. by stopping the combustion air supply or by stopping the air signal to the device(s) in such a way as to simulate stopping the combustion air supply]. Failure to prove the device in the “no flow” condition shall prevent start-up.

Airflow rate shall be monitored by either of the following:

- pressure detector;
- flow rate detector.

It shall be shown that any of these devices provide satisfactory and reliable proof of the flow for all operating conditions.

This requirement shall not apply to portable gas burners, work station burners and equipment-integrated burners with open flame, supervised continuously by trained furnace operators, and having a maximum burner input rating of 70 kW or under.

Air pressure detectors shall comply with **JIS C 9730-2-6** or shall be evaluated to ensure appropriate reaction time and accuracy. They shall be suitable for the number of operations foreseeable for the application.

4.2.3.3 Air/fuel ratio

The air/fuel ratio shall always be such that a stable and safe combustion is maintained at each individual burner throughout the operating range in order to ensure safe ignition. The ratio does not need to be the same value at all operational conditions.

If the variation of pressure and/or temperature of air and fuel gas affect the safety and combustion stability, then correction for pressure and/or temperature is required.

The design of the air/fuel ratio control has to consider process conditions as well as fuel and combustion air properties. Defect or malfunction should effect that the system will tend towards higher excess air or proceed to lock-out if the air/fuel ratio results in an unsafe condition.

Pneumatic air/fuel ratio controls shall comply with **ISO 23551-3**, if applicable.

Electronic air/fuel ratio controls shall comply with **ISO 23552-1**, if applicable.

To ensure their reliability, air/fuel ratio controllers complying with **ISO 23551-3** or **ISO 23552-1** shall be used in conditions (temperature, pressure, flow rate) for which they have been designed. These conditions and instructions for maintenance shall be specified in the instruction handbook.

In case other methods/technologies are used for the ratio control and depending on the combustion air and fuel gas properties, additional protective measures shall be applied according to the results of the risk assessment (e.g. air/fuel ratio monitoring by protective system specified in **JIS B 8415-3**). The method/technology and the procedure for the functional test shall be described in the instruction handbook.

4.2.4 Supply of pre-mixed fuel gas/air

4.2.4.1 Mixture pipework

The mixture pipework volume shall be minimized to reduce risk in the event of flashback, but shall not compromise pressure and flow distribution needed for stable burner operation. The system shall be designed so as to provide a sufficiently high mixture flow velocity such that flame propagation upstream cannot occur, or shall be fitted with flame trap(s)/arrestor(s), pressure relief devices or blowout devices to prevent damage in the mixture pipework and mixing equipment. Flame trap(s)/arrestor(s) if used shall be located as close to the burner(s) as practicable.

Alternatively, the system shall be fitted with a sensor which causes lock-out in the event of the flow velocity falling below a pre-determined limit or a temperature sensor which causes lock-out in the event of flashback. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

These devices are not required for burners where the manufacturer can demonstrate that flashback cannot occur in any circumstances (e.g. pilot burners with their own pre-mixing devices).

4.2.4.2 Air and gas supply to the pre-mixing device

The presence of fuel gas/air mixture in the pipework supplying either fuel gas or air to the pre-mixing device (e.g. due to back-flow of the mixture, ingress from outside or interior leakage) shall be prevented.

If a non-return valve is used for this purpose and if it is not resistant to flashback, then an additional high gas pressure switch located downstream of this non-return valve shall be incorporated to shut off the flow of fuel gas to the equipment by means of the relevant automatic shut-off valves specified in **4.2.2.6** in the event of a flame flashback.

In the case where a mixing blower is used for the pre-mixing device, the gas supply shall be automatically shut off when the mixing blower stops.

A flashback shall trigger an alarm. The required measures after a flashback shall be described in the instruction handbook.

4.2.5 Burners

4.2.5.1 Main burners

All burners shall be suitable for the service conditions and shall provide operating safety for:

- the fuels used (type, pressure, etc.);
- the operating conditions (pressure, temperature, atmosphere, etc.);
- the nominal input rate and range of regulation (maximum and minimum capacity);
- ease of visual monitoring (sight glasses, sight holes, etc.).

4.2.5.2 Radiant tube burner systems

Radiant tube burner systems shall be suitable and allow safe operation. They shall:

- be constructed of suitable materials for the thermal input rate, temperature and furnace atmosphere;
- minimize the probability of combustion products having contact with the furnace atmosphere.

4.2.5.3 Ignition device and pilot burner

The ignition device shall be reliable and of sufficient capacity, so that immediate, low noise and smooth ignition is obtained. Detail verification procedure for use in commissioning, operation and maintenance shall be included in the instruction handbook.

The construction and location of a pilot burner shall be such that, under all operating conditions, the pilot flame remains stable and of such a shape that the main flame is ignited.

For safety requirements, pilot burner(s) shall be treated as main burners and **4.2.2.3**, **4.2.2.4**, **4.2.2.5**, **4.2.2.6**, **4.2.2.7**, **4.2.2.8**, **4.2.3.2**, **4.2.3.3**, **4.2.6** and **4.2.7** shall apply.

Where pilot burners are used in the case of main burners supplied with gas or combustible vapours with uncertain combustion characteristics, (e.g. varying calorific value), permanent pilots shall be independently supplied with a clean fuel gas of constant quality (e.g. natural gas, liquefied petroleum gas) and be fitted with automatic burner control systems in accordance with **4.2.6**.

Where use is made of a portable pilot burner or ignition device:

- the pilot burner or ignition device shall be capable of being fitted in one way only and in such a way that it occupies a fixed position with respect to the burner to be ignited. If necessary, the correct position shall be monitored;
- the connections for fuel, air and ignition energy shall be so designed that a reliable link-up is obtained, and errors of fitting of connections are avoided.

4.2.5.3A Permanent pilots

In the case where the pilot burner is of a continuous ignition type or intermittent ignition type, the flame of pilot burner should be extinguished after the extinguishment of flame of main burner.

4.2.5.4 Burner input rate control

In any combustion system, the turndown ratio shall be such that the burner(s) is/are fully stable at all firing conditions. Means shall be provided to allow the determination of the burner input rate.

4.2.5.5 Flue gas venting

4.2.5.5.1 General

Flue gases shall be vented in a safe way.

The equipment with a closed combustion chamber or combustion chamber with at least three surrounding walls shall be equipped with a flue system. The cross sectional area of the flue system shall be calculated according to volume, pressure and temperature of the flue gases (combustion products, excess air and process emissions).

For the furnace equipment equipped with natural draught burners, the flue system shall be fitted with an appropriate draught break above the height of furnace operator, or control damper (for typical example of a draft break, see Figure C.7).

If the flue gases are extracted by a fan or the draught is controlled by a damper and the risk is not adequately reduced by the inherently safe design or mechanical design, the system shall be fitted with a safety device to cause a safety shut down of the burner(s) or a switching over to a backup duct system in the event of a failure in the flue venting. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

For all the furnace equipment burners supplied without a flue system, the combustion products shall be directed away from the workplace. The instruction handbook shall refer to the need for sufficient venting to ensure the correct air quality for the furnace operators.

4.2.5.5.2 Device for detecting abnormal pressure loss in heat exchangers

The device for detecting abnormal pressure loss in a heat exchangers shall be as follows.

- a) A heat exchanger should be equipped with a differential pressure detector or the like to prevent the passage pressure loss from increasing excessively resulting in adverse effects on the combustion, and should send a failure signal as necessary.
- b) For a burner, such as a regenerative burner, equipped with a heat reservoir in the charge air and exhaust flow passage as a heat exchanger, a device capable of detecting the differential pressure and flow rate should be installed, as necessary, in order to prevent defects in combustion due to the excessive pressure loss in the heat reservoir.

4.2.6 Automatic burner control systems

4.2.6.1 General

The main flame and, if applicable, the pilot burner flame, shall be supervised by means of an automatic burner control system or a flame detector complying with **JIS C 9730-2-5**. Exceptions are only permitted when specified in this Standard (e.g. see **4.2.6.2** and **4.2.6.3**). Flame supervision and burner control function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

For systems where the pilot burner remains in use during main burner operation, separate flame detector device to supervise the pilot and main flames shall be fitted. The main flame detector device shall be so positioned that it cannot in any circumstances detect the pilot flame. Output signals from the flame detector devices for regenerative

burners or burners controlled by the ignition/extinction of flame shall be synchronized with the start and stop of the fuel supply, and the detector device shall monitor whether flame is present or not.

Where the pilot burner and the main burner are each provided with their own flame detector device, the pilot flame shall not influence the response of the main flame sensor. A single flame detector device shall be sufficient:

- for systems where the pilot flame is extinguished during main burner operation;
- for any radiant tubes, explosion resistant and equipped with a burner fitted with permanent pilot burner.

Where fitted, flame sensors shall be unresponsive to unintended radiation.

Where a burner is required to fire continuously for periods in excess of 24 h, the automatic burner control system shall be designed for permanent operation as described in **JIS C 9730-2-5**.

The detection of a flame when there should not be a flame or a defect of the automatic burner control system or the protective system shall result into lock-out.

4.2.6.2 Low-temperature equipment

Low-temperature equipment fitted with a single burner shall be equipped with an automatic burner control system in accordance with **4.2.6.1**.

For low-temperature multiple burner equipment, each burner shall be equipped with an automatic burner control system.

Only one of the burners in multiple burner equipment may be equipped with an automatic burner control system operating continuously provided that the burners guarantee stable combustion throughout the range of regulation, are on the same air/fuel ratio control system and are arranged adjacent and in such a way that, if one of them is extinguished, it is re-ignited quickly and smoothly by the flame from the next burner. This shall not apply to burners controlled by “on/off” systems.

4.2.6.3 High-temperature equipment

During high-temperature operation, the temperature inside the furnace shall be monitored. In the event the temperature inside the furnace falls below the limit, the control system shall automatically shut off the gas supply or shall switch over to flame supervision by means of an automatic burner control system in accordance with **4.2.6.1**. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

The temperature limit for high-temperature operation shall not be less than 750 °C and the temperature inside the furnace shall be detected at the lowest-temperature point.

During start-up period, flame supervision, either by means of an automatic burner control system or by the furnace operator, shall be provided when the temperature inside the furnace is the temperature limit for high-temperature operation or under. For the furnace equipment intended to be started more than 4 times a year, flame supervision below 750 °C shall be by means of an automatic burner control system. Additional burners that operate during high-temperature operation without flame supervision shall

be isolated from the fuel gas supply by two automatic shut-off valves until the temperature is above the limit for high-temperature operation. This function shall meet the requirements of the protective system specified in **JIS B 8415-3**.

The high-temperature operation, the method and procedure for flame supervision during start-up period and switch over to high-temperature shall be described in the instruction handbook.

4.2.7 Start-up of heating system and burner ignition

4.2.7.1 Pre-purging of the combustion chamber

Except when specified below, start-up of the furnace equipment or re-start of the furnace equipment after a lock-out shall not be initiated until adequate steps have been taken to ensure that no combustible mixture is present in the combustion chamber, connected spaces and flue system (heat exchangers and dust extractors). This condition shall be achieved by means of a period of pre-purging immediately prior to ignition.

The pre-purge time shall be such as to ensure that the concentration of any combustible products in any part of the combustion chamber/connected spaces and flue system is 25 % or under of LFL of the fuel gas; this being calculated with the combustion chamber/connected spaces and the flue duct assumed as being initially filled up with flammable gases.

In general, five complete air changes of the combustion chamber/connected spaces and flue system will suffice. The airflow rate used for a pre-purge shall be at least 50 % of the maximum combustion airflow rate. In the case of natural draught, the condition to achieve the above requirements shall be defined in the instruction handbook.

The pre-purge time and purge procedure and/or methodology shall be specified in the instruction handbook.

The system for ensuring correct pre-purge time and the airflow rate shall meet the requirements of the protective system specified in **JIS B 8415-3**.

Inert or non-flammable gases shall be used instead of air if required by the equipment or process. Other methods of ensuring that the combustion chamber and connected spaces do not contain flammable gases may be utilized providing that the equivalent level of safety is achieved.

Restarting after a lock-out shall be initiated with pre-purging.

The cases where the pre-purge may be omitted are limited to the following:

- a) case where the combustion chamber temperature is 750 °C or higher is proved (synonymous with the case as to be defined as a high-temperature equipment);
- b) the case where, in a common combustion zone of multiple burner equipment, one or more burners continue to burn even if one burner is in an extinguished state and the burner(s) continuing the operation ignites the fuel released unintentionally through the burner under suspension, without forming a hazard;
- c) case where burners are started after shut-down for control purpose, satisfying the following:
 - a pilot burner equipped with a dedicated flame detector is carrying out the combustion continuously;