
Forced draught gas burners

Brûleurs à air soufflé pour combustibles gazeux

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22967 was prepared by Technical Committee ISO/TC 109, *Oil and gas burners*.

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Introduction

This International Standard is primarily intended for application to automatic forced draught gas burners having a combustion air fan, operated with gaseous fuels and intended to be marketed as a complete assembly.

Many burners are designed to operate on a wide range of fuel gases with little or no modification other than adjustment of the air supply.

When applying the requirements specific to a country or region, which are given in the various annexes, it is essential that a level of safety be ensured that is at least equivalent to that provided for by the requirements of the main body of this International Standard.

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Forced draught gas burners

1 Scope

This International Standard specifies the terminology, test procedures and general requirements for the construction and operation of automatic forced draught gas burners, and the provision of related control and safety devices.

It is applicable to the following:

- a) automatic gas burners (hereinafter called "burners") fitted with a combustion air fan that are equipped as described in Clause 4, intended for use in appliances of different types and operated with fuel gases;
- b) total pre-mixed burners and nozzle mixed burners;
- c) single burners with a single combustion chamber, for which, where such burners are fitted to a single appliance, the requirements of the relevant appliance standard also apply;
- d) single-fuel and dual-fuel burners when operating only on gas;
- e) the gas function of dual-fuel burners designed to operate simultaneously on gaseous and liquid fuels, which, for the latter, the requirements of ISO 22968 also apply.

It is not applicable to burners used in direct fired processes either with defined combustion chamber applications or where the combustion chamber wall surface temperature is greater than 750 °C or the heat-transfer medium temperature is greater than 500 °C.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references only the edition cited applies. For undated references the latest edition of the referenced document (including any amendments) applies.

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

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

ISO 1129, *Steel tubes for boilers, superheaters and heat exchangers — Dimensions, tolerances and conventional masses per unit length*

ISO 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 7005 (all parts), *Pipe flanges*

ISO 9329-1, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steels with specified room temperature properties*

ISO 22967:2010(E)

ISO 9330-1, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steel tubes with specified room temperature properties*

ISO 22968, *Forced draught oil burners*

ISO 23551-1, *Safety and control devices for gas burners and gas-burning appliances — Particular requirements — Part 1: 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 23551-4, *Safety and control devices for gas burners and gas-burning appliances — Particular requirements — Part 4: Valve-proving systems for automatic shut-off valves*

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*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60335-1:2001, *Household and similar electrical appliances — Safety — Part 1: General requirements, as amended 2004 and 2006*

IEC 60335-2-102:2004, *Household and similar electrical appliances — Safety — Part 2-102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections*

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

IEC 60730-2-5:2004, *Automatic electrical controls for household and similar use — Part 2-5: Particular requirements for automatic electrical burner control systems*

IEC 60730-2-6, *Automatic electrical controls for household and similar use — Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

IEC 60947-5-1, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices*

IEC 61810-1, *Electromechanical elementary relays — Part 1: General requirements*

IEC 60747-5-2, *Discrete semiconductor devices and integrated circuits — Part 5-2: Optoelectronic devices — Essential ratings and characteristics*

3 Terms and definitions

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

3.1 General

3.1.1

forced draught burner

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

3.1.2**automatic forced draught burner**

burner that is fitted with an automatic ignition, flame monitoring and burner control devices where the ignition, flame monitoring and the on/off switching of the burner occur automatically

NOTE The heat input of the burner can be adjusted during operation either automatically or manually.

3.1.3**dual-fuel burner**

burner in which both gaseous and liquid fuels can be burnt either simultaneously or in succession

3.1.4**total pre-mixed burner**

burner in which part or all of the air for complete combustion of the gas is mixed with the gas upstream of the mixture outlet ports

3.1.5**nozzle mixed burner**

burner in which part or all of the air required for combustion of the gas is mixed with the gas at, or downstream of, the air and gas ports

3.1.6**integrated ignition burner**

burner with direct main ignition burner at reduced rate with bypass start gas supply

3.1.7**start gas rate**

gas rate ignited by the ignition device during the start-up of the burner

3.1.8**combustion chamber**

part of the appliance in which the combustion takes place

3.1.9**burner head**

device for mixing fuel and air comprising, for example, a stabilizing disc and nozzle, that keeps the flame in its safe position during operation of the burner

3.1.10**heat-transfer medium**

gaseous or liquid substance for the transport of heat energy from the appliance

3.1.11**appliance**

heat generator into which the burner fires having a combustion chamber and heat exchanger are used to indirectly transmit the heat input from the burner combustion gases to the heat-transfer medium

3.2 Combustible gases**3.2.1****reference conditions**

conditions corresponding to a temperature of 15 °C and a pressure of 0,101 325 MPa, unless otherwise specified

NOTE Based on standard reference conditions specified in ISO 13443.

3.2.2

calorific value

quantity of heat produced by the combustion, at a constant pressure equal to 0,101 325 MPa, of unit volume or mass of gas, the constituents of the combustible mixture being taken at reference conditions and the products of combustion being brought back to the same conditions

NOTE A distinction is made between

- a) the superior calorific value (H_s) in which the water produced by combustion is assumed to be condensed, and
- b) the inferior calorific value (H_i) in which the water produced by combustion is assumed to be in the vapour state.

The units used for calorific value are either

- c) megajoules per cubic metre (MJ/m^3) of dry gas at the reference conditions, or
- d) megajoules per kilogram (MJ/kg) of dry gas.

See ISO 14532.

3.2.3

relative density

d

(fuel gas) ratio of the masses of equal volumes of dry gas and dry air at the same conditions of temperature and pressure

NOTE Adapted from ISO 80000-4:2006, 4-3.

3.2.4

Wobbe index

ratio of the calorific value of a gas per unit volume and the square root of its relative density under the same reference conditions

NOTE 1 The Wobbe index is said to be superior (W_s) or inferior (W_i) depending on whether the calorific value used is superior or inferior.

NOTE 2 The units used for the Wobbe index are either

- a) megajoules per cubic metre (MJ/m^3) of dry gas at the reference conditions, or
- b) megajoules per kilogram (MJ/kg) of dry gas.

NOTE 3 Adapted from ISO 14532:2005, definition 2.6.4.4.

3.2.5

gas pressure

static pressure of the moving gas, relative to the atmospheric pressure, measured at right angles to the direction of flow of the gas

NOTE Gas pressure is expressed in pascals or units thereof (Pa, kPa, MPa).

3.2.6

line-conveyed gas

gaseous fuels available by line-conveyed supply on site on which burners operate under nominal conditions when supplied at the corresponding normal pressure

3.2.7

normal pressure

pressure under which burners operate in nominal conditions when supplied with the corresponding line-conveyed gas

3.2.8**limit pressures**

pressures representative of the extreme variations in the burner supply conditions

NOTE The test pressures are given in Table 4.

3.2.9**supply pressure**

pressure measured immediately upstream of all gas line components but downstream of the manually operated shut-off valve

3.2.10**adjustment pressure**

pressure measured immediately downstream of the pressure regulator

3.2.11**burner head pressure**

pressure measured immediately before the burner head

3.3 Test rig and combustion chamber**3.3.1****combustion chamber pressure**

p_F

effective positive pressure or negative pressure relative to the atmospheric pressure prevailing in the combustion chamber

NOTE Combustion chamber pressure is measured in kilopascals (kPa).

3.3.2**length of the combustion chamber**

l_1

distance between the face of the nozzle or the fuel outlet and the rear wall of the test flame tube or combustion chamber or any lateral contraction

NOTE The length of the combustion chamber is measured in metres (m).

3.3.3**diameter of the combustion chamber**

d_1

inner diameter of the combustion chamber around the flame tube of the burner

NOTE The diameter of the combustion chamber is measured in metres (m).

3.3.4**burner flame tube**

device which hosts the mixing device and the root of the flame

3.3.5**test flame tube**

cylindrical part of the test rig where the combustion takes place

3.4 Composition of the gaseous combustion products

3.4.1

content of carbon dioxide

CO₂

ratio of the volume of carbon dioxide to the total volume of dry gaseous products in which it is present

NOTE The carbon dioxide content is expressed as a percentage volume fraction.

3.4.2

content of oxygen

O₂

ratio of the volume of oxygen to the total volume of dry gaseous products in which it is present

NOTE The oxygen content is expressed as a percentage volume fraction.

3.4.3

content of carbon monoxide

CO

ratio of the volume of carbon monoxide to the total volume of dry gaseous products in which it is present

NOTE The carbon monoxide content is expressed as a volume fraction, in units of millilitres per cubic metre (ml/m³) for measuring purposes and in milligrams per kilowatt hour (mg/kWh) related to inferior calorific value (H_i) for calculation purposes and declaring values.

3.4.4

content of nitrogen oxides

NO_x

ratio of the combined volume of nitrogen oxides to the total volume of dry gaseous products in which they are present

NOTE The nitrogen oxides content is expressed as a volume fraction, in units of millilitres per cubic metre (ml/m³) for measuring purposes and in milligrams per kilowatt hour (mg/kWh) related to inferior calorific value (H_i) for calculation purposes and declaring values.

3.4.5

excess air ratio

λ

ratio between the effectively introduced quantity of air and the theoretically required quantity of air

3.5 Burner operation

3.5.1 Gas rate

3.5.1.1

volume flow rate

q_V

volume of gas consumed by the burner in unit time during continuous operation

NOTE The units used for volume flow rate are either

- cubic metres per hour (m³/h),
- litres per minute (l/min),
- cubic decimetres per hour (dm³/h), or
- cubic decimetres per second (dm³/s).

3.5.1.2**nominal volume flow rate**

volume flow rate stated by the manufacturer, expressed in cubic metres per hour (m³/h) at reference conditions

3.5.1.3**maximum flow rate**

highest flow rate stated by the manufacturer, expressed in cubic metres per hour (m³/h) at reference conditions

3.5.1.4**minimum flow rate**

lowest flow rate stated by the manufacturer, expressed in cubic metres per hour (m³/h) at reference conditions

3.5.1.5**mass flow rate**

q_m

mass of gas consumed by the burner in unit time during continuous operation

NOTE The units used for mass flow rate are

- a) kilograms per hour (kg/h), or
- b) grams per hour (g/h).

3.5.1.6**nominal mass flow rate**

mass flow rate stated by the manufacturer

3.5.1.7**heat input**

Q_F

amount of heat expressed as a function of time released by the burner at a given throughput

NOTE Heat input is expressed in kilowatts (kW) and is calculated as gas flow rate \times inferior calorific value ($q_{vg}H_i$) of the fuel.

3.5.1.8**nominal heat input**

Q_{FN}

value of the heat input declared by the manufacturer

NOTE 1 It is expressed in kilowatts (kW).

NOTE 2 Fixed heat input or range-rated burners have a single nominal heat input. Range-rated burners can be adjusted between the maximum nominal heat input and the minimum nominal heat input declared by the manufacturer.

3.5.1.9**minimum heat input**

Q_{Fmin}

lowest heat input specified by the manufacturer at which the burner can operate in accordance with the operational requirements

NOTE It is expressed in kilowatts (kW).

3.5.1.10

maximum heat input

Q_{Fmax}

highest heat input specified by the manufacturer at which the burner can operate in accordance with the operational requirements

NOTE It is expressed in kilowatts (kW).

3.5.1.11

start heat input

Q_s

maximum heat input at the start of ignition as a percentage of the heat input, Q_F

3.5.2 Running conditions

3.5.2.1

burners for permanent operation

burners that are designed to remain in the running condition for more than 24 h without interruption

3.5.2.2

burners for intermittent operation

burners that are designed to remain in the running condition for less than 24 h

3.6 Gas line components

3.6.1

gas line

part of the burner made up of the valves, controls and safety devices, in which gas is conveyed between the inlet connection and the burner head

3.6.2

range-rating device

component on the burner intended to be used for adjusting the heat input, within a range of heat inputs stated by the manufacturer, to suit the actual heat requirements of the installation

NOTE This adjustment may be progressive or in discrete steps.

3.6.3

automatic shut-off valve

valve which opens when energized and closes automatically when de-energized

3.6.4

filter

strainer

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

3.7 Adjustment, control and safety devices

3.7.1

pressure regulator

device which maintains the downstream pressure constant to within fixed limits independent of variations, within a given range, of the upstream pressure

3.7.2

adjustable pressure regulator

pressure regulator fitted with a means of adjusting the loading on the diaphragm and thus the downstream pressure

3.7.3**gas pressure protection device**

device that compares the actual value of the pressure with the desired value, gives a signal when the actual value exceeds or drops below the desired value and initiates the shut-off sequence

3.7.4**flame detector device**

device by which the presence of a flame is detected and signalled

NOTE It can consist of a flame sensor, an amplifier and an element for signal transmission. These parts, with the possible exception of the actual flame sensor, may be assembled in a single housing for use in conjunction with a programming unit.

3.7.5**automatic burner control system**

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

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

3.7.6**programming unit**

unit that reacts to signals from control and safety devices, gives control commands, controls the start-up sequence, supervises the burner operation and causes controlled shut-down and, if necessary, safety shut-down and non-volatile lock-out

NOTE The programming unit follows a predetermined sequence of actions and always operates in conjunction with a flame detector device.

3.7.7**safe start check**

procedure employing a protection circuit or circuits to establish whether or not a fault in a safety system or flame simulating condition exists prior to start-up

3.7.8**controlled shut-down**

process by which the power to the gas shut-off valve(s) is immediately removed before any other action takes place (e.g. as a result of activating a controlling function)

3.7.9**safety shut-down**

process that is effected immediately following the response of a safety limiter or the detection of a fault in the automatic burner control system and which puts the burner out of operation by immediately removing the power to the fuel shut-off valve(s) and the ignition device

NOTE Safety shut-down can also occur as a result of an interruption/decrease of the power supply.

3.7.10**non-volatile lock-out**

safety shut-down condition of the system, such that a restart can only be accomplished by a manual reset of the system and by no other means

3.7.11**start signal**

signal (e.g. from a thermostat) which releases the system from its start position and commences the predetermined programme

3.7.12**recycling**

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

3.7.13

valve-proving system

VPS

system used to check the effective closure of the start gas or main gas safety shut-off valves, and which is capable of detecting small gas leakage rates

3.7.14

ignition device

any means used to ignite the fuel at the ignition burner or at the main burner

EXAMPLE Flame, electrical ignition.

3.7.15

running position

position of the system in which the burner is in normal operation under the supervision of the programming unit and its flame detector device

3.7.16

purge

forced introduction of air into the combustion chamber and flue passages, in order to displace any remaining fuel/air mixture and/or products of combustion

3.7.17

pre-purge

purge which takes place between the start signal and energizing of the ignition device

3.7.18

post-purge

purge which takes place immediately after a controlled shut-down

3.8 Sequencing times

3.8.1

pre-purge time

period during which purge takes place at the proven air rate prior to energizing the ignition device

NOTE It is expressed in seconds (s).

3.8.2

post-purge time

period between any shut-down and the moment the fan is switched off

NOTE It is expressed in seconds (s).

3.8.3

ignition time

period between the release of the fuel and the first indication of the flame by the flame detector device

NOTE It is expressed in seconds (s).

3.8.4

first safety time

period between the energizing and de-energizing of the pilot gas valve, start gas valve or main gas valve(s), as applicable, if the flame detector device signals the absence of a flame

NOTE Where there is no second safety time, this period is simply called the "safety time".

3.8.5**second safety time**

period, in the case of a first safety time applicable to either a pilot or start gas flame only, between the energizing and de-energizing of main gas valves if the flame detector device signals the absence of a flame

3.8.6**flame extinction safety time**

period that starts with the signal that the flame has been extinguished and ends with the signal to de-energize the safety shut-off valve of the gas supply

3.8.7**total closing time**

period that starts with the signal that the flame has been extinguished and ends with the shut-off valves being closed

3.9 Combustion**3.9.1****flame stability**

capacity of the flame to remain on the burner head or in the flame reception zone intended by the design

3.9.2**flame lift**

total or partial lifting of the base of the flame away from the burner head or the flame holding zone provided by the design

3.9.3**light back**

unintended movement of the flame front to a point upstream of its normal stable operating position

3.10 Diagrams**3.10.1****working diagram**

admissible range of application of the burner (pressure in the combustion chamber as a function of heat input)

3.10.2**test diagram**

test range of the burner during the tests (pressure in the combustion chamber as a function of heat input)

4 Constructional and operational requirement**4.1 Operation with different fuels****4.1.1 Conversion to different gases**

The types of gas for which the burner is designed shall be declared by the manufacturer on the data plate of the burner and in the instructions.

The precautions to be taken when converting a burner and its equipment from one type of gas to another (e.g. from propane to natural gas supply) and/or to adapt for different gas supply pressures shall be given by the manufacturer in the operating instructions.

4.1.2 Operation with dual fuel supply or simultaneous supply

Burners shall be designed such that when operating under dual fuel or simultaneous supply no fuel shall adversely influence the flow of the other fuel.

4.2 Construction

4.2.1 Design

The effective lifetime of a burner is primarily controlled by its operation and maintenance.

The design of the burner shall be based on its intended lifetime as declared by the manufacturer. The intended lifetime of the equipment into which the burner is to be installed shall also be taken into account.

NOTE 1 The lifetime of components can differ from that of the burner.

Lever and similar devices which have to be operated by the installer or user shall be appropriately identified.

NOTE 2 The burner head can be lengthened as long as the performance of the burner is not affected in an unsafe manner. The geometry of the mixing device and its position in the flame tube can remain unchanged.

Back-flow prevention devices shall be installed:

- a) upstream of automatic shut-off valves when there is the possibility of back-flow of air or other fluid in burners;
- b) on combustion airflow when there is the possibility of back-flow of fuel gas into combustion airflow while the burner is operating.

Pre-mix burners shall have an anti-backfiring structure with two levels of flame arrestor devices located one after the other upstream of the flame zone; alternatively, backfiring detection sensors shall be installed to detect any backfiring and to initiate a safety shut-down followed by non-volatile lock-out.

The pre-mix volume of fuel and air shall be such that no potential risk occurs if flashback happens.

4.2.2 Accessibility for maintenance and use

Components requiring regular maintenance shall be so arranged or designed that they are easily detachable. They shall be designed or marked such that reasonable interpretation of the manufacturer's instructions would provide for proper re-installation.

Constructional parts accessible during use and maintenance shall be free from sharp edges and corners that might cause damage or personal injury. Burners that can be withdrawn or swivelled out of position without the use of tools shall be interlocked (e.g. by means of limit switches) so that they cannot be operated in the withdrawn or swivelled position.

The interlock device shall be fail-safe in design and, if a limit switch, shall conform with IEC 60204-1 or IEC 60947-5-1, depending on the design.

If the burner is installed according to the manufacturer's instructions, the surface temperatures of accessible burner parts not intended to be touched shall not exceed the ambient temperature by more than 60 K.

If, for technical reasons, these temperature limits cannot be respected, adequate warnings shall be provided.

4.2.3 Soundness

Holes (e.g. for screws and studs) intended for the assembly of parts shall not open into gasways. The wall thickness between drillings and gasways shall be at least 1 mm. This requirement shall not apply to orifices for measurement purposes or to components within the burner head.

The soundness of parts and assemblies making up the gas circuit and likely to be dismantled during regular maintenance shall be achieved only by means of mechanical joints (e.g. metal-to-metal joints, gaskets or O-ring joints) and not by the use of sealing materials (e.g. tape, paste or liquid).

All sealing materials shall remain effective under normal conditions of burner use.

4.2.4 Materials

The quality and thickness of the materials used in the construction of the burner shall be selected so that the constructional and performance characteristics of the system do not deteriorate during operation. In particular, all burner components shall withstand the mechanical, chemical and thermal loads that can be encountered during operation. Under normal conditions of use, maintenance and adjustment, the burner components shall not show any changes that could affect their normal functioning. The influence of higher heat-transfer media temperatures shall be considered too.

If the burner housing contains any metal parts not made of corrosion-resistant material, these shall be suitably protected with an effective anti-corrosion coating.

Asbestos or materials containing asbestos shall not be used.

Copper shall not be used for gas-carrying parts where its temperature is likely to exceed 100 °C. Solder that has a melting point below 450 °C after application shall not be used for gas-carrying parts.

The pipework material shall be in accordance with ISO 3183, ISO 9329-1, ISO 9330-1 or ISO 1129, as applicable.

4.2.5 Mounting

The burner shall be designed such that it can be effectively mounted on the appliance.

The burner shall be mounted on the appliance such that no ejection of high temperature gas or flame can occur.

The burner shall be mounted such that back radiation and high refractory temperatures do not adversely affect the stability and lifetime of the burner parts inside the combustion chamber.

The burner components shall be arranged and secured such that their correct operating position and — above all — the correct position of the burner orifices cannot change during operation. The correct operating position shall be maintained when accessories are removed and refitted.

Parts of the burner that are set or adjusted during manufacture and which are not intended to be manipulated by the user or installer shall be sealed.

4.2.6 Connections

The following connections shall be designed in accordance with ISO 7-1:

- a) those with inlet gas pressure-tight joints made on the threads;
- b) those within the burner with pressure-tight joints made on the threads that are not loosened for maintenance;
- c) connections for parts that are not frequently dismantled and refitted.

Connections which have to be loosened for maintenance purposes shall be designed in accordance with ISO 228-1.

Flange connections shall be in accordance with ISO 7005-1, ISO 7005-2 and ISO 7005-3.

In the USA, Europe and Japan, the specific requirements given respectively in normative Annexes G, H and I apply.

4.3 Equipment

4.3.1 Motors and fans

Guards, grilles and shields shall be used to protect high-temperature or moving parts such that they cannot be touched accidentally. If this protection is not possible, warning signs shall be used.

Removal of such guards, grilles and shields shall be possible only with the use of tools.

The degree of protection provided shall be at least IP 20, according to IEC 60529.

Belt drives, where used, shall be so designed or positioned as to afford protection to the operator.

Means shall be provided to facilitate adjustment of belt tension. Access to such means shall be possible only with the use of tools.

Motors and fans shall be mounted such as to minimize noise and vibration. Lubrication points, if provided, shall be readily accessible.

4.3.2 Electrical safety

4.3.2.1 Controls conformant with IEC 60730 and ISO 23550

The provisions given in 4.3.2.2 are not applicable to controls that conform with the electrical requirements of IEC 60730 and ISO 23550.

4.3.2.2 Electrical safety of the burner

4.3.2.2.1 General

The leakage current and electrical strength tests of the complete burner need not be performed if the components and sub-assemblies have been separately tested and the interconnection is carried out in accordance with the manufacturer's instructions.

If the measurements of the leakage current as required in IEC 60335-1:2001, 13.2 are not possible because the protective impedance circuits or radio interference filters cannot be disconnected, then the limit specified for leakage current shall be calculated taking into account the current through those circuits.

The electrical safety of

- a) the burner,
- b) those of its control devices not in accordance with IEC 60730 and ISO 23550, and
- c) the interface between control devices which do fulfil the requirements of IEC 60730 and ISO 23550

shall be in accordance with IEC 60335-2-102, modified by the additions and replacements given in 4.3.2.2.2.

4.3.2.2.2 Modifications, additions and replacements

a) Moisture resistance

The requirements of IEC 60335-1:2001, Clause 15, apply.

IEC 60335-2-102:2004, 15.2, does not apply.

b) Leakage current and electric strength

The following replaces IEC 60335-2-102:2004, 16.2:

For gas burners, the limit is 10 mA.

The following replaces IEC 60335-2-102:2004, 16.3:

Compliance of spark ignition circuits shall be checked by inspection. In case of doubt, spark ignition circuits or crucial parts shall be submitted to an endurance test performed under the following conditions:

- i) the maximum duration of switch-on given by the manufacturer (complete switch-on duration shall correspond with the realistic time of use);
- ii) the relation between on/off cycles as declared by the manufacturer;
- iii) the maximum rated voltage;
- iv) the maximum ambient temperature of all parts under test.

During this test no breakdown of other circuits or — if the limits specified in IEC 60335-2-102:2004, 8.101, are exceeded — accessible surfaces shall occur. Breakdown of conductive parts which are connected to earth is allowed if this does not result in a critical failure of a circuit(s) with safety-related functions.

NOTE In case of doubt, compliance can normally be achieved by increasing the clearance at any part of the spark ignition circuit likely to cause an unacceptable breakdown.

c) Abnormal operation

In addition to the provisions of IEC 60335-2-102:2004, 19.11.2, the following failure mode applies:

Short-circuit and mechanical breakdown of relay contacts in protective electronic circuits, these failure modes need not be considered if components conform with footnote g) of IEC 60730-2-5:2004, Table H.27.1.

The following replaces the last paragraph of IEC 60335-1:2001, 19.11.2:

In each case, the test is ended if:

- i) for risks of electrical origin, interruption of the supply occurs within the appliance;
- ii) for risks concerning the fuel, shut-down occurs.

The following is additional to the provisions of IEC 60335-2-102:2004, 19.11.3:

Tests are not to be repeated for protective electronic circuits conforming with the relevant control standard according to 4.3.2.1.

The following replaces IEC 60335-2-102:2004, 19.13:

During the tests described in 19.11.4, the appliance shall either continue to operate normally or reach a safe situation for risks concerning the fuel safety shut-down or non-volatile lock-out.

d) **Components**

The following is additional to IEC 60335-2-102:2004, 24.1.1:

Relays and optocouplers which ensure electrical isolation between live parts and accessible metal parts shall conform with IEC 61810-1 and IEC 60747-5-2.

e) **IEC 60335-2-102:2004, Annex Q**

The following is additional to the provisions of the annex:

NOTE Repeat testing of a protective electronic circuit is not required where the system has already been certified to conform with published International Standards where compliance requires that the fault behaviour of the fail-safe system is assessed on a second fault analysis basis.

4.3.3 Adjustable air damper

Any adjustable air damper or similar device for controlling the airflow shall be adjustable only by means of a tool. The adjusting positions of the air damper shall be visible (e.g. after removal of a cap).

If the burner is provided with a manual means of adjusting the combustion airflow, this means shall be so designed that, after adjustment according to the manufacturer's instructions, it is capable of being set and sealed.

4.3.4 Installation of the automatic burner control unit

The automatic burner control unit shall be in accordance with IEC 60730-2-5 and, in the installed condition (e.g. in the burner housing/control panel), shall have at least an IP 40 degree of protection, as specified in IEC 60529.

In Japan and Korea, the specific requirements given respectively in normative Annexes I and K apply.

4.3.5 Gas line components

4.3.5.1 General

All gas line components shall be designed for the individual inlet pressure of the burner or shall be protected against any excessive increase in pressure by means of suitable safety devices.

4.3.5.2 Manually operated shut-off valve

A quick-acting, manually operated shut-off valve shall be provided upstream of all controls to isolate the burner. This valve need not be supplied by the manufacturer, but it shall be specified in the manufacturer's installation instructions.

Burners shall be provided with such manually operated shut-off valves as are essential for their commissioning and normal operation.

The manually operated shut-off valve shall be readily accessible and capable of rapid operation.

The manually operated shut-off valve shall be capable of operating at a pressure equal to 1,5 times the maximum supply pressure.

The manually operated shut-off valve shall be of the 90° turn type and shall be designed so as to prevent inadvertent operation, shall be easy to operate and the open and closed positions shall be readily distinguishable.

Manually operated shut-off valves used solely for open/close operation shall be provided with mechanical stops at the open and closed positions.

4.3.5.3 Filter/strainer

A filter/strainer shall be fitted immediately upstream of the inlet of the gas line of the burner (see Figure 1) to prevent the ingress of contaminants.

The maximum strainer hole dimension shall not be greater than 1,5 mm and the mesh shall not permit the passage of a 1 mm pin gauge.

In the USA, the specific requirements given in normative Annex G apply.

4.3.5.4 Gas pressure regulator

The burner gas supply shall be controlled by a pressure regulator to ensure that the pressure at the burner head of the main burner or any ignition burner of greater than 2 kW heat input remains stable.

The burner heat input shall not vary by more than $\pm 5\%$ from the specified value if the supply pressure changes within the limits shown in Table 4.

The main burner and any ignition burner may be governed separately.

The gas pressure regulator shall be in accordance with ISO 23551-2. Where its operating pressure falls outside the scope of ISO 23551-2, the gas pressure regulator shall be suitable for its purpose.

The accessibility of the pressure regulator shall be such that it can be easily adjusted and precautions shall be taken to make unauthorized adjustment difficult.

If the outlet side of the gas pressure regulator and/or the gas valve of the gas line section with its equipment up to the burner are not designed for the maximum supply pressure under fault conditions, then

- a) a high gas pressure shut-off valve, capable of shutting off the gas supply before an excessively high pressure occurs, shall be installed upstream of the gas pressure regulator, and
- b) a safety relief valve, vented to a safe area, shall be installed downstream of the gas pressure regulator.

The high gas pressure shut-off valve and the safety relief valve may be integrated in one unit with the gas pressure regulator.

The high gas pressure shut-off valve shall close before the operational overpressure value of the downstream gas line components is exceeded.

In the USA, Japan and Korea, the specific requirements given respectively in normative Annexes G, I and K apply.

NOTE The safety relief valve can operate before the high pressure shut-off valve closes. Excessive operation of the safety relief valve can be avoided, thereby preventing the release of unburned gases to the atmosphere.

4.3.5.5 High gas pressure overload protection device

When a gas pressure regulator is not installed, a high gas pressure protection device in accordance with ISO 23551-2 and IEC 60730-2-6 shall be fitted, except when

- a) the pressure drop across the gas pressure regulator(s) is less than 30 % of the normal operating minimum regulator pressure, and
- b) the failure of any item in the gas line, including a gas pressure regulator, may result in an unsafe start-gas rate being obtained.

Where a high gas pressure protection device is fitted, it shall cause a non-volatile lock-out if

- a) the heat input to the burner exceeds 1,15 times the nominal input, or
- b) the pressure at the burner head exceeds 1,3 times the burner head pressure at the nominal inlet pressure.

4.3.5.6 Low gas pressure protection device

The burner shall be fitted with a low gas pressure protection device conforming to the requirements of IEC 60730-2-6, Type 2, able to initiate a safety shut-down when the supply pressure falls below a predetermined value.

The low gas pressure protection device may be omitted if, when the inlet pressure falls to 25 % of the nominal value, the burner

- a) continues to operate safely and the CO content does not exceed 2 000 ml/m³ by volume of the dry, air-free combustion products, or
- b) proceeds to non-volatile lock-out.

In Japan, the specific requirements given in normative Annex I apply.

4.3.5.7 Adjustment devices

An adjustment device shall be provided to allow the specified gas rate to be achieved with the fuel gases intended by the manufacturer and over the intended range of gas pressures. Precautions shall be taken to make unauthorized adjustment of the device difficult.

This adjustment device may be that of the gas pressure regulator.

All adjustment devices shall require a tool for adjustment.

Setting of adjustment devices shall not change easily if properly fastened.

4.3.5.8 Automatic safety shut-off valves

All burners shall be fitted with two automatic safety shut-off valves in accordance with ISO 23551-1 and ISO 23551-4 and installed in accordance with Table 1.

Where main flame establishment is achieved by means of a start-gas flame, the start gas supply shall be either

- a) under the control of the downstream main gas safety shut-off valve, which shall incorporate a start gas limit position, or
- b) under the control of safety shut-off valves according to Table 1.

Table 1 — Safety shut-off valve requirements

Nominal heat input Q_{FN} kW	With pre-purge				Without pre-purge			
	Main gas	Start gas			Main gas	Start gas		
		≤ 70	> 70 $\leq 1\ 200$	$> 1\ 200$		≤ 70	> 70 $\leq 1\ 200$	$> 1\ 200$
≤ 70	$2 \times B$	$2 \times B$	N/A	N/A	$2 \times A$ or $2 \times B$ + VTC ^b	$2 \times A$	N/A	N/A
$> 70 \leq 1\ 200$	$2 \times A + VTC^a$	$2 \times A$	$2 \times A + VTC^a$	N/A	$2 \times A + VTC^b$	$2 \times A$	$2 \times A + VTC^b$	N/A
$> 1\ 200$	$2 \times A + VTC^c$	$2 \times A$	$2 \times A + VTC^a$	$2 \times A + VTC^c$	$2 \times A + VTC^c$	$2 \times A$	$2 \times A + VTC^b$	$2 \times A + VTC^c$

VTC valve tightness check (see 4.3.5.10).

a CPI or POC or VPS.

b POC or VPS.

c Only VPS.

In the USA and Australia, the specific requirements given respectively in normative Annexes G and J apply.

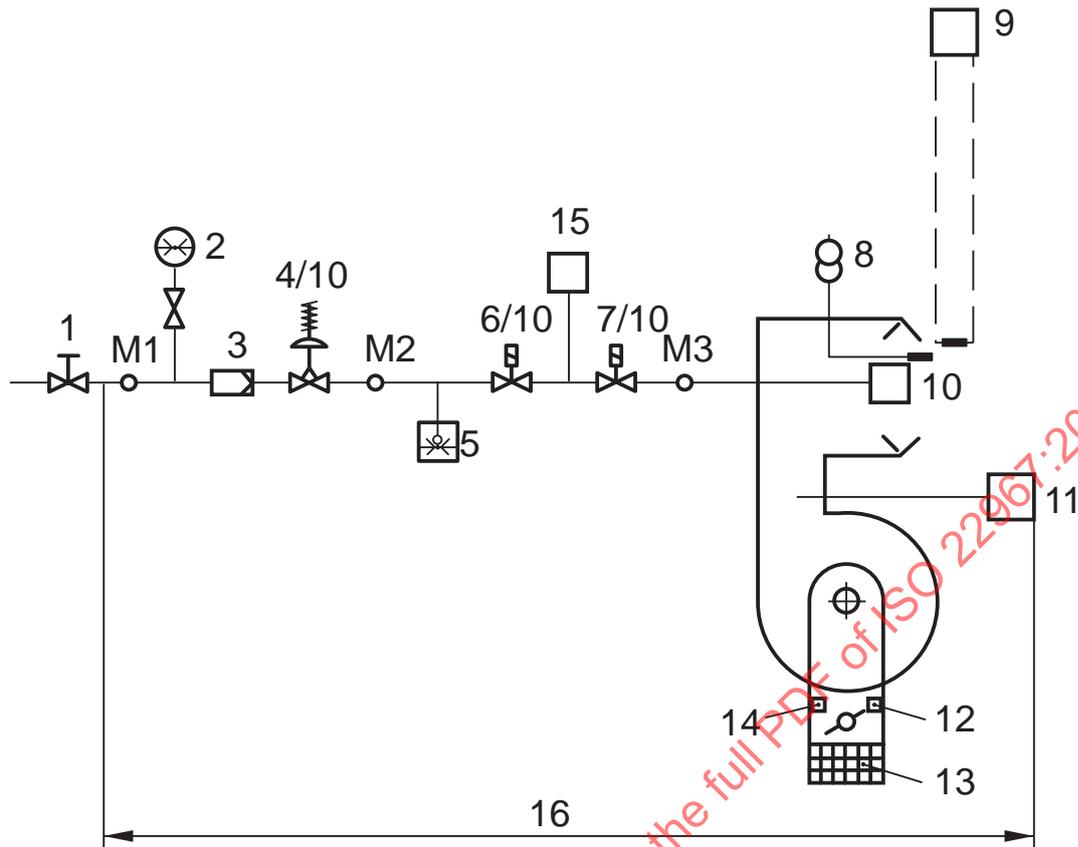
4.3.5.9 Pressure test points

Test points or pressure measuring devices shall be provided to enable checking of the gas inlet pressure, gas adjustment pressure, the pressure in the burner head and the air pressure. See Figure 1.

NOTE A single pressure test point can be provided for measuring the adjustment and burner head pressures.

Pressure test points shall have a maximum internal diameter of 1 mm, an external diameter of $9_{-0,5}^0$ mm and a length of 10 mm and shall be such that they can be tightly closed or self-sealing.

In the USA, the specific requirements given in normative Annex G apply.



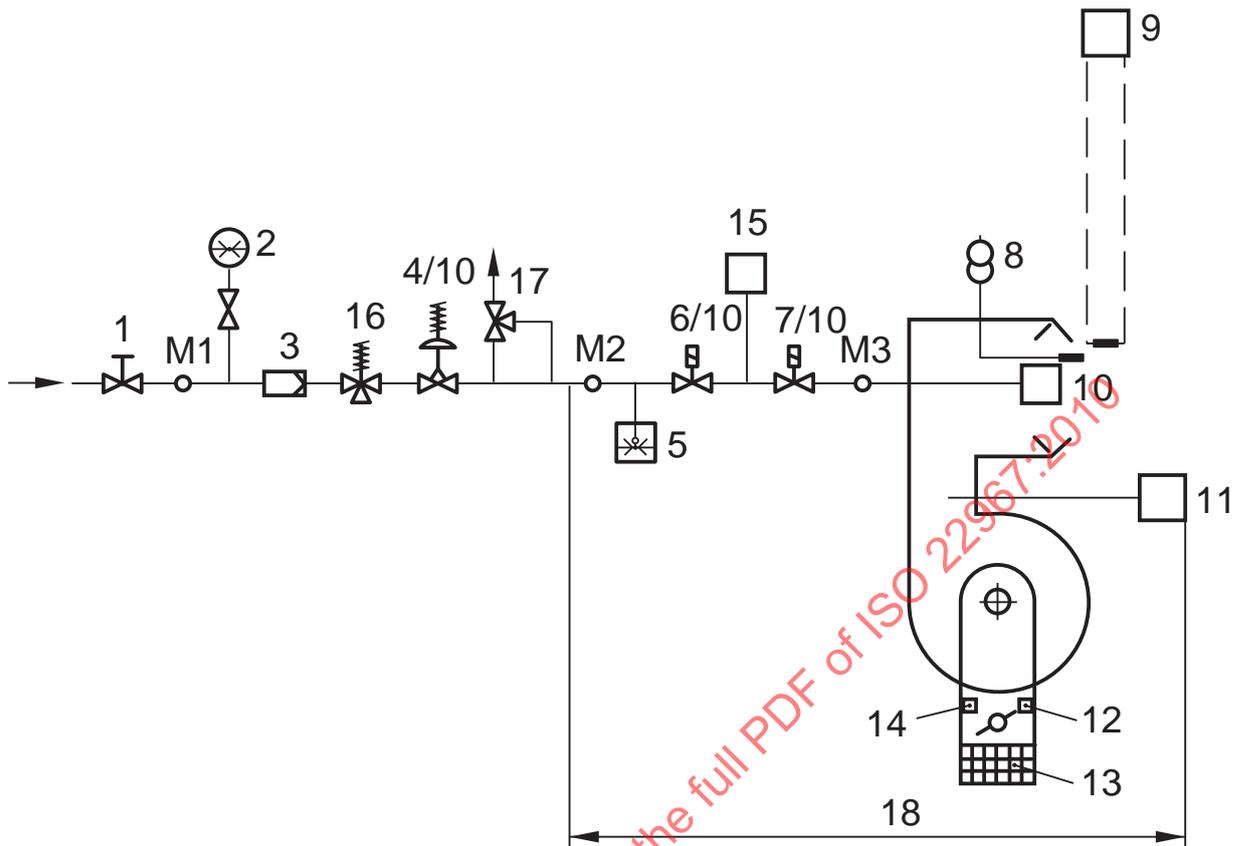
Key

- | | |
|---|--|
| 1 manually operated shut-off device | 9 flame detector |
| 2 gas pressure gauge | 10 preliminary adjusting device |
| 3 filter | 11 air-proving device |
| 4 gas pressure regulator according to ISO 23551-2 | 12 low airflow position switch |
| 5 low gas pressure protection device | 13 safety device for moving parts, e.g. grille |
| 6 first safety shut-off device ^a | 14 high airflow position switch |
| 7 second safety shut-off device ^a | 15 valve-proving system (> 1,2 MW) |
| 8 ignition device | 16 minimum equipment for type testing |
| M1 measuring point for supply pressure | |
| M2 measuring point for adjustment pressure | |
| M3 measuring point for burner head pressure | |

^a One or more functions can be incorporated into a single device (e.g. filter and safety shut-off device) and the location of the filter, safety shut-off valves and pressure governor can vary.

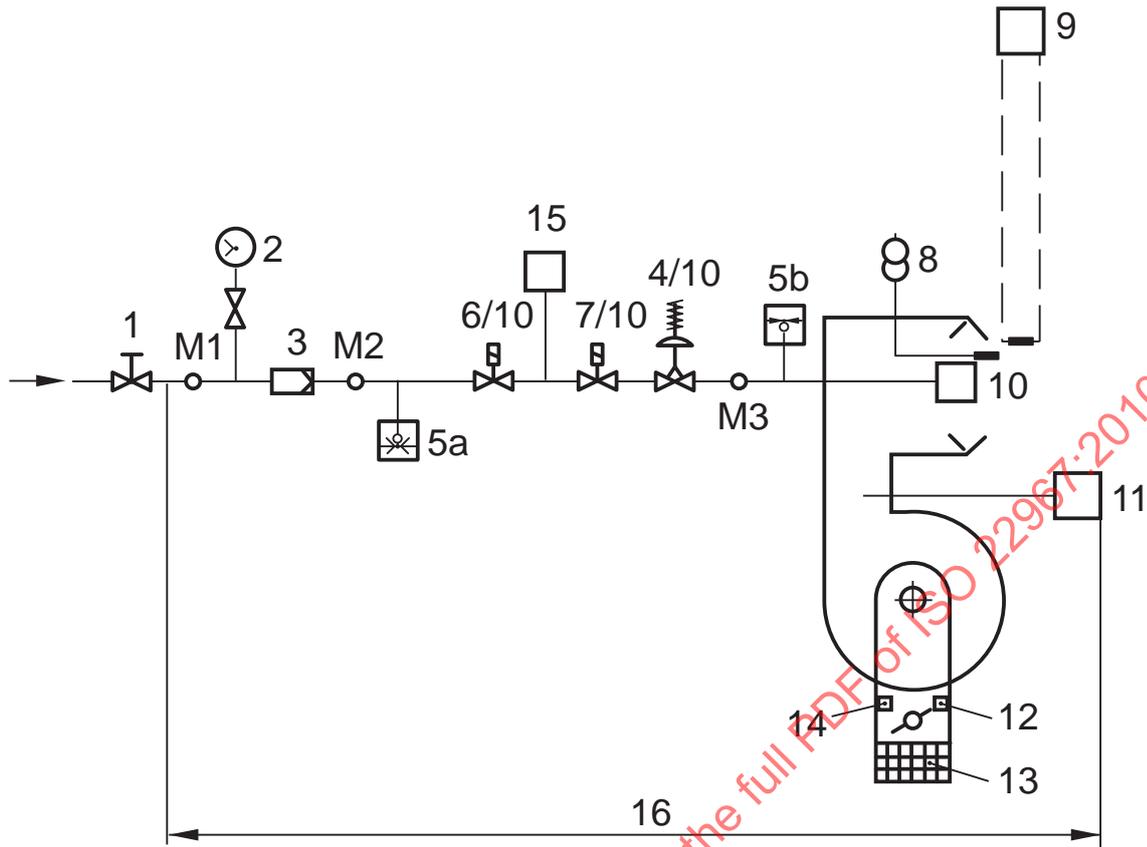
a) Gas supply pressure not exceeding design pressure of gas line components used

Figure 1 — Examples of equipment (continued)

**Key**

- | | |
|---|--|
| 1 manually operated shut-off device | 10 preliminary adjusting device |
| 2 gas pressure measuring device | 11 air-proving device |
| 3 filter | 12 low airflow position switch |
| 4 gas pressure regulator according to ISO 23551-2 | 13 safety device for moving parts, e.g. grille |
| 5 low gas pressure protection device | 14 high airflow position switch |
| 6 first safety shut-off device ^a | 15 valve-proving system (> 1,2 MW) |
| 7 second safety shut-off device ^a | 16 high gas pressure shut-off valve |
| 8 ignition device | 17 safety relief valve |
| 9 flame detector | 18 minimum equipment for type testing |
| M1 measuring point for supply pressure | |
| M2 measuring point for adjustment pressure | |
| M3 measuring point for burner head pressure | |
- ^a One or more functions can be incorporated into a single device (e.g. filter and safety shut-off device) and the location of the filter, safety shut-off valves and pressure governor can vary.

b) Gas supply pressure exceeding design pressure of gas line components used**Figure 1 — Examples of equipment (continued)**



Key

- | | | | |
|----|---|----|--|
| 1 | manually operated shut-off device | 9 | flame detector |
| 2 | gas pressure measuring device | 10 | preliminary adjusting or range rating device |
| 3 | filter | 11 | air-proving device |
| 4 | gas pressure regulator according to ISO 23551-2 | 12 | low airflow position switch |
| 5a | low gas pressure protection device | 13 | safety device for moving parts, e.g. grille |
| 5b | high gas overload protection device | 14 | high airflow position switch |
| 6 | first safety shut-off device ^a | 15 | valve-proving system (> 1,2 MW) |
| 7 | second safety shut-off device ^a | 16 | minimum equipment for type testing |
| 8 | ignition device | | |
| M1 | measuring point for supply pressure | | |
| M2 | measuring point for adjustment pressure | | |
| M3 | measuring point for burner head pressure | | |

^a One or more functions can be incorporated into a single device (e.g. filter and safety shut-off device) and the location of the filter, safety shut-off valves and pressure governor can vary.

c) Gas supply pressure not exceeding design pressure of gas line components used downstream M1 with high gas pressure overload protection device

Figure 1 — Examples of equipment

4.3.5.10 Valve tightness check (VTC)

In Japan, the specific requirements given in normative Annex I apply.

4.3.5.10.1 Closed position indicator (CPI)

If a CPI is used, it shall be in accordance with ISO 23551-1.

4.3.5.10.2 Proof of closure indicator (POC)

If a POC is used, it shall be in accordance with ISO 23551-1.

4.3.5.10.3 Valve-proving system (VPS)

Where a VPS is used, it shall be in accordance with ISO 23551-3.

The downstream valve of two gas valves in series installed as part of a VPS that vents into the combustion chamber shall not open for a period of more than 3 s before or during the pre-purge or post-purge.

After a gas burner lock-out or power failure, valve proving shall be carried out prior to, or during, the pre-purge of the next burner start.

In Australia, the specific requirements given in normative Annex J apply.

4.3.6 Ignition device

The ignition device shall ensure safe ignition of the ignition and/or main burner under the specified conditions of operation.

4.3.7 Flame detector device

Flame detector devices shall be in accordance with IEC 60730-2-5. Main and ignition burner flames shall each be monitored by a suitable flame detector device.

Flame detector devices shall be mounted on the burner such that they do not receive any extraneous light.

Where the ignition burner and the main burner are each provided with their own flame detector device, the ignition burner flame shall not influence detection of the main burner flame. The main gas supply shall be opened only after the means of burner ignition is switched off and the ignition burner flame has been established and detected.

For systems where the ignition burner remains in use during main burner operation, separate flame sensors for monitoring the ignition and main flames shall be fitted. The main flame sensor shall be so positioned that it cannot detect the ignition burner flame.

For systems where the ignition burner is extinguished during main burner operation, a single flame detector device may be fitted. The ignition burner flame shall not influence detection of the main flame.

The flame detector device shall be such that upon flame failure, there is no noticeable delay between flame extinction and detection of the flame failure signal. This delay is part of the flame extinction safety time under 4.4.1.6.2.

The type of flame detector device fitted shall be suitable for the burner thermal rating and mode of operation. When installed on the burner, the flame detector device shall comply, at least, with protective category IP 40 (for indoor installations) and with protective category IP 54 (for open air installations) according to IEC 60529.

The flame detector device shall be subjected to a safe start check in order to establish that if flame presence is detected at any time during pre-purge this shall lead to a safety shut-down or non-volatile lock-out.

The safe start check may cease during the 5 s preceding any attempt at ignition. If a flame simulating condition exists, non-volatile lock-out shall occur.

NOTE See 4.4.1.6.2 for flame extinction safety time requirements.

In the USA, the specific requirements given in normative Annex G apply.

4.3.8 Air-proving device

A device for proving adequate airflow during the pre-purge, ignition and operation of the burner shall be fitted.

Airflow failure at any time during the ignition or operation of the burner shall cause a non-volatile lock-out.

Airflow failure during pre-purge shall at least result in a safety shut-down (see 4.4.1.2).

For burners with a heat input up to and including 120 kW, a safety shut-down followed by a single restart attempt is permitted. If the restart attempt fails then non-volatile lock-out shall occur.

Proof of adequate airflow to the burner shall be achieved by one or another of the following:

- a) pressure sensing;
- b) flow sensing;
- c) any other system which does not only rely on fan rotation.

An air damper interlock or an air damper actuator interlock alone is not sufficient. If an air pressure sensing device is used, it shall be in accordance with IEC 60730-2-6. Any other sensing device shall have at least a comparable safety level.

The air-proving device shall be proved in the no-flow state prior to start-up. Failure to prove the device in the no-flow state shall prevent start-up or cause non-volatile lock-out.

This check is not necessary if failure of the air-proving device leads to a safe condition.

The air-proving device shall be adjusted such that, if there is insufficient air supply at the highest or lowest burner operating stage, the device will operate before the CO content at the controlled stage of the combustion products exceeds 10 000 ml/m³ by volume, air-free/dry.

Where the burner is fitted with automatic gas/air ratio control in which an airflow device provides the lead signal, continuous monitoring of the airflow by the air-proving device during the operation of the burner is not necessary. In the event of the failure of the air lead signal, the gas valves shall be closed.

NOTE For multi-stage and modulating burners only one air-proving device is necessary to control the airflow. In such cases, adequate airflow will be ensured.

An air-proving device may be omitted if the burners are fitted with all of the following:

- a) a device for checking the actual fan speed if no safety shut-down occurs;
- b) a device for checking the state of the adjustable air damper during pre-purge, if no gas opening occurs;
- c) a device for a positive coupling between motor/fan;
- d) a device for fuel release via gas/air ratio control;
- e) a device which shall close the gas valve in the event of air reference signal failure.

If a separate combustion air fan is used, proof of adequate airflow is in principle the same as for a burner conforming to the requirements of this International Standard, with the exception that the positioning of the safety devices can be dependent on the installation on site. The air-proving device shall be located in a position ensuring that sufficient combustion air supply is detected.

The test method for the air-proving device shall be effective and take into account the design of the burner upon which it is installed (see Annex E).

4.3.9 Gas/air ratio control device

Each burner shall be provided with an airflow adjustment device.

For two-stage or multi-stage burners, the combustion airflow and gas flow rates can be controlled in tandem by a sequential switching system. The air and gas adjustment devices shall be interconnected (e.g. by mechanical, pneumatic, electric or electronic means) such that the relationship between combustion air and gas is fixed in a repeatable way at any operating point of the burner.

On multi-stage or modulating burners where the airflow and gas flow are not altered simultaneously, there shall be either

- a) air lead on increasing firing rate and gas lead on reducing firing rate, or
- b) sufficient excess air to prevent gas-rich firing.

The combined control or the sequential switching shall be effected in such a manner that even in the case of a fault the system will tend towards higher excess air or proceed to a safety shut-down.

Where a pneumatically operated gas/air ratio device is fitted, it shall be in accordance with ISO 23551-3.

Where an electronically operated gas/air ratio device is fitted, it shall be in accordance with ISO 23552-1.

Where a combustion quality control system influencing the ratio between the gas and air supply is used, it shall be in accordance with ISO 23552-1.

NOTE These requirements apply to burners used for both continuous and intermittent operation with electronic fuel/air ratio control.

4.3.10 Automatic burner control unit

The automatic burner control unit shall be in accordance with IEC 60730-2-5 and shall be suitable for the individual output stages of the burner.

The automatic burner control unit shall be suitable for the mode of burner operation (intermittent or permanent).

4.3.11 Interfacing with appliances

See Annex L for an example of the application, interfacing and wiring of a burner. This interfacing can facilitate the on-site assembly of burners and boilers/oil appliances.

4.4 Functional and operational requirements

4.4.1 General

The components specified in 4.3 shall be designed such that the requirements of 4.4.1.1 to 4.4.1.9 are satisfied.

The functioning of any safety device shall not be overridden by that of any control device.

4.4.1.1 Burner start-up

Burner start-up shall be possible only if

- a) any burner mounting interlock (see 4.2.2) indicates the correct location for the safe operation of the burner,
- b) any installation interlock (e.g. flue damper) indicates its correct position,
- c) the flame detector has been checked for flame simulation, with this check also permitted to be carried out during the pre-purge or after a controlled shut-down,
- d) any valve-proving system has completed its check successfully, with this check permitted to be carried out during the pre-purge or after a controlled shut-down, and
- e) the airflow proving device has been proven to be functioning correctly.

4.4.1.2 Pre-purge

Before energizing the ignition device, the combustion chamber shall be pre-purged.

The duration of the pre-purge shall be either

- a) at least 20 s at the full combustion air rate corresponding to the maximum nominal heat input, or
- b) where the air rate is reduced, a time period increased by an amount inversely proportional to the reduced air rate (e.g. 100 % air rate at least 20 s pre-purge time, 50 % air rate at least 40 s pre-purge time, 33 % air rate at least 60 s pre-purge time), and this reduced airflow rate shall be not less than 33 % of the full combustion air rate.

This duration can deviate from a) and b) above if at least five air volume changes in the combustion chamber are ensured.

The pre-purge airflow rate shall at least correspond to the adjusted heat input.

If the pre-purge airflow falls below the required rate at any time during the pre-purge, either

- the burner shall proceed to at least a safety shut-down and restart, or
- the pre-purge shall be continued until the required air rate is restored, provided that the total controlled pre-purge time is not reduced.

Two-stage or multi-stage burners with air dampers driven by servo drivers of any kind shall have low and high airflow positions. Depending on the selected airflow rate, one of these positions indicates the correct location during the pre-purge sequence. If this position is incorrect during the pre-purge, it shall cause a stop in the pre-purge sequence and prevent the burner from starting-up until it is re-established.

The duration of the pre-purge may be different or the pre-purge may be omitted if this is permitted in the appropriate appliance standard.

After a controlled shut-down, burner start-up (see 4.4.1.1) without a pre-purge may be achieved with the following:

- a) with burners of heat input up to and including 70 kW fitted with either two Class A safety shut-off valves in series or two Class B safety shut-off valves in series plus VTC (see Table 1);
- b) with burners of heat input greater than 70 kW fitted with two Class A safety shut-off valves in series plus VTC (see Table 1).

A pre-purge shall be carried out after

- a non-volatile lock-out,
- a standstill of more than 24 h,
- an electrical power failure,
- a shut-down caused by lack of gas.

In Japan and Australia, the specific requirements given respectively in normative Annexes I and J apply.

4.4.1.3 Start heat input

Burners shall start up at an excess air ratio value greater than or equal to those given in Table 8.

Burners with a nominal heat input up to and including 120 kW may be ignited directly.

For burners with a nominal heat input exceeding 120 kW, the start heat input shall not exceed 120 kW or the value given by Equation (1):

$$t_s \times Q_s \leq 100 \quad (1)$$

If burners are ignited by an independent ignition burner, the start heat input of the ignition burner shall not exceed the value given by Equation (2):

$$t_s \times Q_s \leq 150 \quad (2)$$

where

t_s is the safety time, in seconds (s);

Q_s is the maximum start heat input, expressed as a percentage of the main gas rate.

For the maximum start heat input and safety times, see Table 2.

A means shall be provided for the start heat input rate to be determined (see 5.2.4).

In Japan, the specific requirements given in normative Annex I apply.

4.4.1.4 Start gas ignition

The start gas valves shall not be energized before the ignition spark (or other means of ignition) is energized, except for purposes of valve proving.

Where a hot-surface ignition system is used, the ignition system shall be so energized that the ignition source is capable of igniting incoming gas before the start gas valve(s) are opened.

The start gas flame proving period shall establish that the flame is stable on its own. If the flame fails during this period, a non-volatile lock-out shall result.

For burners with a heat input of 120 kW and above, and on which the start gas supply is taken from between the main gas safety shut-off valves, the downstream main gas safety shut-off valve shall be de-energized prior to start-up.

Where the start gas rate is controlled by a start gas rate position contained within the downstream main safety shut-off valve, any means of adjustment of the start gas rate shall be in accordance with 4.3.5.7.

4.4.1.5 Main burner ignition

4.4.1.5.1 Establishment by means of a start gas flame

If the start gas flame has been ignited at a separate ignition burner and proved, the second safety time shall be not more than 5 s, at the end of which time sensing of the main flame shall begin. If the main flame is not detected at the end of this period, a non-volatile lock-out shall result.

4.4.1.5.2 Direct establishment of the main gas flame

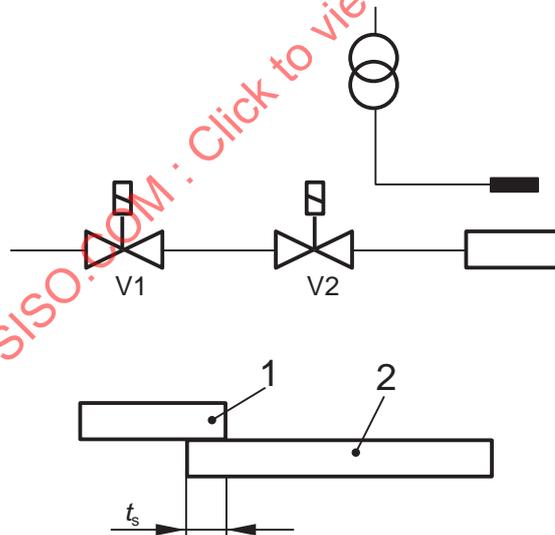
The ignition source shall not be energized before completion of the pre-purge period and shall be de-energized at or before the end of the safety time.

Where a hot surface ignition system is used, the ignition system shall be so energized that in each burner configuration the ignition source is capable of igniting incoming gas before the main gas valves are opened.

4.4.1.5.3 Energizing the main gas safety shut-off valves

The main gas safety shut-off valve immediately up-stream of the burner shall not be energized — except during the valve proving sequence in accordance with the requirements of 4.3.5.8 —

- a) before the ignition spark or other means of ignition is energized (in the case of direct main flame ignition) [see Figure 2 a)],
- b) after ignition, other than to permit the start gas flow (in the case of staged valve opening) [see Figure 2 b)],
- c) until the start gas flame has been established [see Figures 2 c) and 2 d)].

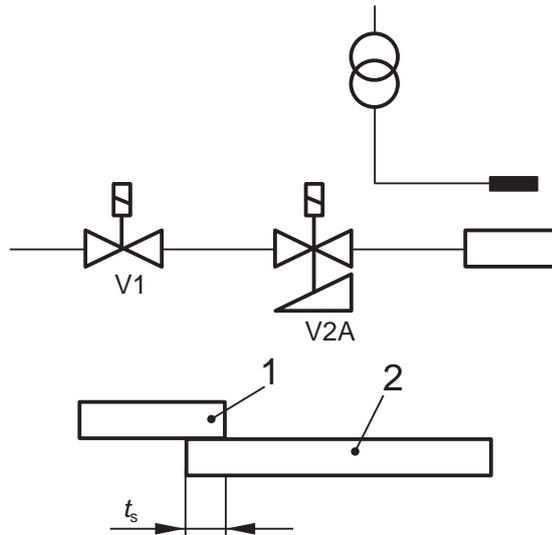


Key

1	ignition
2	main gas safety shut-off valves (V1 + V2)
V1, V2	main gas safety shut-off valves
t_s	first safety time

a) Direct main burner ignition at full rate

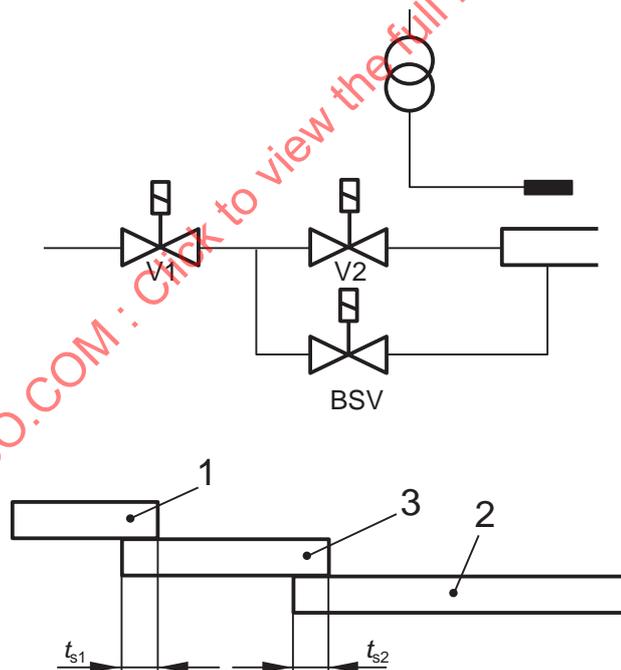
Figure 2 — Main burner ignition (continued)



Key

- 1 ignition
- 2 main gas safety shut-off valves (V1 + V2)
- V1 first safety shut-off valve
- V2A second safety shut-off valve
- t_s first safety time

b) Direct main burner ignition at reduced rate

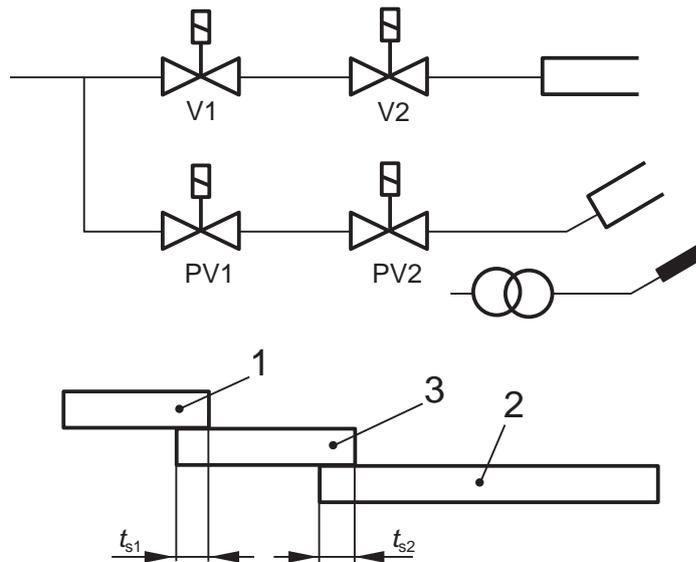


Key

- 1 ignition
- 2 main gas safety shut-off valves (V1 + V2)
- 3 bypass start gas valve (BSV + V1)
- V1, V2 main gas safety shut-off valves
- BSV bypass start gas valve
- t_{s1} first safety time
- t_{s2} second safety time

c) Direct main burner ignition at reduced rate with bypass start gas supply

Figure 2 — Main burner ignition (continued)



Key

- 1 ignition
- 2 main gas safety shut-off valves (V1 + V2)
- 3 start gas valves (PV1 + PV2)
- V1, V2 main gas safety shut-off valve
- PV1, PV2 ignition burner safety shut-off valve
- t_{s1} first safety time
- t_{s2} second safety time

d) Main burner ignition with independent ignition burner

Figure 2 — Main burner ignition

4.4.1.6 Safety times

4.4.1.6.1 First safety time

The first safety time shall be determined from Equation (1) or (2) as a function of the start gas rate, but in no case shall the first safety time exceed 5 s.

The ignition of the main and ignition burners, the maximum start gas rate and the corresponding safety time shall be as specified in Table 2, according to the maximum heat input of the burner (see also Figure 2).

Burner start-up may be achieved by one of the following:

- a) direct ignition of the main burner at full rate Q_N [see Table 2, column 2 and Figure 2 a)];
- b) direct ignition of the main burner at reduced rate [see Table 2, column 3 and Figure 2 b)];
- c) direct ignition of the main burner at reduced rate with bypass start gas supply [see Table 2, column 4 and Figure 2 c)];
- d) ignition of the main burner by means of an independent ignition burner [see Table 2, column 5 and Figure 2 d)].

The safety times declared by the manufacturer shall not be exceeded when the electrical supply voltage, U_N , varies between 85 % and 110 % of the mean value specified by the manufacturer.

Table 2 gives the start heat inputs and safety times for cases where the burner size is matched by the burner manufacturer to the test rig/appliance by at least

- thermal rating, and
- combustion chamber diameter, and
- combustion chamber length, and
- combustion chamber pressure.

Table 2 — Maximum start heat inputs (Q_s) and safety times (t_s)

1 Main burner	2 Direct main burner ignition at full rate		3 Direct main burner ignition at reduced rate		4 Direct main burner ignition at reduced rate with bypass start gas supply		5 Main burner ignition with independent ignition burner			
	Rate	Safety time	Rate	Safety time	Rate	Safety time	Ignition burner ignition		Main burner ignition	
Q_{Fmax} kW	Q_s %	s	Q_s %	s	Q_s %	s	Rate	First safety time	Rate	Second safety time
≤ 70	100	5	100	5	100	5	≤ 10	5	100	5
> 70 ≤ 120	100	3	100	3	100	3	≤ 10	5	100	3
> 120	not permitted		120 kW or $t_s \times Q_s \leq 100$ (max. $t_s = 3$ s)				≤ 10	3	120 kW or $t_s \times Q_s \leq 150$ (max. $t_s = 5$ s)	
Q_{Fmax}	maximum burner heat input (kW)									
Q_s	maximum start heat input expressed as a percentage of Q_F									
t_s	safety time (s)									

In the USA, Japan, Australia and Korea, the specific requirements given respectively in normative Annexes G, I, J and K apply.

4.4.1.6.2 Flame extinction safety time

The flame extinction safety time shall not be more than

- a) 1 s, and
- b) 2 s where a flame detector device self-check test is performed at the same time as flame failure.

In the USA and Japan, the specific requirements given respectively in normative Annexes G and I apply.

4.4.1.6.3 Total closing time

The total closing time shall not exceed 2 s. The two valves shall close simultaneously, but where a valve-proving system is used, there may be a delay for the second valve of up to 2 s.

4.4.1.7 Failure to ignite

Failure to ignite shall lead to either one or the other of the following.

- a) There shall be a maximum of three recycling attempts, where each recycling attempt has to perform the full start-up sequence. The flame signal shall be present by the end of the first safety time of the last permitted recycle attempt. If it is not, the system shall immediately react with safety shut-down followed by a non-volatile lock-out; or
- b) There shall be an immediate safety shut-down, followed by a non-volatile lock-out.

4.4.1.8 Flame failure during the running condition

If a flame failure during running is detected, the flame sensing system shall perform either one or the other of the following.

- a) It shall initiate a recycle, with a full start-up sequence. The flame signal shall be present by reaching the running position of the burner after the permitted recycle attempt. If it is not, the system shall immediately react with safety shut-down followed by a non-volatile lock-out; or
- b) It shall initiate an immediate safety shut-down followed by non-volatile lock-out.

4.4.1.9 Burner shut-down

The operation of a safety device, other than a low gas pressure sensing device, shall cause non-volatile lock-out without delay.

In the case of permanent loss of the actuating energy, the burner shall proceed to a safe condition.

4.4.2 Operational requirements

4.4.2.1 External soundness

When tested as specified in 5.3.1, the gas-carrying parts of the burner, up to the last downstream shut-off device, shall be sound.

4.4.2.2 Resistance of the burner to overheating

Under the conditions specified in 5.3.2, the various parts of the burner shall not suffer any deterioration other than the superficial alterations inherent in combustion.

4.4.2.3 Temperatures of the control and safety devices

Under the conditions specified in 5.3.3, the temperature of the adjusting, control and safety devices shall not exceed the value stated by the manufacturer of the device and their operation shall remain satisfactory.

The surface temperature of knobs and levers intended to be manipulated shall not exceed the ambient temperature by more than

- a) 35 K for metals,
- b) 45 K for porcelain or equivalent materials,
- c) 60 K for plastics or equivalent materials.

4.4.2.4 Ignition, operation and flame stability

Under the conditions specified in 5.3.4 and 5.3.5, as appropriate, ignition shall be effected correctly, rapidly and without pulsation. The flames shall be stable and shall not create any disturbing noise. A slight tendency to lift at the moment of ignition is permissible, but the flames shall be stable thereafter.

Flames shall be stable at the position declared by the manufacturer and shall not move by lighting back to nozzles located upstream in the burner during operation between its minimum and maximum heat input.

For burners fitted with a range-rating device, these requirements shall be satisfied at the nominal maximum and minimum heat inputs declared by the manufacturer.

4.4.3 Heat input range of the burner

The maximum nominal and minimum nominal heat inputs shall be measured under the conditions specified in 5.7 and shall be in accordance with the values stated by the manufacturer within $\pm 5\%$.

4.4.4 Dual-fuel burner

Safe operation of the burner shall not be affected by the operational state of the control and safety devices intended for the alternative fuel.

4.4.5 Working and test diagrams

4.4.5.1 Working diagram

The working diagram represents the permitted range of application of the burner in terms of the combustion chamber pressure expressed as a function of the burner heat input.

Its boundaries are defined by points 1 to 5 inclusive for single-stage burners [see Figure 8 a)] and 1 to 6 inclusive for multi-stage burners [see Figure 8 b)], determined in accordance with 5.4, 5.5, 5.6 and Table 6.

4.4.5.2 Test diagram

The test diagram represents the ranges of combustion chamber pressure and burner input over which the burner is tested to establish conformity to this International Standard.

It comprises the working diagram and a test zone defined by a series of points Hp1, Hp2, Hp3 and Hp5 for single-stage burners [see Figure 8 a)] and Hp1, Hp2, Hp3, Hp5 and Hp6 for multi-stage burners [see Figure 8 b)], determined in accordance with 5.4, 5.5, 5.6 and Table 6.

4.4.6 Determination of flame stability and the safe range of operation

The burner shall operate correctly and safely under the test conditions specified in 5.3.5.

The flames shall be stable without pulsation.

4.4.7 Limiting values for combustion emissions

4.4.7.1 General

Under the test conditions specified in 5.5, the CO and Q_{NO_x} content of the dry air-free combustion products shall not exceed the values specified in 4.4.7.2 and 4.4.7.3.

4.4.7.2 Carbon monoxide (CO)

The CO content shall not exceed the following:

- a) the values given in Table 3 when the burner is tested at the supply voltage declared by the manufacturer with the appropriate line-conveyed gas for which the burner is designed;
- b) 2 140 mg/kWh (2 000 ml/m³) when the burner is tested at 0,85 times the supply voltage declared by the manufacturer with the appropriate line-conveyed gas for which the burner is designed;
- c) for total pre-mix burners, 2 140 mg/kWh (2 000 ml/m³) when the burner, under the same conditions as in 4.4.7.2 a), is tested at the supply voltage declared by the manufacturer with the incomplete combustion gas of the gas family or group(s) for which the burner has been designed.

The burner shall be provided with means to ensure that in the event of the supply voltage falling below 0,85 times the manufacturer's declared value, either it continues to operate safely and the CO content of the combustion products does not exceed 2 000 ml/m³ by volume or it proceeds to a safety shut-down.

NOTE This requirement can be satisfied by the incorporation of one or another of the following:

- a) a motor speed checking device;
- b) a voltage checking device in the automatic burner control unit;
- c) an O₂ checking device;
- d) an airflow checking device;
- e) an gas/air ratio control device;
- f) a CO monitoring device.

This list is not exhaustive and other methods may achieve the same result.

In the USA, the specific requirements given in normative Annex G apply.

4.4.7.3 Nitrogen oxide (NO_x)

The Q_{NO_x} content of the combustion products shall be expressed under the ambient test conditions given in 5.1.3.5 (see also Annex A). Where the burner is designed to operate, after adjustment, on more than one gas family, the maximum Q_{NO_x} levels shall be as given in a) or b) below, as appropriate:

- a) 240 mg/kWh, when the burner is tested at the supply voltage declared by the manufacturer with natural gas;
- b) 300 mg/kWh, when the burner is tested at the supply voltage declared by the manufacturer with liquefied petroleum gas (LPG).

In Japan, the specific requirements given in normative Annex I apply.

4.4.7.4 Emission classes for burners

The emission classes for NO_x and CO are standardized according to Annex A and shall not exceed the values given in Table 3.

Where the burner is designed to operate on natural gas and/or LPG, the maximum CO and NO_x levels shall be in accordance with Table 3.

Table 3 — Emission classes for NO_x and CO

Class	Q _{NO_x} emissions mg/kWh ^{a b c}		Q _{CO} emission mg/kWh ^{a d}
	Natural gas	LPG	Natural gas and LPG
0	≤ 240	≤ 300	≤ 350
1	≤ 170	≤ 230	≤ 100
2	≤ 120	≤ 180	≤ 100
3	≤ 80	≤ 140	≤ 100

^a The maximum Q_{NO_x} value shall not exceed 240 mg/kWh for natural gas and 300 mg/kWh for LPG; the maximum CO value shall not exceed 350 mg/kWh.

^b No measured value shall exceed that of the next class up.

^c An arithmetic average value for determining the NO_x class is formed from the measuring points of the working diagram (see Annex A, $\bar{\varphi}_{NO_x, M}$) and shall be within the NO_x-class according to Table 3.

^d No single CO value shall exceed the limits for the class.

In European countries and Japan, the specific requirements given respectively in normative Annexes H and I apply.

4.4.8 Starting characteristics

Under the test conditions specified in 5.6, no excessive pressure fluctuations or flame pulsation shall occur. Any pressure fluctuations after ignition shall be reduced to the operating condition within 20 s. These requirements shall be verified by inspection.

4.4.9 Burner gas supplies

Forced draught burners using fans are exclusively commissioned using the supply gas and the supply gas pressure available on site.

5 Test methods

5.1 General

In European countries, Japan and Korea, the general requirements given in normative Annexes H, I and K apply.

5.1.1 Test gases for forced draught burners

For nozzle mixed burners, proof of burner performance shall be achieved by the use of line-conveyed natural gas or LPG.

For pre-mix burners of less than 150 kW, additional tests with the following gases shall be performed (see Table 7).

- a) Light back gas, which has a higher flame speed than line-conveyed gas by a larger content of hydrogen H₂ up to 50 % in the composition.

NOTE 1 Light back gas tests are carried out with burners having significant combustible pre-mixtures of air and gas upstream of the flame stabilizing device.

- b) Flame lift gas, which has a lower flame speed than line-conveyed gas by a larger content of nitrogen N₂ up to 50 % in the composition. Flame lift effect can be simulated by a higher excess air than in normal operation.
- c) Incomplete combustion gas, which has a higher energy content than the line-conveyed gas owing to a larger propane content of up to 15 %. Incomplete combustion can be simulated by increasing the burner load by 9 % without changing the air amount.

In European countries, Japan and Korea, the specific requirements respectively given in normative Annexes H, I and K apply.

5.1.2 Test pressures

The minimum test pressures are given in Table 4. Other pressures which are higher than those shown in Table 5 may be declared by the manufacturer, provided they derive from the gas distribution network.

Where a test pressure is declared by the manufacturer, the minimum test pressure will be equal to 0,8 times the nominal pressure declared by the manufacturer and the maximum pressure will be equal to 1,2 times the nominal pressure declared by the manufacturer.

Table 4 — Test pressures

Gas type	Normal pressure	Minimum pressure kPa	Maximum pressure
Town	0,8	0,6	1,5
Natural	2,0	1,7	2,5
LPG	2,9	2,5	3,5
	3,7	2,5	4,5
	5,0	4,25	5,75

In European countries, Japan and Korea, the specific requirements respectively given in normative Annexes H, I and K apply.

5.1.3 Combustion test chamber

5.1.3.1 General

Testing may be carried out in a combustion chamber nominated by the manufacturer. However, in cases where the manufacturer has not nominated a combustion chamber, the tests shall be carried out on a combustion test chamber as specified in 5.1.3.2 or 5.1.3.3.

A heat-transfer medium temperature that is as low as possible:

- a) combined with a low ambient temperature of the burner parts, provides the most critical condition for the *burner start-up* and the immediate turn-up of the heat input to the maximum with regard to flame lift and pulsation (higher heat-transfer medium temperatures and burner parts temperature support the burner start-up);
- b) provides the most critical condition for the *combustion quality* with regard to CO, unburned hydrocarbons and smoke on cool walls (higher heat-transfer medium temperatures support the combustion process).

5.1.3.2 Test rig for a heat input of less than or equal to 2,4 MW

The test rig shall include test flame tubes (see Figure 3).

Each flame tube is defined by

- a) its internal diameter (0,225 m, 0,300 m, 0,400 m, 0,500 m, 0,600 m, 0,800 m),
- b) its length, and
- c) its corresponding heat input (see Figure 4).

Individual flame tubes can be operated with a difference of $\pm 10\%$ in the given inputs.

The manufacturer shall nominate the flame tube to be used at minimum or maximum input.

The length of the flame tube, l_1 , shall be calculated using Equation (3):

$$l_1 = 0,23 \sqrt{\frac{Q_F}{10}} \quad (3)$$

where Q_F is the heat input, in kilowatts (kW).

The flame tube length is adjusted by means of a sliding rear wall, which moves longitudinally inside the flame tube itself.

At the manufacturer's option, the burners may be tested on a flame tube either with

- a) direct flame operation, or
- b) reversed flame operation.

For direct flame operation, an uncooled steel cylinder sleeve having the same internal diameter as the flame tube combustion chamber and a wall thickness of 3 mm shall be inserted in the combustion chamber inlet so as to seal the entry of the heat exchanger tubes.

The flame tube is equipped with a shutter device to enable a variable pressure drop to be created at the combustion chamber outlet or in the flue. It is by means of this device that the pressure within the combustion chamber may be adjusted.

All walls, with the exception of the front wall, shall be cooled.

The flame tube shall be fitted with sealed windows enabling visual inspection of the flame to be made. It shall be possible to measure the pressure in the flame tube.

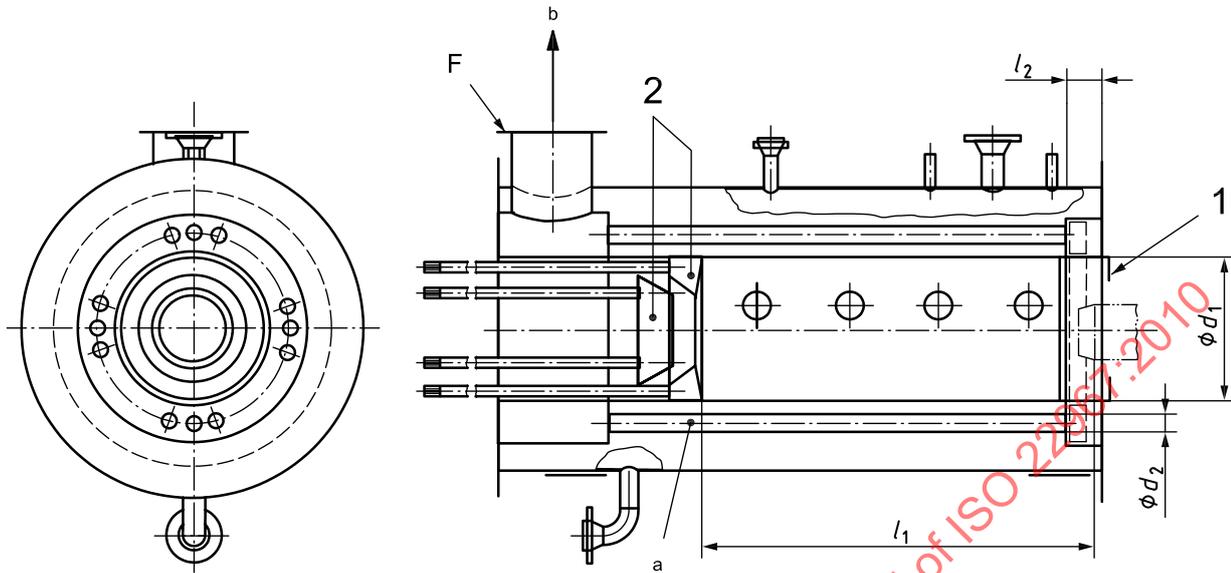
NOTE The pressure measurement can be carried out by means of a device fitted in the combustion chamber door (flame tube door).

It is acceptable for the flames to strike the cooled rear wall.

If the manufacturer develops a burner intended to fire into a combustion chamber with dimensions significantly different from those given in Figure 3, then the tests shall be carried out on a typical boiler or on another test flame tube pending the development of a new standard test flame tube. In this case, special mention shall be made in the burner instruction manual.

If the test is carried out on site in the actual application, the test results shall be recognized regardless of the temperature of heat-transfer medium and the position of installation of the burner. At the same time, the heat load rate (kWh/m^3 or kWh/m^2) shall be given in the commissioning report (see 6.4).

For burners with a heat input above the values given in Figure 4, the test shall be carried out on a test rig as specified by the manufacturer.

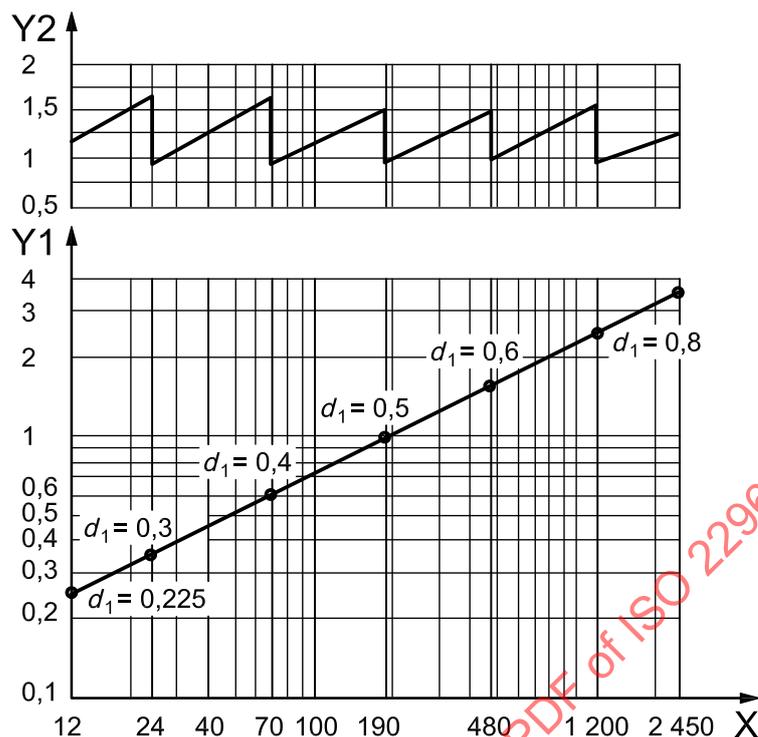


Test flame tube d_1 m	Heat exchanger tube		l_2 mm
	Internal	External	
0,225	16	20	8
0,3	21	25	14
0,4	36,5	41,5	12
0,5	39,5	44,5	26
0,6	51,5	57	30
0,8	80,9	88,9	28

Key

- 1 steel cylinder sleeve for direct flame operation ($l_2 + 30$ mm)
- 2 test flame tube rear wall (two parts)
- F flue duct flange interface
- d_1 diameter of combustion chamber
- l_1 length of combustion chamber
- ^a At the manufacturer's option, the test may also be carried out with flame reversal. When the flame is reversed, this shall be clearly stated in the instruction manuals.
- ^b Direction of flue gas flow.

Figure 3 — Test flame tube — Schematic representation

**Key**

- X heat input, Q_F , kW
 Y1 test flame tube length, m
 Y2 test flame tube firing intensity, MW/m^3
 d_1 test flame tube diameter, m

Figure 4 — Firing intensity, diameter and length of test flame tube as function of heat input

5.1.3.3 Test rig for a heat input greater than 2,4 MW

The test rig can be a boiler/oil appliance with a combustion chamber defined by the manufacturer on site.

Each combustion chamber is defined by

- its minimum length [see Equation (4) and Figure 5],
- its internal minimum diameter [see Equation (5) and Figure 6],
- its corresponding heat input, and
- heat load rate (kWh/m^3 or kWh/m^2).

If the test is carried out on site in the actual application, the test results shall be recognized regardless of the temperature of the heat-transfer medium and the position of installation of the burner. At the same time, the heat load rate (kWh/m^3 or kWh/m^2) shall be given in the commissioning report (see 6.4).

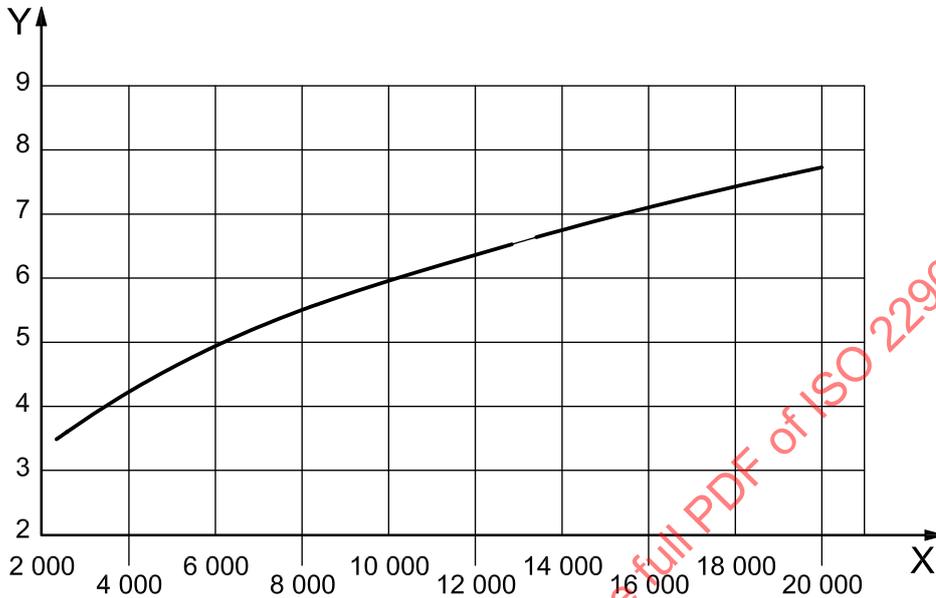
Individual combustion chambers can be operated with a difference of $\pm 5\%$ in the given inputs.

The manufacturer shall define the combustion chambers to be used at minimum and maximum inputs.

The length of the combustion chambers, l_1 , shall be calculated using Equation (4):

$$l_1 = 0,2 \times Q_F^{0,3682} \tag{4}$$

where Q_F is the heat input, in kilowatts (kW).



Key

- X heat input, Q_F , kW
- Y length, l_1 , of combustion chamber, m

Figure 5 — Minimum length of combustion chamber as function of heat input

The minimum length should apply if no other length is defined by the manufacturer (see 5.1.3.1).

At the manufacturer's option, the burner may be tested on a combustion chamber either with

- a) direct flame operation, or
- b) reversed flame operation.

The combustion chamber shall be equipped with a shutter device to enable a variable pressure drop to be created at the combustion chamber outlet or in the flue. The pressure within the combustion chamber may be adjusted by means of this device.

All walls, with the exception of the front wall, shall be cooled.

The combustion chamber shall be fitted with at least a single sealed window or spy glass enabling visual inspection of the flame to be made. It shall be possible to measure the pressure in the combustion chamber.

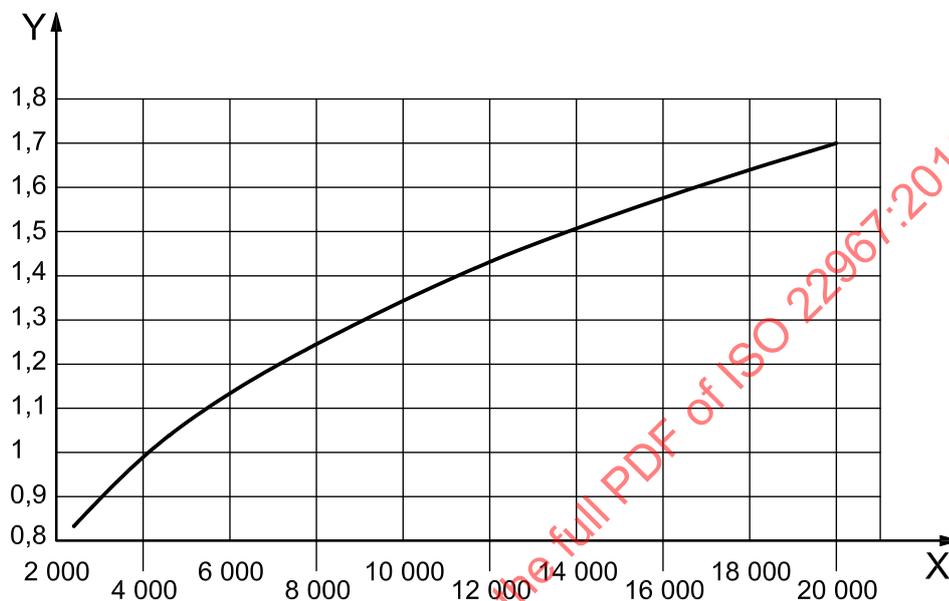
NOTE The pressure measurement can be carried out by means of a device fitted in the combustion chamber door.

It is acceptable for the flames to strike the cooled rear wall.

The diameter, d_1 , of the combustion chamber shall be calculated using Equation (5)

$$d_1 = 0,1350^3 \sqrt{\frac{Q_F}{10,1}} \quad (5)$$

where Q_F is the heat input in kilowatts (kW).



Key

X heat input, Q_F , kW

Y diameter, d_1 , of combustion chamber, m

Figure 6 — Minimum diameter of combustion chamber as function of heat input

The minimum diameter should apply if no other diameter is defined by the manufacturer (see 5.1.3.1).

5.1.3.4 Heat-transfer medium

The temperature of the heat-transfer medium in the test flame tube is maintained as low as possible, and in all cases in the range 15 °C to 60 °C (see also 5.1.3.1) during

- start-up (see 5.6),
- determination of the flame stability and the safe operational limits (see 5.1.3.1 and 5.3.5), and
- the flame stability test (see 5.3.4).

The heat-transfer medium temperature shall be between 40 °C and 80 °C and thermal equilibrium shall be maintained (see also 5.1.3.1) during

- tests for the flame stability and safe operational range (see 5.3.5),
- determination of the combustion characteristics (see 5.5), and
- determination of the input range (see 5.7).

5.1.3.5 Ambient test conditions

The burner shall be installed in a well-ventilated, draught-free environment, under the following conditions:

- a) an ambient temperature of $20\text{ °C} \pm 15\text{ °C}$;
- b) an ambient pressure of $101,325\text{ kPa} \pm 4\%$ at sea level;
- c) a humidity of 5 g to 30 g of water/kg of air.

The test results (working diagram, see 4.4.5) shall be corrected to reference conditions

- for the ambient temperature of 20 °C ,
- for the ambient pressure of $101,325\text{ kPa}$, and
- for the humidity of 10 g of water/kg of air.

NOTE For the Q_{NO_x} emission correction method, see Annex A.

Other ambient temperatures are acceptable provided that the test results are not affected.

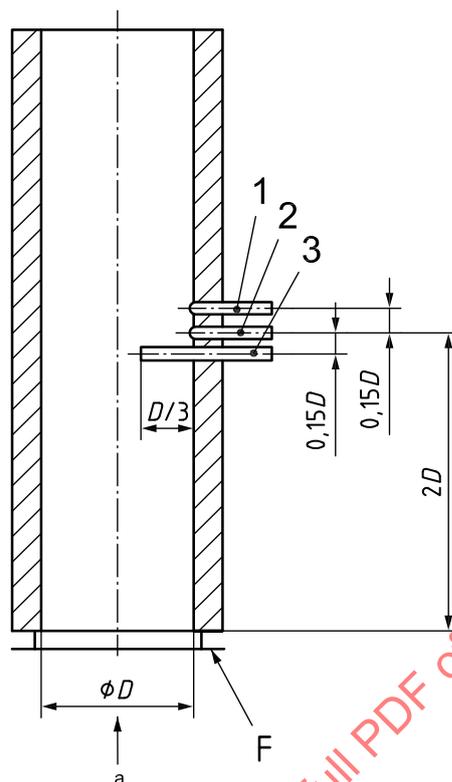
The quality of the air available in the test environment shall not affect the validity of the test parameters measured.

5.1.3.6 Evacuation of the combustion products

The test flame tube shall be connected to a flue as described in Figure 3.

The combustion products are to be sampled as shown in Figure 7.

When using analysers which measure temperature, pressure and flue gases, measuring points 1 and 2 may be omitted.

**Key**

- 1 temperature
- 2 draught/pressure
- 3 flue gas analysis
- D flue gas tube diameter
- F flue duct flange interface
- a Flue gas flow direction.

Figure 7 — Flue gas measurement section — Schematic representation

5.1.3.7 Electrical supply

The burner shall be supplied with electricity at the nominal voltage, U_N , except where otherwise stated.

5.1.3.8 Installation

The manufacturer shall supply to the test laboratory a burner fitted with all the accessories necessary for the burner's installation according to the manufacturer's instructions.

The burner to be tested shall be connected to the test flame tube as described in Figure 3, and distance l_1 between the flame stabilizer and the adjustable rear wall of the combustion chamber shall be adjusted according to Figure 4 or 5.

Overpressure in the combustion chamber is created by adjusting the shutter device in the rear wall, or any other system placed downstream, either separately or in combination.

For burners operating at a negative pressure in the combustion chamber, an induced draught fan (downstream of the measuring device) is required, or the required values are obtained with the help of a manual adjusting device or an automatic combustion chamber pressure control system.

Burners to be tested on a particular appliance or another test flame tube shall be installed in accordance with the manufacturer's instructions.

5.1.3.9 Measurement accuracies

5.1.3.9.1 Measuring instrument accuracies

Except where otherwise stated in the relevant requirements, the measuring instruments used shall enable measurements to be made in accordance with Table 5.

Table 5 — Measuring instrument accuracies

Measuring instrument for:	Accuracy
Calorific value	±0,5 %
Density	±0,5 %
Gas temperature	±0,2 K
Time	±0,1 s
Gas pressure	±10 Pa
Atmospheric pressure	±50 Pa
Combustion products (NO _x , CO)	±5 ml/m ³
Mass	±0,5 %
Gas volume	±0,5 %
Surface temperature	±2 K
Gas part soundness	±10 Pa

5.1.3.9.2 Measurement uncertainties

The allowable test measurement uncertainties shall be in accordance with Table 6.

Table 6 — Test measurement uncertainties

Parameter	Uncertainty
Combustion chamber length, l_1	±3 %
Burner inlet air temperature	±2 K
Combustion chamber pressure during operation	±5 %
Combustion chamber pressure during start-up	±10 %
Fuel throughput	±2,5 %
CO ₂ content	±0,3 % by volume
O ₂ content	±0,3 % by volume
CO content	±10 ml/m ³
NO _x content	±10 ml/m ³

5.1.4 Test types

5.1.4.1 General

A burner shall be tested as a separate unit.

A complete unit consists of the burner and its accessories (see Figure 1).

5.1.4.2 Structural testing

After the conclusion of the tests, a comparison between the drawings and the construction of the burner shall be made. If necessary, the burner shall be disassembled for this comparison.

If conversion from one type of gas to another is intended, all the parts required for the conversion shall be tested together with the burner and using the appropriate test gas.

5.2 Functional tests

5.2.1 General

The burner shall be installed according to the manufacturer's instructions and in accordance with 5.1.3.6.

The electrical supply voltage shall be adjusted to the nominal voltage, except where otherwise stated.

The normal condition is at nominal voltage and exceptions are 85 % or 110 % of the nominal voltage. It is under these conditions that the correct operation of the individual components and of the burner is verified.

Where tests are specified using line-conveyed or test gases, they shall be carried out on the appropriate gas for each gas type for which the burner is designed.

5.2.2 Start-up

The burner shall be installed according to the manufacturer's instructions and in accordance with 5.1.3.

The requirements of 4.4.1.1 shall be met.

5.2.3 Pre-purge

The burner shall be operated from the beginning of the burner control programme.

The requirements of 4.4.1.2 shall be met.

5.2.4 Start-up heat input

The burner shall be operated with the electrical supply at its nominal voltage. The requirements concerning the maximum start-up heat input specified in 4.4.1.3 shall be met.

The heat input range shall be measured in accordance with 5.7.

5.2.5 Ignition

The main burner and ignition burner shall be supplied with each line-conveyed gas at its specified supply pressure gas for the burner category at their normal pressures so as to obtain the nominal heat input.

The requirements of 4.4.1.4 and 4.4.2.4 shall be verified.

5.2.6 Safety times

5.2.6.1 General

The tests shall be carried out using the line-conveyed gas at its specified supply pressure.

5.2.6.2 Flame extinction safety time

With the burner in operation, flame failure is simulated by putting the flame sensor out of action. The time is measured between this operation and the moment at which the safety device de-energizes the gas supply safety shut-off valves.

5.2.6.3 Failure to ignite

The relevant burner shall be started and the flame detector device put out of action.

The requirements of 4.4.1.7 shall be met.

5.2.6.4 Flame failure during the running condition

With the burner in operation, flame failure shall be simulated by putting the flame sensor out of action.

The requirements of 4.4.1.8 shall be met.

5.3 Operation

5.3.1 External soundness

Tests shall be carried out at ambient temperature using air or gas at a pressure of 1,5 times the manufacturer's declared maximum supply pressure, whichever is the higher, in the direction of gas flow.

The air or gas supply shall be connected to the burner gas inlet line.

All safety shut-off valves shall be maintained in the open position, except for the last downstream means of isolation.

The inlet pressure shall be adjusted to the specified value and all gas-carrying parts subjected to this pressure.

The soundness test shall be carried out either by applying a suitable foaming agent to all joints and unions at the beginning of the test or by the pressure loss method. The system is deemed to be sound if no bubbles form or pressure losses are less than or equal to appropriate values.

5.3.2 Resistance of the burner to overheating

5.3.2.1 General

The burner shall be installed in accordance with 5.1.3 and the temperature of the cooling medium shall be maintained between 20 °C and 60 °C.

5.3.2.2 Nozzle-mixed burners

The burner shall be supplied with line-conveyed gas at its specified supply pressure and at 1,09 times its nominal maximum heat input, and the pressure in the flame tube shall be adjusted to the maximum value corresponding to the nominal maximum heat input specified by the manufacturer.

The burner shall be operated for 10 min, after which the requirements of 4.4.2.2 shall be met (point Hp1).

5.3.2.3 Total pre-mixed burners

The burner shall be adjusted in accordance with 5.3.2.2.

Without re-adjustment, the burner shall be supplied with the appropriate light back gas (see 5.1.1) and operated for 10 min.

At the end of this time, the requirements of 4.4.2.2 shall be met.

NOTE These requirements are applicable only if the light back gas is specified.

5.3.3 Temperature of the control and safety devices

The burner shall be installed in accordance with 5.1.3 and supplied with the appropriate line-conveyed gas, each at its specified supply pressure and at the maximum heat input.

The temperatures of the control and safety devices shall be measured with the burner in the cold condition.

The burner shall then be operated for 30 min and the temperatures of the control and safety devices measured again.

The requirements of 4.4.2.3 shall be met.

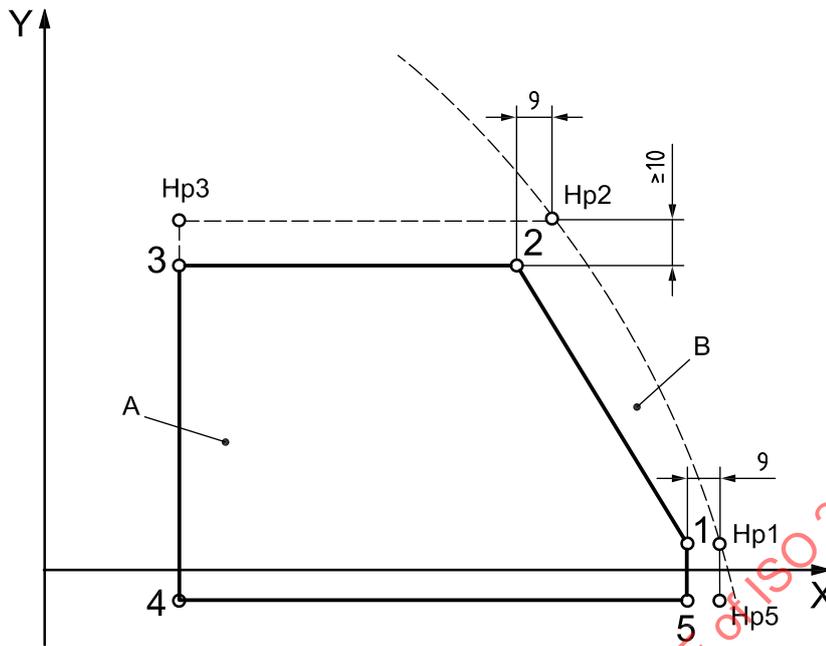
If an electrical component (e.g. an automatic shut-off valve) is itself likely to cause a rise in temperature, the temperature of the component shall not be measured. The temperature measuring probes shall be placed so as to measure the air temperature around the device.

5.3.4 Ignition — Flame stability

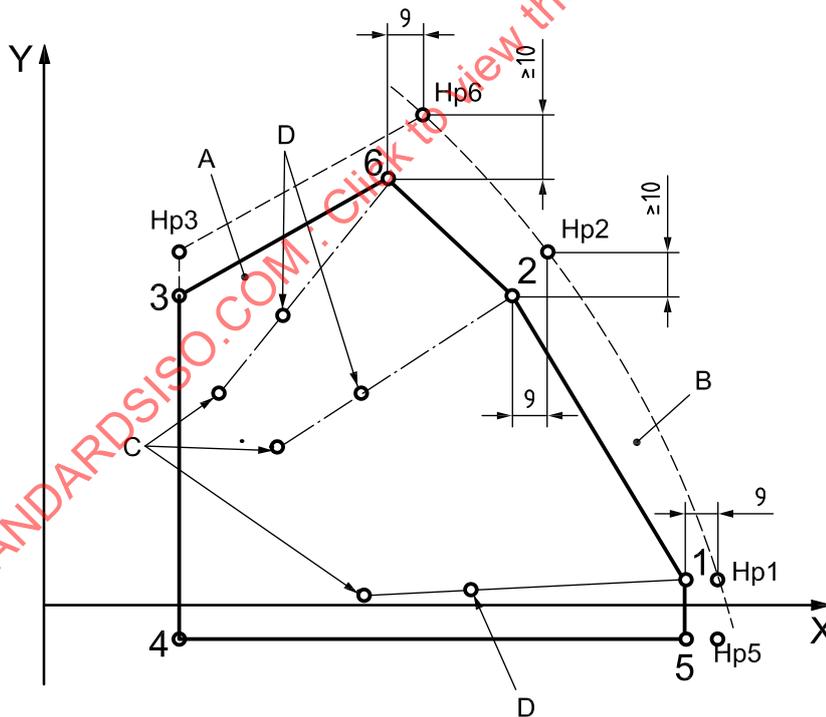
At test point 3 and test point 4 (see Figure 8) safe ignition and safe operation shall be checked at an excess air ratio, λ , greater than or equal to 1,5 or with the air dampers fully opened.

In addition, for pre-mixed burners, a stability test shall be carried out at test points 1 and 4 using a light back limit gas (see 5.1.1).

Values in percent



a) Single-stage burners



b) Two-stage, multi-stage and modulating burners

Key

- | | | | |
|---|----------------------------------|---|---------------------------------------|
| X | heat input, kW | B | test diagram |
| Y | combustion chamber pressure, kPa | C | minimum burner heat input points |
| A | working diagram | D | intermediate burner heat input points |

Figure 8 — Working and test diagrams

5.3.5 Operation — Flame stability

The burner shall be installed in accordance with 5.1.3.

The flame stability shall be observed in the cases of the following:

- a) nozzle-mixed burners supplied with line-conveyed gas at the specified supply pressure for which the burner is designed;
- b) total pre-mixed burners
 - 1) of heat input up to and including 150 kW, with the burner adjusted to the manufacturer's specified value of excess air ratio, λ , for the relevant line-conveyed gas, then changed to operation on the corresponding flame lift gas (see 5.1.1) without readjustment [test point 1 and test point 4 (see Figure 8)],
 - 2) of heat input greater than 150 kW when supplied with line-conveyed gas (e.g. natural gas or LPG) for which the burner is designed.

For line-conveyed and flame-lift limit gases in Europe and Japan, the specific requirements respectively given in normative Annexes H and I apply.

5.4 Tests to be carried out at points identified on working and test diagrams

5.4.1 Test point 1

For all burners: supply the burner with the appropriate line-conveyed gas at the specified supply pressure and normal supply pressure, and adjust

- a) the heat input to the maximum nominal value,
- b) the electrical supply voltage to the nominal value,
- c) the excess air ratio, λ , to the declared value, and
- d) the combustion chamber pressure to the minimum value.

Then carry out the following steps.

- e) Check the combustion: CO, NO_x and λ (see 4.4.7 and Table 7).
- f) Check the temperature of the control and safety devices (see 5.3.3).
- g) Reduce the voltage to 85 % of the nominal value and check combustion: CO (see 4.4.7.2).
- h) Reduce the voltage below 85 % of the nominal value. Check for safe behaviour of the burner or safety shut-down.
- i) Check the heat input variation with variation in supply pressure (see 4.3.5.4).

For total pre-mixed burners, additionally, see 5.1.1 and

- j) replace the reference gas by light back gas and check ignition (see 5.3.4);
- k) if the heat input is equal to or less than 150 kW, replace the reference gas by lift limit gas, and check the ignition and flame stability (see 5.3.4 and 5.3.5).

For single-stage burners only,

- l) additionally, check the ignition and flame stability (see 5.3.4 and 5.3.5).

For the application of the reference gas and flame-lift limit gases in Europe and Japan, the specific requirements respectively given in normative Annexes H and I apply.

5.4.2 Test point Hp1

For all burners: adjust the burner and combustion chamber pressure as specified in 5.4.1.

For nozzle mixed burners, then increase the heat input with line-conveyed gas by 9 %.

For pre-mix burners, replace line-conveyed gas with a corresponding incomplete combustion gas (see 5.1.1).

Then carry out the following steps.

- a) Check the combustion: CO [see 4.4.7.2 c)].
- b) Check the ignition and flame stability (see 5.3.4 and 5.3.5).
- c) Check for resistance to overheating (see 5.3.2).

NOTE Extra test points for extended flame tubes could be required.

5.4.3 Test points 2, 5 (single-, multi-stage and modulating burners) and 6 (multi-stage and modulating burners)

For all burners: supply the burner with the appropriate line-conveyed gas at normal supply pressure and then adjust

- a) the heat input to the declared value,
- b) the electrical supply voltage to the nominal value,
- c) the excess air ratio, λ , to the declared value,
- d) the combustion chamber pressure to the maximum value (positive at points 2 and 6, negative or zero at point 5).

Then check the combustion: CO, NO_x and λ (see 4.4.7 and Table 7).

For single-stage burners only, additionally check the ignition and flame stability (see 5.3.4 and 5.3.5).

5.4.4 Test points Hp2 (single-, multi-stage and modulating burners) and Hp6 (multi-stage and modulating burners)

For all burners: supply each burner with the appropriate line-conveyed gas at normal supply pressure, and

- a) make the adjustments as specified in 5.4.3, points 2 and 6, and
- b) adjust combustion chamber pressure to 1,1 times the maximum value and readjust the nominal heat input, noting that the excess air ratio, λ , could require readjustment.
- c) For nozzle mix burners, increase the heat input by 9 %.
- d) For pre-mix burners, replace the line-conveyed gas with a corresponding incomplete combustion gas (see 5.1.1).

Then carry out the following steps.

- e) Check the combustion: CO (see 4.4.7.2).
- f) Check the ignition and flame stability (see 5.3.4 and 5.3.5).

5.4.5 Test point 3

For all burners: supply with the appropriate line-conveyed gas at normal supply pressure and adjust

- a) the heat input to the minimum nominal value,
- b) the electrical supply voltage to the nominal value,
- c) the excess air ratio, λ , to the declared value, and
- d) the combustion chamber pressurization device to the same position as that for test point 6.

Then carry out the following steps.

- e) Check the combustion: CO, NO_x and λ (see 4.4.7 and Table 7).
- f) As appropriate, adjust the excess air ratio, λ , to 1,5 or greater, or open the air damper fully.
- g) Check the ignition and flame stability (see 5.3.4 and 5.3.5).

5.4.6 Test point 4

For all burners: adjust

- a) the heat input to the minimum nominal value,
- b) the electrical supply voltage to the nominal value,
- c) the excess air ratio, λ , to the declared value, and
- d) the combustion chamber pressure to the minimum value (this value may be zero or negative).

Then carry out the following steps.

- e) Check the combustion: CO, NO_x and λ (see 4.4.7 and Table 7).
- f) As appropriate, adjust the excess air ratio, λ , to 1,5 or greater, or open the air damper fully.
- g) Check the ignition and flame stability (see 5.3.4 and 5.3.5).

For total pre-mixed burners of less than or equal to 150 kW (see 5.1.1), additionally perform the following tests:

- h) replace the line-conveyed gas by the light back gas, operate the burner for 10 min, then check ignition and flame stability (see 5.3.4 and 5.3.5);
- i) replace the reference gas by the flame lift gas and check ignition and flame stability (see 5.3.4 and 5.3.5).

For reference and flame-lift limit gases in Europe and Japan, the specific requirements respectively given in normative Annexes H and I apply.

5.4.7 Tests at first stage points or minimum heat input

For all multi-stage or modulating burners, adjust

- a) the burner and combustion chamber settings for points 2, 5 and 6 or points 1, 2 and 6, as appropriate,
- b) then operate the burner at its first stage or its minimum heat input, as appropriate.

Then carry out the following steps.

- c) Check the combustion: CO, NO_x and λ (see 4.4.7 and Table 7).
- d) Check the ignition and flame stability (see 5.3.4 and 5.3.5).
- e) Repeat d) at the mid-point of the heat input range.

5.4.8 Summary

The measurements to be made and the corresponding requirements and test procedures are given in Table 7.

Table 7 — Test summary

Test point	1	2	3	4	5	6	Hp1	Hp2	Hp6	Subclause/Table
$U = 100 U_N$	x	x	x	x	x	x	x	x	x	4.4.7
$U = 0,85^b U_N$	x	—	—	—	—	—	—	—	—	4.4.7 and 5.5
Heat input variation	x	—	—	—	—	—	—	—	—	4.3.5.4
λ^a	x	x	x	x	x	x	—	—	—	Table 8 and 5.5
CO < 100 mg/kWh ^a	x	x	x	x	x	x	—	—	—	4.4.7
NO _x < 170 mg/kWh ^a	x	x	x	x	x	x	—	—	—	4.4.7
CO < 2140 mg/kWh	—	—	—	—	—	—	x	x	x	4.4.7
Ignition at $\lambda \geq 1,5$ or air damper fully open	—	—	x	x	—	—	—	—	—	4.4.2.4
Ignition and flame stability ^a	x	x	x	x	x	x	x	x	x	4.4.2.4
Start-up single-stage burner	x	x	x	x	x	—	x	x	—	5.6
Start-up multi-stage burner	x	x	—	—	x	x	x	x	x	5.6
Pre-mixed burner, light back	x	—	—	x	—	—	—	—	—	4.4.2.4, 5.1.1
Pre-mixed burner, flame lift ≤ 150 kW	x	—	—	x	—	—	—	—	—	4.4.2.4, 5.1.1
Resistance to overheating	—	—	—	—	—	—	x	—	—	4.4.2.2
Temperature of control and safety devices	x	—	—	—	—	—	—	—	—	5.3.3

^a Tests carried out at the first stage test points corresponding to points C [see Figure 8 b)].

^b At the end of the test, which is carried out at the maximum mass flow rate, another test is performed at voltages below 85 % until a safety shut-down or lock-out takes place. At no voltage shall unsafe behaviour of the burner occur.

In Europe, the specific requirements given in normative Annex H apply.

5.4.9 Functional test

After completion of the test, it shall be ascertained at room temperature that the burner materials or components do not exhibit any deformation, maladjustment or degradation.

5.5 Combustion

The burner shall be installed in accordance with 5.1.3, operated with line-conveyed gas, and set at the nominal voltage for which it is designed. Then carry out the following steps.

- a) At points 1 to 6, adjust the excess air ratio, λ , in accordance with Table 8. The CO and Q_{NO_x} values shall be in accordance with the requirements of 4.4.7.2 and 4.4.7.3 respectively.
- b) At point 1 (see Figure 8), with λ adjusted in accordance with the requirements of Table 8 and the supply voltage adjusted to 85 % of the value declared by the manufacturer, the CO values shall meet the requirements of 4.4.7.2.
- c) At points 1, 2 and 6 (see Figure 8), increase the combustion chamber pressure in accordance with 5.4 and either
 - 1) for nozzle mix burners, increase the heat input by 9 % at the nominal voltage without adjusting the airflow rate, or
 - 2) for pre-mix burners, replace the line-conveyed gas with a corresponding incomplete combustion gas (see 5.1.1).

Under these conditions (at points Hp1, Hp2 or Hp6), the CO content in the dry air-free products of combustion shall not exceed the value given in 4.4.7.2.

- d) In addition, when adjustment is made in accordance with a), the supply voltage at point 1 shall be reduced to voltages below 85 % until a safety shut-down or lock-out takes place. At all voltages, no unsafe behaviour of the burner shall occur.

Table 8 — Excess air ratio

Burner type	Turn-down ratio	Excess air ratio, λ					
		Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Single-stage	—	$\leq 1,2$	$\leq 1,2$	$\leq 1,3$	$\leq 1,3$	$\leq 1,2$	—
Multi-stage or modulating	≤ 1 to 4	$\leq 1,2$	$\leq 1,2$	$\leq 1,3$	$\leq 1,3$	$\leq 1,2$	$\leq 1,2$
	> 1 to 4	$\leq 1,2$	$\leq 1,2$	$\leq 1,5$	$\leq 1,5$	$\leq 1,2$	$\leq 1,2$

For pre-mix burners of Q_{NO_x} Class 3, the excess air ratio may be less than or equal to 1,4 at full and part load.

5.6 Start-up

The burner shall be supplied with line-conveyed gas and the value of λ adjusted to give an excess air ratio value greater than or equal to those given in Table 8.

The electricity supply to the burner shall be adjusted to 85 % of the manufacturer's minimum specified voltage range.

The start-up tests shall be carried out with the conditions in the test flame tube corresponding to the points of the working and test diagrams as determined in accordance with 5.4.

Three start-up tests shall be carried out at each point, the first test being carried out with the cooling medium cold.

For the second and third start-up tests, the burner shall be switched off and immediately switched on again. The interval between switching off and on shall be not more than 5 s.

During the start-up tests, no excessively high pressure fluctuations or flame pulsations shall occur in the test flame tube. This shall be verified by visual check.

5.7 Obtaining the nominal heat input

The nominal heat input, Q_N , in kilowatts, is given by Equation (6) or (7):

$$Q_N = 0,278 \times q_{m,N} \times H_i \quad (6)$$

or

$$Q_N = 0,278 \times q_{V,N} \times H_i \quad (7)$$

where

$q_{m,N}$ is the nominal mass flow rate (kg/h) obtained under reference conditions (dry gas, 15 °C; 101,325 kPa);

$q_{V,N}$ is the nominal volume flow rate (m³/h) obtained under reference conditions (dry gas, 15 °C; 101,325 kPa);

H_i is the inferior calorific value of the gas in MJ/kg [Equation (7)] or in MJ/m³.

These mass and volume flow rates correspond to a measurement and flow of gas under reference conditions (i.e. assuming the gas to be dry at 15 °C and under 101,325 kPa pressure).

In practice, the values obtained during the tests do not correspond to these reference conditions. They therefore need to be corrected to the values that would actually have been obtained had the reference conditions existed during the tests.

When the determination is made by weight (LPG), the corrected mass rate, $q_{m,0}$, is given by Equation (8):

$$q_{m,0} = q_m \sqrt{\frac{101,325 + p}{p_{at} + p} \times \frac{273,15 + t_g}{288,15} \times \frac{d_r}{d}} \quad (8)$$

When the determination is made from the volume flow rate, $q_{V,0}$, the correction formula shown in Equation (9) is used:

$$q_{V,0} = V \sqrt{\frac{101,325 + p}{101,325} \times \frac{p_{at} + p}{101,325} \times \frac{288,15}{273,15 + t_g} \times \frac{d}{d_r}} \quad (9)$$

The corrected mass rate, $q_{m,0}$, is then calculated using Equation (10):

$$q_{m,0} = 1,226 \times V_0 \times d \quad (10)$$

where

q_m is the mass flow rate obtained under test conditions;

q_V is the volume flow rate obtained under test conditions (measured at pressure $p_{at} + p$ and temperature t_g);

p_{at} is the atmospheric pressure (kPa);

p is the gas pressure measured at the meter (kPa);

t_g is the temperature of the gas measured at the meter (°C);

d is the density of the dry gas relative to dry air;

d_r is the density of the dry reference gas relative to dry air.

For reference and flame-lift limit gases in Europe and Japan, the specific requirements respectively given in normative Annexes H and I apply.

5.8 Electrical safety

Examination of the electrical equipment and burner connections as specified in 4.3.2.2.1 shall be carried out visually, by functional test or by measurement.

The burner manufacturer shall provide a detailed declaration of conformity showing that the requirements of 4.3.2.2.1 have been fulfilled.

The electrical connections for, and correct integration of, the individual components shall be examined by means of the electrical wiring diagram provided by the manufacturer.

6 Marking, labelling and packaging

6.1 General

The burner, its packaging and other relevant components shall be marked with the information specified in 6.2, 6.3 and 6.5.

6.2 Data plate

Each burner shall have fitted in a visible position after installation — but not after the removal of part of the case — a data plate stating in indelible characters and as a minimum the following:

- a) name, address and/or the trade mark of the manufacturer;
- b) serial number and year of manufacture (coded);
- c) trade name under which the burner is presented for testing;
- d) line-conveyed gas type;
- e) nominal heat input expressed in kilowatts (kW) and, where necessary, the fuel consumption in kilograms per hour (kg/h);
- f) for range-rated burners, the maximum nominal and minimum nominal heat inputs expressed in kilowatts (kW);
- g) supply pressure or pressure range which can be used;
- h) electrical supply type (i.e. direct or alternating) and voltage;
- i) burner power consumption.

6.3 Other markings

The burner shall carry a suitable plate or durable label indelibly marked with the following:

“This burner shall be installed in accordance with the rules in force and used only in a sufficiently well-ventilated space. Consult the instructions before installation and use of this burner.”

The burner shall also carry all useful information relating to any electrical equipment, particularly the voltage and the current to be used and the appropriate insulation code in accordance with IEC 60529.

Permanent warning notices shall be provided in readily visible positions on the burner stating that the burner is to be switched off and the gas supply isolated before any servicing operation is carried out.

Provision shall be made on the burner or the data plate for marking the appliance category and the gas pressure in accordance with 4.4.9.

6.4 Instructions for application, installation, adjustment, commissioning, maintenance and operation

The burner shall be accompanied by instructions giving information regarding its correct application, installation, adjustment, commissioning, maintenance and operation, such as the following:

- a) that the burner shall be commissioned prior to automatic operation;
- b) appropriate warning notes shall be included in the instructions;
- c) that each burner shall only be installed, set-up, adjusted and maintained by suitably trained and certified personnel;
- d) that all gas line components shall be assembled and mounted without bending, torque or other mechanical or thermal stress;
- e) a declaration as to which measures shall be taken to minimize the risk of accident throughout the foreseeable lifetime of the burner and its safety equipment;
- f) information on the wear of parts and the adequate changing/lifetime periods in which they have to be exchanged to incorporate adequate safety margins;
- g) about the application of firing aggressive gases.

The installation instructions shall indicate how to connect external safety limiters to the burner control system and a declaration shall be included as to whether the burner will go only to a safety shut-down or to a non-volatile lock-out.

A commissioning report showing on site measured data noted by qualified and trained technicians is required. The measured data values shall be available on site and shall include, as a minimum, the following:

- a) line-conveyed gas type;
- b) Wobbe index (calorific value);
- c) volumetric gas flow rate;
- d) minimum and maximum heat output rates;
- e) start gas rate;
- f) supply gas pressure;
- g) adjustment gas pressure;

- h) CO and CO₂ percentage (or O₂ percentage) content of the flue gases;
- i) combustion air temperature;
- j) flue gas temperature.

All documents shall show a date of issue.

In addition, the instructions shall include a wiring diagram and details of control box sequencing.

A simplified electrical connection diagram shall be made available for display at or near the electrical junction box. The gas types suitable for the burner shall also be stated.

The installation instructions shall contain full details of the intended range of operation as well as the parameters necessary for matching the burner to the appliance (e.g. working diagram, connection dimensions). In addition, details shall be included on the gas supply connection for the burner (e.g. the burner head, inlet pressure, pressure monitoring and adjustment pressure).

In addition, where the burner has been designed for operation in a combustion chamber whose dimensions are significantly different from those of the test flame tube then this shall be indicated in the installation instructions.

The commissioning instructions shall describe the method to be used for determining the start gas rate.

The operating instructions shall provide information on the mode of use of monitoring devices fitted to the burner. The operating instructions shall also contain details of the measures to be taken in the event of a fault or an emergency.

Concise instructions for the user concerning the procedure for start-up and shut-down of the burner shall be made available for display at or near the burner.

The manufacturer's instructions shall provide technical information on the procedures to be followed when converting a burner and its equipment from one type of gas to another gas (e.g. from propane to natural gas supply) and/or to adapt for different gas supply pressures.

6.5 Marking on the packaging

The minimum information shown on the packaging shall be the type of gas in relation to the gas pressure for which the burner has been adjusted.

No other information shall be included on the package if this could lead to confusion with regard to the current state of adjustment of the burner and corresponding burner category or categories and the direct country or countries of destination.

In addition, the burner packaging shall carry a label indelibly marked with

“This burner shall be installed in accordance with the rules in force, and used only in a sufficiently well-ventilated space. Consult the instructions before installation and use of this burner.”

Annex A (informative)

Determination of combustion characteristics — Carbon monoxide and nitrogen oxides and conversion factors

A.1 CO content, calculation from ml/m³ into mg/kWh

For multi-stage or modulating burners, the tests are carried out at the nominal heat input and the minimum heat input stated by the manufacturer.

Modulating burners are tested at the nominal heat input and the minimum heat input given by the controls.

A representative dry sample of the combustion products is taken when the burner has reached thermal equilibrium.

The CO content of the dry, air-free combustion products is given by Equation (A.1):

$$Q_{\text{CO}} = 1,08 \times f_{\text{CO},\text{M}} \frac{f_{\text{CO}_2,\text{N}}}{f_{\text{CO}_2,\text{M}}} \quad (\text{A.1})$$

where

Q_{CO} is the CO content in mg/kWh, referring to the energy input;

$f_{\text{CO}_2,\text{N}}$ is the maximum possible carbon dioxide content as a percentage by volume of the air-free combustion products;

$f_{\text{CO},\text{M}}$ is the measured concentration, expressed in ml/m³ by volume of carbon monoxide in the sample taken during the combustion test;

$f_{\text{CO}_2,\text{M}}$ is the measured concentration, expressed as a percentage by volume of carbon dioxide in the sample taken during the combustion test.

The CO content in mg/kWh, referring to the energy input, may also be calculated by using Equation (A.2).

$$Q_{\text{CO}} = \frac{21}{21 - f_{\text{O}_2,\text{M}}} \times f_{\text{CO},\text{M}} \times 1,08 \quad (\text{A.2})$$

where $f_{\text{O}_2,\text{M}}$ is the measured concentration, expressed as a percentage by volume, of oxygen in the sample taken during the combustion test.

The use of Equation (A.2) is recommended where it gives greater accuracy than Equation (A.1), which is based on the CO₂ content.

A.2 NO_x content, calculation from ml/m³ into mg/kWh

The NO_x content of the dry, air-free combustion products is given by Equation (A.3):

$$Q_{\text{NO}_x} = f_{\text{NO}_x, \text{M}} \left(\frac{21}{21 - f_{\text{O}_2, \text{M}}} \right) 2,056 \left(\frac{V_{\text{A, th, tr, min}}}{H_i} \right) \quad (\text{A.3})$$

where

- Q_{NO_x} is the NO_x emission in mg/kWh, referring to the energy input;
- $f_{\text{NO}_x, \text{M}}$ is the measured NO_x emission in ml/m³, volumetric;
- $f_{\text{O}_2, \text{M}}$ is the measured concentration, expressed as a percentage by volume, of oxygen in the sample taken during the combustion test;
- 2,056 is the NO₂ density in kg/m³;
- $V_{\text{A, th, tr, min}}$ is the theoretical reference flue gas volume, dry, in m³/m³;
- H_i is the inferior calorific value in kWh/m³ (referring to 15 °C and 101,3 kPa).

Reference values, e.g. for natural gas (100 % CH₄):

- H_i is 9,968 kWh/m³;
- $V_{\text{A, th, tr, min}}$ is 8,52 m³/m³.

NOTE For calculation, the reference values or the real values of the used line-conveyed gas can be applied.

A.3 Correction for the influence of combustion air temperature and humidity on NO_x emissions

Equation (A.4) should be used to correct the influence of combustion air temperature and humidity on Q_{NO_x} emissions from burners to reference conditions (10 g/kg for humidity and 20 °C for temperature):

$$Q_{\text{NO}_x, \text{R}} = Q_{\text{NO}_x} + \left[\frac{0,02Q_{\text{NO}_x} - 0,34}{1 - 0,02(h_{\text{M}} - 10)} \right] (h_{\text{M}} - 10) + [0,85(20 - T_{\text{M}})] \quad (\text{A.4})$$

where

- $Q_{\text{NO}_x, \text{R}}$ is the value of Q_{NO_x} corrected to the reference conditions (10 g/kg for humidity and 20 °C for temperature). $Q_{\text{NO}_x, \text{R}}$ is expressed in mg/kWh;
- Q_{NO_x} is the calculated NO_x content in mg/kWh, measured at h_{M} and T_{M} ;
- h_{M} is humidity during the measurement of $f_{\text{NO}_x, \text{M}}$ in g/kg;
- T_{M} is the temperature during the measurement of $f_{\text{NO}_x, \text{M}}$ in °C.

If the ambient conditions differ from the values given in 5.1.3.5 a) to c), regional experiences for corrections have to be taken into account. Nevertheless, the conditions have to be within the range given in 5.1.3.5.

A.4 NO_x mean value for evaluating the NO_x classes

Determination of the arithmetical NO_x mean value of the working diagram is given by Equation (A.5):

$$\bar{\varphi}_{\text{NO}_x, \text{M}} = \sum_{i=1}^n \left(\frac{Q_{\text{NO}_x, \text{R}, i}}{n} \right) \quad (\text{A.5})$$

where

$\bar{\varphi}_{\text{NO}_x, \text{M}}$ is the arithmetical mean value in mg/kWh of the corrected nitrogen emission in the working diagram;

$Q_{\text{NO}_x, \text{R}, i}$ is the corrected NO_x concentration at the points $i = 1 \dots n$ in the working diagram;

n is the number of points in the working diagram.

A.5 CO₂ content

The values, as a percentage by volume, of $f_{\text{CO}_2, \text{N}}$ for the typical line-conveyed gases are given in Table A.1.

Table A.1 — $f_{\text{CO}_2, \text{N}}$ values of typical line-conveyed gases

Gas designation	Town gas	Natural gas	LPG
$f_{\text{CO}_2, \text{N}}$ % volume	7,6	11,8	14,0
NOTE For further data, see fuel supplier's specifications.			

A.6 Other conversion factors for emissions, calculated from ml/m³ into mg/m³ at O₂ reference gas conditions

See Equations (A.6) and (A.7):

$$Q_{\text{NO}_x} = f_{\text{NO}_x, \text{M}} \times 2,056 \times \left(\frac{21 - f_{\text{O}_2, \text{ref}}}{21 - f_{\text{O}_2, \text{M}}} \right) \quad (\text{A.6})$$

$$Q_{\text{CO}} = f_{\text{CO}, \text{M}} \times 1,25 \times \left(\frac{21 - f_{\text{O}_2, \text{ref}}}{21 - f_{\text{O}_2, \text{M}}} \right) \quad (\text{A.7})$$

where

Q_{NO_x} is the calculated NO_x content in mg/m³ at 3 % O₂ in dry flue gas, calculated as NO₂;

Q_{CO} is the calculated carbon monoxide content in mg/m³ at 3 % O₂ in dry flue gas;

$f_{\text{O}_2, \text{ref}}$ is the O₂ reference gas condition (3 % oxygen in dry flue gas);

$f_{\text{O}_2, \text{M}}$ is measured O₂ concentration in the gaseous combustion products;

2,056 is the density of NO₂ (kg/m³);

1,25 is the density of CO (kg/m³).

Annex B
(informative)

Examples of control box sequencing

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	Heat demand		Start up sequence				Main burner		End of heat demand			Result			Comment		
	↓	↑	Start-up fan	Pre-purge	First safety time	Second safety time	Nominal operation	Controlled shut-down	Safety shut-down	Non-volatile lock-out							
Subclause																	
4.3.8 No-flow state check air-proving device			█										x				
4.3.8 Air-proving device				█									x		x		
4.3.5.6 Low gas pressure detection device													x				
4.3.5.5 High gas pressure over load protection device															x		
4.4.1.1 Self-check flame detector (incl. flame simulation)				█												Intermittent operation Permanent operation	
4.3.5.10.3 Valve-proving system VP > 1 200 kW				█												x	
4.4.1.1 Burner interlock																x	Only when fitted
█	Mandatory																
▬	Optional																

Annex C (informative)

Tests

C.1 Supplementary testing

Supplementary testing is carried out in order to assess the effect of any subsequently attached or modified components of the burner on its conformity to standards.

With the consent of the notified body, a supplementary test can be dispensed with if the modifications involved concern the adjustment of type-tested burners to a particular appliance to allow for the effects of the fuel, the combustion chamber and the operation of the appliance as a whole. This assumes that modifications to the air supply, air compression, jet systems, mixing device and gas/air ratio control device will be necessary. Such measures are only permissible if

- a) they are carried out by properly qualified personnel,
- b) flame stability is maintained,
- c) no increase in burner rating results,
- d) criteria of relevance to safety are not affected,
- e) combustion characteristics such as CO and CO₂ content remain within the permitted limits, and
- f) the notified body is provided with documentation of successful completion of the work by way of records of the measurements made (additional measurements could be required by the notified body).

C.2 Drawing review

The manufacturer may request a drawing review if

- a) changes or supplements have been made to the burner design compared to the previous design, or
- b) gas burners of different input stages of the same construction have been manufactured by a manufacturer, but proof of conformity with the standard has only been supplied for individual input stages.

The extent of the drawing review depends on whether the changes resulting from a) or b) above have an effect on meeting the requirements of this International Standard.

Gas burners having been successfully tested on the basis of a drawing review are regarded as being in accordance with the standard.

C.3 Individual test and inspection

If in order to check conformity to standards the burner manufacturer or a public authority requests testing of an individual, or individually manufactured, gas burner as a substitute for type testing, this individual test or individual inspection is carried out with the appropriate appliance or within the framework of the inspection of the complete installation. For testing purposes, the appliance equipped with the burner to be tested is regarded as a test rig.

The requirements for testing the burner are as follows:

- a) proof that the equipment meets the requirements of this International Standard;
- b) functional testing of all safety equipment;
- c) testing of the burner control system according to the requirements of IEC 60730-2-5;
- d) proving the maximum and minimum burner heat input;
- e) proving flame stability on burner start-up, at maximum and minimum burner heat input and on alteration of the heat input with respect to the appropriate combustion chamber pressure — during testing, excessive pressure variations should not occur;
- f) proof that the required pre-purge and the safety times are observed;
- g) proof of the combustion performance [i.e. CO₂ (or O₂), CO and C_{NOx} content] at minimum, nominal and maximum heat input.

C.4 Test report

A test report should be compiled after testing has been satisfactorily completed. The test report should show the nature of the test concerned (e.g. type testing). It should contain a description of the burner together with the details required and should set out the results of the tests. At the end of the test report, the essential data relating to the use of the burner should be given.

Annex D (informative)

Use of alternative gas lines and test documentation

D.1 Use of alternative gas trains

Where the manufacturer specifies alternative gas lines for use with a particular burner model:

- a) each burner type can be treated as a unit and tested in accordance with this International Standard, and can structurally be of defined extent (e.g. up to the connecting flange upstream of the gas isolating valve);
- b) as with any other burner, this burner unit is subject, on being modified, to retesting as specified in the test procedure;
- c) the manufacturer is responsible for measuring the inherent losses due to the gas lines intended for use in conjunction with the burner and for developing a reproducible method of calculating these values;
- d) the selection of gas lines is undertaken by the manufacturer on the basis of tests carried out by the manufacturer and are the subject of a test report;
- e) the object of such tests is to establish by calculation whether the performance of the burner when operated in conjunction with a given gas train still lies within the working diagram as determined by the test facility.

D.2 Test documentation

The manufacturer or the applicant provides, at the time of the test, the notified body with two copies of each of the following.

- a) Workshop drawings, dated and duly signed: the drawings are executed with the relevant sectional views so that a clear picture is obtained of the construction of the burner and its principal components. An overall drawing of the unit is also provided.
- b) A description of the burner together with, where applicable, details of the components used, the design and construction, including information with regard to installation, maintenance, heat input ranges, connection methods and burner pressure ranges.
- c) A declaration by the manufacturer that the electrical components and their assembly satisfy the electrical regulations in force in the country or countries of destination.
- d) A statement of the type number or designation of the burner.
- e) Information on the materials used (if applicable, from a parts list).
- f) A statement of the type of gas and burner inlet pressure for which the burner is intended.
- g) Information on the electrical connection data of the burner.
- h) Instructions for the installation, adjustment and operation of the burner, together with diagrams illustrating the switching, wiring and functional operation.

For individual testing or an individual inspection, the notified body can also be supplied, in addition to the listed test documentation, with a wiring diagram and description of the whole installation.

Annex E (informative)

Air-proving device check

The operation of the air-proving device is checked alternatively at the lowest or highest input. The air pressure can be changed by

- changing the motor speed,
- closing the air damper, closing the air inlet openings, or
- other means.

A non-volatile lock-out occurs before a CO content of 2 000 ml/m³ air-free/dry is reached in the burner operating stage.

During the test on the flame tube the mode of operation of the air-proving device should be checked in reference to the burner design. Installation influences (e.g. flue installation, boiler, installation room or air supply) on the air-proving device and its adjustment have to be taken into account during operation.

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Annex F (informative)

Additional recommendations for specific applications

F.1 General

Conformity with the requirements of this International Standard does not guarantee a burner will be suitable for a particular application.

Its suitability and conformity for a particular application, and any local statutory requirements, should be assessed.

F.2 Preheating of the combustion air

If an ISO 22967-conformant burner is operated with preheated combustion air, then the temperature of the combustion air should not exceed 50 K above the ambient temperature.

If an ISO 22967-conformant burner is used within the limits given above, then

- a) the surface temperatures of knobs and levers intended to be manipulated should not exceed the ambient temperature by more than the values given in 4.4.2.3,
- b) the components should not exceed the maximum temperatures declared by the component manufacturer or supplier, and
- c) the flame stability should not be affected during initial start-up of the burner at any rate.

Pre-heating of combustion air can limit the working diagram.

F.3 Continuous working of the air ventilator

Modifications are necessary for the air-proving device to make it possible to check the no-flow state prior to start-up (see 4.3.8).

F.4 Variable excess of combustion air

The requirements given in Table 8 are not mandatory for ISO 22967-conformant gas burners at high ratings. The flame should be stable under all conditions and the combustion should be in accordance with this International Standard.

F.5 Burner with start gas flame

For burners with start gas flame it should be guaranteed that under all operation conditions of the main burner, the burner with start gas flame can ignite the main burner.

Otherwise, separate flame sensors to supervise the start gas flame and main flame should be fitted. The main flame sensor should be so positioned that it cannot in any circumstances detect the start gas flame.

F.6 Air filtering

In a dusty environment it can be necessary to filter the inlet combustion air.

Thus the function of the air-proving device may be impacted (see 4.3.8).

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Annex G (normative)

Requirements specific to the USA

General

Only those provisions of this International Standard that are affected by requirements specific to the USA have been identified in this annex, numbered correspondingly to the respective subclauses in the main body of the standard.

The requirements of this annex shall ensure a level of safety at least equivalent to that provided by the requirements in the main body of this International Standard.

Normative references

For the purposes of this annex, the following normative references apply.

ANSI/ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ANSI/ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800*

ANSI/UL 1998, *Standard for Software in Programmable Components*

NEMA 250, *Enclosures for Electrical Equipment (1000 Volts Maximum)*

UL 372, *Primary Safety Controls for Gas- and Oil-Fired Appliances*

UL 296, *Oil Burners*

UL 795, *Commercial-Industrial Gas Heating Equipment*

Requirements

G.4.2.6 Connections

Replaces 4.2.6:

The following connections shall be designed in accordance with ANSI/ASME B1.20.1 [national pipe thread taper (NPT)]:

- a) those with inlet gas pressure-tight joints made on the threads;
- b) those within the burner with pressure-tight joints made on the threads that are not loosened for maintenance;
- c) connections for parts that are not frequently dismantled and refitted.

Connections which have to be loosened for maintenance purposes shall be designed in accordance with ANSI/ASME B.1.20.1 [nominal pipe size (NPS)].

Flanges are required to be constructed in accordance with the dimensional specifications for Class 125 cast iron flanges given in ANSI/ASME B16.1.

G.4.3.5.3 Filter/strainer

Additional to 4.3.5.3:

A sediment trap may be used as an alternative to a filter or a strainer.

G.4.3.5.4 Gas pressure regulator

Additional to 4.3.5.4, paragraph 6, a) and b):

Two overpressure protection devices (OPDs) in series shall be used. One OPD shall be a service regulator or line pressure regulator. The other shall be any one of the following:

- a) a spring-loaded relief device fully capable of relieving the outlet pressure and preventing an over-pressurization of the downstream gas piping;
- b) an automatic shut-off device that requires manual reset to open, which shuts off the gas pressure to the downstream piping;
- c) a second service or line pressure regulator installed downstream of the main service or line pressure regulator.

Replaces 4.3.5.4, paragraph 8:

If an automatic shut-off device is used as an overpressure protection device, the high gas pressure shut-off valve shall close before the operational overpressure value of the downstream gas line components is exceeded.

G.4.3.5.8 Automatic safety shut-off valves

Replaces 4.3.5.8:

A burner having an input less than or equal to 5,000,000 Btu/hr (1 465 356 W):

- a) shall be equipped with two safety shut-off valves in series, which may be in a single valve body, or one safety shut-off valve with a proof of closure interlock function;
- b) shall have a pilot burner equipped with at least one safety shut-off valve.

A burner having an input greater than 5,000,000 Btu/hr (1 465 356 W) and less than 12,500,000 Btu/hr (3 663 389 W):

- c) shall be equipped with two safety shut-off valves in series, and at least one of the safety shut-off valves shall incorporate a proof of closure interlock function;
- d) shall have a pilot burner equipped with at least one safety shut-off valve.

For a burner having an input of 12,500,000 Btu/hr (3 663 389 W) or greater, the main burner and pilot burner shall each be equipped with two safety shut-off valves in series, with proof of closure interlock function, and either an automatic vent valve shall be provided between the two safety shut-off valves or the two safety shut-off valves shall be supervised by a valve-proving system.

Modifies Table 1:

Operation without pre-purge shall not be permitted.