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Industrial thermoprocessing equipment — Safety requirements for combustion and fuel-handling systems

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Table of changes

Change No.	Date	Scope

Foreword

This South African standard was approved by National Committee SABS/TC 1019, *Gas supply, handling and control (fuel, industrial and medical gases)*, in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

This document was published in January 2014.

This document supersedes SANS 329:2008 (edition 1).

Reference is made in 3.5(a), 3.5(b), 3.14, 5.1.6, 5.2.2.7, 5.3.2.9 and 5.7.2 to the "relevant national legislation". In South Africa this means the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Reference is made in 5.2.2.7 to the "relevant national legislation". In South Africa, this means the Environmental Regulation for Workplaces (section 5: Ventilation) in terms of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Reference is made in 3.5(b) to the "relevant national legislation". In South Africa, this means the Mine Health and Safety Act, 1996 (Act No. 29 of 1996).

This document was written in order to support specific South African regulations and includes references to South African legislation. It therefore might not be suitable for direct application in other jurisdictions where conflicting legislation exists.

Annexes B and C form an integral part of this document. Annex A is for information only.

Introduction

This document was prepared to provide a means of compliance with the essential safety requirements of the Pressure Equipment Regulations in the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

The extent to which hazards are covered is indicated in the scope of the standard. This document assumes that the equipment is operated and maintained by trained personnel.

Where, for clarity, an example of a preventative measure is given in this document, this should not be considered as the only possible solution. Any other solution leading to the same risk reduction is permissible if an equivalent level of safety is achieved.

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Industrial thermoprocessing equipment — Safety requirements for combustion and fuel-handling systems

1 Scope

1.1 This standard specifies the list of hazards, the safety requirements and associated measures, as well as the user instructions relating to fuel-handling and combustion equipment, and its design, ordering, construction and use.

It specifies the requirements to be complied with by either the manufacturer or the installer (or both) for commissioning, start-up, operation, shutdown and maintenance, as well as in the event of foreseeable faults or malfunctions.

1.2 This standard applies to all combustion and fuel-handling equipment used in industrial thermoprocessing equipment and systems that operate above 0,5 GJ/h. It also applies to the handling of fuel immediately adjacent to the equipment but downstream of, and including, the main plant fuel shut-off valve.

It applies to all forms of gaseous, liquid and solid fuel and any combinations of these in combustion with air or other gas that contains free oxygen.

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. Information on currently valid national and international standards can be obtained from the SABS Standards Division. .

AISI 321, *Stainless steel, annealed sheet*.

API Spec 5L, *Specification for line pipe*.

ASTM A106, *Standard specification for seamless carbon steel pipe for high-temperature service*.

ASTM G63, *Standard guide for evaluating nonmetallic materials for oxygen service.*

ASTM G93, *Standard practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environments.*

ASTM G127, *Standard guide for the selection of cleaning agents for oxygen systems.*

EIGA 13-12/E, *Organisation – Human reliability*.

EN 88-1, *Pressure regulators and associated safety devices for gas appliances – Part 1: Pressure regulators for inlet pressures up to and including 500 mbar*.

EN 125, *Flame supervision devices for gas burning appliances – Thermoelectric flame supervision devices.*

EN 126, *Multifunctional controls for gas burning appliances.*

EN 161, *Automatic shut-off valves for gas burners and gas appliances*.

EN 230, *Automatic burner control systems for oil burners*.

EN 298, *Automatic burner control systems for burners and appliances burning gaseous or liquid fuels*.

EN 334, *Gas pressure regulators for inlet pressures up to 100 bar*.

EN 730-2, *Gas welding equipment – Safety devices – Part 2: Not incorporating a flame (flashback) arrestor*.

EN 751-1, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water – Part 1: Anaerobic jointing compounds*.

EN 751-2, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water – Part 2: Non-hardening jointing compounds*.

EN 1092, Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated (all parts).

EN 1643, *Valve proving systems for automatic shut-off valves for gas burners and gas appliances*.

EN 12067-2, *Gas/air ratio controls for gas burners and gas burning appliances – Part 2: Electronic types*.

EN 14382, *Safety devices for gas pressure regulating stations and installations – Gas safety shut-off devices for inlet pressures up to 100 bar*.

EN 13774, *Valves for gas distribution systems with maximum operating pressure less than or equal to 16 bar – Performance requirements.*

EN 50156-1, *Electrical equipment for furnaces and ancillary equipment – Part 1: Requirements for application design and installation*.

IEC 61508-3, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*.

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

ISO 4413, *Hydraulic fluid power – General rules and safety requirements for systems and their components.*

ISO 4414, *Pneumatic fluid power – General rules and safety requirements for systems and their components.*

ISO 7005-3, *Metallic flanges– Part 3: Copper alloy and composite flanges*.

ISO 8434, *Metallic tube connections for fluid power and general use* (all parts).

ISO 15590-3, *Petroleum and natural gas industries – Induction bends, fittings and flanges for pipeline transportation systems – Part 3: Flanges.*

ISO 22967, *Forced draught gas burners.*

ISO 23550, *Safety and control devices for gas burners and gas-burning appliances - General requirements.*

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

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

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

ISO 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.*

ISO 23553-1, *Safety and control devices for oil burners and oil-burning appliances – Particular requirements – Part 1 – Shut-off devices for oil burners*.

NFPA 53, *Recommended practice on materials, equipment, and systems used in oxygen-enriched atmospheres.*

SANS 24, *Soft solders*.

SANS 62-1, *Steel pipes – Part 1: Pipes suitable for threading and of nominal size not exceeding 150 mm*.

SANS 62-2, *Steel pipes – Part 2: Screwed pieces and pipe fittings of nominal size not exceeding 150 mm.*

SANS 347, *Categorization and conformity assessment criteria for all pressure equipment.*

SANS 460, *Plain-ended solid drawn copper tubes for potable water*.

SANS 1109-1/ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances and designation*.

SANS 1306-1/ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation*.

SANS 1774, *Liquefied petroleum gases*

SANS 4437/ISO 4437, *Buried polyethylene (PE) pipes for the supply of gaseous fuels – Metric series – Specifications.*

SANS 7005-1/ISO 7500-1, *Metallic flanges – Part 1: Steel flanges*.

SANS 7005-2/ISO 7500-2, *Metallic flanges – Part 2: Cast iron flanges*.

SANS 10140-3, *Identification colour markings – Part 3: Contents of pipelines*.

SANS 10142-1, *The wiring of premises – Part 1: Low-voltage installations.*

SANS 10142-2, *The wiring of premises – Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 000 kW installed capacity.*

SANS 10260-1, *Industrial gas pipelines – Part 1: Distribution of oxygen, nitrogen and argon at consumer sites*.

SANS 10400 (all parts),*The application of the National Building Regulations..*

SANS 50125/EN 125, *Flame supervision devices for gas burning appliances – Thermoelectric flame supervision devices*.

SANS 50331/EN 331, *Manually operated ball valves and closed bottom taper plug valves for gas installations for buildings*.

SANS 50676/EN 676, *Automatic forced draught burners for gaseous fuels.*

SANS 50730-1/EN 730-1, *Gas welding equipment – Safety devices – Part 1: Incorporating a flame (flashback) arrestor*.

SANS 51854/EN 1854, *Pressure sensing devices for gas burners and gas burning appliances*.

SANS 60204-1/IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*.

3 Definitions

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

3.1
acceptable
acceptable to the authority administering this standard, or to the parties concluding the purchase contract, as relevant

3.2
air:fuel ratio
ratio between the mass flow of combustion air and the mass flow of fuel

3.3
alternating pilot burner
pilot burner that lights the main burner and that is extinguished at the end of the main burner ignition period and is re-ignited immediately when the main burner is shut down for control purposes

3.4
approved
approved by the approving authority

3.5
approving authority
appropriate of the following:

a) within the scope of the relevant national legislation (see foreword): the Chief Inspector;

b) within the scope of the relevant national legislation (see foreword): the Chief Inspector; and

c) within the scope of SANS 10400: the local authority concerned

3.6
automatic burner control system
system comprising at least a programming unit and all the elements of a flame detector device

3.7
automatic shut-off valve
valve which opens when energized and closes automatically when de-energized

3.8
burner
combustion system under the control of individual automatic shut-off valves

3.9
burner input rate
highest quantity of fuel used by a burner in unit time corresponding to the volumetric or mass flow rates

3.10
by-pass
passage that conveys fuel from the upstream side to the downstream side of a component within the pipework so as to be independent of the action of such component

3.11
calorific value
quantity of heat produced by the combustion of unit volume or mass of fuel at a constant pressure of 101,3 kPa

3.12
combustion air
any gas (e.g. air, oxygen, oxygen-enriched air) that contains oxygen but that does not contain fuel and that is used for combustion

3.13
combustion chamber
that part of the industrial thermoprocessing equipment (IThE) in which combustion takes place

3.14
competent person
any person having the knowledge, training and experience specific to the work or task being performed in accordance with the requirements of the relevant legislation (see foreword).

3.15
condensate drain
pipe designed to collect and drain condensates from a low point in the gas circuit

3.16
control system
system which responds to input signals from the process or the operator (or both) and generates output signals which cause the process control to operate in the required way

3.17
cross-ignited burners
group of burners designed and arranged such that, by means of their proximity and relative position, ignition of all burners can be ensured if one burner is ignited

3.18
electromagnetic compatibility
EMC
immunity of the IThE to electromagnetic disturbances and the prevention of the IThE system from giving out harmful electromagnetic emissions to the environment.

3.19
explosion relief device
device which is designed to activate when an unsafe increase of internal pressure occurs

3.20
filter
strainer
device that enables foreign elements, which could otherwise cause failures in the system, to be collected

3.21
flame detector
device by which the presence of a flame is detected and signalled

3.22
flame sensor
actual flame-sensing element in the flame detector (see 3.21), the output signal value of which is used as the input for the flame detector amplifier

3.23
flame trap
flame arrestor
device fitted to the pipe that conveys gas or a gas-air mixture, the intended function of which is to prevent the transmission of flames

3.24
flashback
flame propagation from the burner in an upstream direction inside the pipework

3.25
forced draught burner
burner in which combustion air is supplied by mechanical means, usually a fan or a blower

3.26
functional safety
capability of a safety system to reduce risk, and to execute the actions required for achieving or maintaining a safe state for the process and its related equipment

3.27
gas pressure regulator
device which maintains the downstream gas pressure constant to within fixed limits, independent of variations within a given range of the upstream pressure or flow rate (or both)

3.28
gas reticulation system
pipework, connections, instrumentation, relevant valves and equipment found on the customer's property from the meter station or vapourizer to the manual isolation valve

3.29
graded fuel
solid fuel in the form of lumps which are classified according to size

3.30
grate burner
solid fuel combustion system where the burning fuel is supported by a metallic grate

3.31
high temperature equipment
IThE operating at a temperature that exceeds 750 °C measured at the combustion chamber walls or the processing chamber walls (or both)

3.32
ignition
starting up the chemical reaction of combustion of a fuelcombustion air mixture by application of a smaller energy source (for example, the pilot flame)

3.33
ignition burner
burner specially designed for igniting other burners

3.34
induced draught burner
burner in which combustion air is supplied by providing suction in the combustion chamber by mechanical means, usually a fan or a blower

3.35
initial boiling point
temperature of a liquid fuel that is measured at the instant that the first drop of condensate falls from the lower end of the condenser tube in a boiling point test

3.36
lighting torch
hand-held burner which is used to ignite another burner

3.37
lockout
safety shutdown condition of the system, such that a restart can only be accomplished by a manual reset of the system

3.38
low temperature equipment
IThE operating at a temperature measured below 750 °C at any part of the combustion chamber walls or the processing chamber walls (or both)

3.39
LPG
liquefied petroleum gas
commercial butane, commercial propane, or a mixture of light hydrocarbons (predominantly propane, propene, butane and butene) that is gaseous under conditions of ambient temperatures

and pressure, and that is liquefied by an increase of pressure or a lowering of temperature (see also SANS 1774)

3.40
main flame
flame, other than the ignition flame, on the main burner

3.41
manual isolation valve
manually operated valve, which is upstream of all the other fuel controls to the IThE and by means of which the fuel supply to the IThE can be shut off

3.42
manual reset
action after a lockout of a safety-related device (e.g. automatic burner control), carried out manually by the supervising operator

3.43
manual shut-off valve
manually operated valve by means of which the fuel supply to an individual burner or to a group of burners can be shut off

3.44
multiple burner equipment
IThE with several burners with common air and gas pipework

3.45
natural draught burner
burner in which the combustion air is entrained at atmospheric pressure

3.46
non-return valve
device to prevent the backflow of air, fuel, oxygen, etc.

3.47
open firing burner
burner that does not require an enclosed combustion chamber, e.g. a torch, a workstation burner, an equipment-integrated burner, and other burners firing in the open

3.48
operating temperature
temperature, or range of temperatures, at which the IThE is designed to operate

3.49
operator supervision
circumstance by which an operator has continuous control and surveillance of the plant, and he is in a position where he can shut the IThE down in the event of an emergency

3.50
oxygen-enriched air
air with an oxygen concentration higher than 21 % obtained either by the addition of oxygen or the reduction of nitrogen content

3.51
permanent pilot burner
pilot burner that is intended to be left on for the duration of the firing cycle of the system

3.52
pilot burner
independently controlled burner designed to ignite the main burner

3.53
pipework
assembly of components by means of which fuel and combustion air are conveyed from the point(s) of supply to the burner(s)

3.54
portable ignition burner
burner designed to be capable of being transported to ignite other burners in different locations

3.55
pre-purging
forced introduction of air or inert gas into the combustion chamber and flue passages, in order to displace any remaining fuel:air mixture or products of combustion (or both), and which takes place between the start signal and the energizing of the ignition device

3.56
pressure relief valve
valve or regulator designed to relieve excess pressure

3.57
processing chamber
that part of the equipment in which the workpiece(s) being processed is (are) contained

3.58
programmable logic control
PLC
electronic device(s) used for the control of the logical sequence of events in a local system

3.59
protective system
all equipment, units and safety-related circuits the main purpose of which is the protection of the system, which may include but is not limited to, sensors, interruption devices, ventilation bodies, etc.

3.60
pulse firing
burner combustion system where the firing rate is controlled by the number or duration (or both) of burners firing at fixed heat input rates, e.g. high/low or on/off

3.61
pulverized fuel
solid fuel which has been ground to a powder

3.62
purge point
plugged tapping at the extremities of a fuel distribution system to facilitate purging

3.63
radiant tube burner
burner that heats up the IThE indirectly by means of a radiant tube

NOTE The products of combustion are wholly separated from the IThE heating and processing space.

3.64
recycling
process by which, after a safety shutdown, a full start-up sequence is automatically repeated

3.65
remote reset
reset after a lockout, carried out from a location separate to the safety-related device

3.66
safe discharge area
zone which is safeguarded against the risk of combustion of discharged flammable gases

3.67
safety shutdown
process which is effected immediately following the activation of a safety device or the detection of a fault in the automatic burner control system, and which puts the burner out of operation by immediately closing the fuel shut-off valves and the ignition device

3.68
safety time

3.68.1
first safety time
interval between the pilot gas valve, the start gas valve or main gas valve, as applicable, being energized and the pilot gas valve, start gas valve or main gas valve, as applicable, being de-energized if the flame detector signals the absence of a flame

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

3.68.2
second safety time
interval between the main gas valve being energized and the main gas valve being de-energized if the flame detector signals the absence of a flame

3.69
single burner equipment
IThE with only one burner with a common air and gas pipework

3.70
spark restoration
process by which, following the loss of the flame signal, the ignition device will be switched on again automatically without total interruption of the fuel supply

3.71
start fuel
fuel supplied to the pilot burner or to the main burner at a low rate before the start-up of the burner

3.72
system leak-tightness check
system which prevents opening of the central automatic gas shut-off valve before the effective and tight closure of all burner shut-off valves (manual or automatic, as applicable) has been checked

3.73
test pressure
pressure to which pipework is subjected to check for soundness

3.74
thermoprocessing equipment
equipment that is used to transmit thermal energy to material(s) or workpiece(s)

3.75
torch
manually controlled gas or oil-fired open-flame tool or any mobile burner unit firing in the open and used for industrial thermoprocessing

3.76
total closing time
interval between the occurrence of an unsafe condition and the automatic shut-off valves being in the fully closed position

3.77
valve proving system
system to check the effective closure of automatic shut-off valves by checking leak-tightness

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

3.78
Wobbe Index
ratio of the calorific value of a gas per unit volume to the square root of its relative density relative to air

NOTE The Wobbe Index is gross or net depending on whether the calorific value used is gross or net.

3.79
workstation burner
burner used at a particular workstation and firing in the open rather than into a closed combustion chamber

3.80
zone
self-contained space within which an IThE operates under the same conditions/parameters (e.g. temperature, pressure)

4 List of hazards

Table 1 lists the typical hazards that could be experienced in various locations of an IThE system.

Table 1 — List of hazards

1		2
Hazards		**Location**
1	**Mechanical hazards** High pressure fluid injection or ejection hazard	Pipework
2 2.1 2.2	**Electrical hazards** Electrical contact direct or indirect with live parts Electrostatic phenomena Hazards generated by vibration	Control system, power supply to the machine and connectors
3 3.1 3.2	**Thermal hazards, resulting in**: Burns and other injuries by a possible contact of persons with objects or materials with an extremely high temperature, by flames or explosions and also by the radiation of heat sources Damage to health by a hot working environment	Burners Environment of the IThE
4 4.1 4.2 4.3	**Hazards caused by an interruption of the energy supply** Malfunction or break-up of components Malfunction or breakdown of control system Unexpected start-up	Burner and accessories Control system
5	**Hazards caused by (temporarily) missing or incorrectly positioned safety-related measures/means** Specific hazard of maintenance and adjusting	Burners, fans, piping, duct, control system
6 6.1 6.2	**Hazards caused by materials and substances processed or used by the machinery** Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes, and dusts Fire or explosion hazard	Exhaust gases evacuating system Combustion chamber Burners, fans, piping, duct, control system of the combustion chamber
7	**Hazards caused by neglecting ergonomic principles in machinery design** Inadequate design, location or identification of manual controls	Pipework Control system

5 Safety requirements, measures and means of verification

5.1 General

5.1.1 Means of verification of equipment shall be described in the manual of the equipment where such verification is more complex than simple visual inspection.

5.1.2 Choice of the right materials shall be such that all the components of the fuel circuit shall be capable of withstanding the mechanical, chemical and thermal loads to which they might be subjected during normal operation.

5.1.3 The ignition of the fuel/air mixture at the burner(s) shall be reliable and shall occur at the correct time.

5.1.4 Unintentional release of unburned fuels shall be prevented by

a) shutting off the fuel supply in case of a fault,

b) protecting the pipeline to preclude the propagation of flame in reverse flow,

c) preventing firing when the exhaust of combustion products is not ensured,

d) preventing firing when the process condition is not in the safe mode.

5.1.5 Electrical circuits shall be designed in accordance with SANS 60204-1. PLC systems shall comply with IEC 61508-3 or EN 50156-1.

5.1.6 All parts related to the safety of the equipment shall be designed so that, in the case of failure, a safe condition will be maintained. In addition, equipment not covered by this standard shall comply with the relevant health and safety standard as defined in the relevant national legislation (see foreword).

5.2 Gaseous fuels

5.2.1 Gas reticulation system

5.2.1.1 Pipework design

The pipework design shall take into account the composition and properties of the gaseous fuel and the need for venting, purging and cleaning.

Steel pipe for pressure equipment shall be seamless and shall comply with the requirements of SANS 62-1 or API Spec5L or ASTM A106 grade B schedule 40 piping. Copper tube shall comply with the requirements of SANS 460 and be of at least a class 2. Copper tube shall not be used in applications where the temperature is likely to exceed 100 °C. For high density polyethelene (HDPE), SANS 4437 shall be used. The use of galvanised pipes and fittings is strictly prohibited.

Potentially dangerous oscillations in the pipework shall be prevented (e.g. by firm anchoring or the use of flexible coupling). The design of pipework shall be such as to avoid tensile loading of the joints.

Pipes shall not pass through the cavity of cavity walls or through lift shafts, flues, ceiling(s) or ceiling or floor voids and air ducts unless they are sleeved or welded as applicable. Where pipes pass through walls that might or might not be regarded as cavity walls, such pipes shall be sleeved. Pipes shall not be placed vertically or horizontally in the void of a cavity wall.

In cases where the pipework is within the boundaries of category II or III of SANS 347, then the additional requirements of SANS 347 shall apply. For pipework falling under category I, the requirements of SANS 347 can be used as an alternative to the requirements of 5.2.1.2.

5.2.1.2 Pipework connections

5.2.1.2.1 Gas pipework connections shall be of the screwed, compression, flanged, brazed or welded types. Other types of connections, such as couplings for removable equipment, shall ensure a gastight connection.

5.2.1.2.2 Screwed connections shall be used only for the following maximum operating pressure/diameter combinations:

a) pressures up to 10 kPa: diameters up to DN 80,

b) pressures up to 200 kPa: diameters up to DN 50,

c) pressures up to 500 kPa: diameters up to DN 25,

d) pressures up to 1 000 kPa: diameters up to DN 15.

5.2.1.2.3 For pipe diameters greater than DN 100 ormaximum operating pressures greater than 500 kPa (or both), connections shall be by means of welded flanges or welded joints. The number of connections shall be kept to a minimum. In unventilated enclosures, if joints are necessary, then only welded joints shall be used. Flanges shall comply with SANS 7005-1, SANS 7005-2 and ISO 7005-3 or equivalent standards.

5.2.1.2.4 Where the equipment has a threaded connection, such threads shall comply with SANS 1306-1 or SANS 1109-1, as appropriate. In the case of parallel threads, care shall be taken to ensure a leak-tight seal. Other threaded connections (e.g. National Pipe Thread) may be used, providing they ensure leak-tight connections, and are identified. Hemp shall not be used as a seal in threaded connections.

5.2.1.2.5 All flanged fittings shall use full face solid gaskets that are compatible with the product to be used in the pipeline.

5.2.1.2.6 Where compression fittings are used, they shall not be used on pipework larger than 42 mm in diameter. Hardening sealants shall comply with EN 751-1. Sealants and packaging shall not contain asbestos.

Where capillary fittings are made, solder with a melting point below 450 °C and adhesives shall not be used. Where solder is used, it shall comply with the requirements of SANS 24 (S 19 and S 20).

5.2.1.3 Open ended pipework

Any open ended live pipework shall be plugged, capped or blank-flanged by means of metallic parts.

5.2.1.4 Galvanic cells

The formation of galvanic cells shall be avoided by the selection of compatible materials.

5.2.1.5 Flexible tubing

5.2.1.5.1 Connections for flexible tubing shall comply with the following standards:

a) threaded connections: SANS 1109-1;

b) flange connections: EN 1092 (All parts);

c) flexible stainless steel convoluted: AISI 321

5.2.1.5.2 Flexible tubing shall be compatible for the type of gas used, shall comply with the general requirements of 5.2.1.1, and shall

a) be as short as possible;

b) be acceptable for the maximum and minimum operating temperatures;

c) be acceptable for pressure 1,5 times the maximum operating pressure (with a minimum of 15 kPa), at the maximum and minimum operating temperatures;

d) have a directly accessible, upstream single action shut-off device;

e) be mounted in such a way as to avoid distortion, whiplash and damage; and

f) have end fittings as integral parts of the tubing.

5.2.1.6 Marking

The pipework shall be easily identifiable as gas pipework and shall be light stone, where colour coding is used, and shall comply with SANS 10140-3.

5.2.1.7 Testing

5.2.1.7.1 After assembly, the gas reticulation system shall be tested for leak-tightness and the ability to withstand the internal test pressure. The test pressure shall be not less than 1,5 times the maximum working pressure. The system shall be leak-free. However, allowance shall be made for ambient condition fluctuations.

The frequency of testing shall be

a) determined by the conditions surrounding the installation,

b) determined before the installation, and

c) at intervals not exceeding 36 months.

5.2.1.7.2 Burner systems shall be leak tested to at least 1,5 times the maximum operating pressure or a minimum of 5 kPa, whichever is the higher. The methods and frequency of testing shall be specified in the instruction handbook (see 7.2.3).

Acceptable methods for checking leak-tightness include

a) foam-generating liquids,

b) pressure decay monitoring, etc.

5.2.1.8 Condensate drains

In cases where condensates could create a hazard, means shall be provided at the lowest point of the equipment for draining any condensate. When moist gases are being used, condensate drains of a compatible type shall be installed. Any condensate drains, siphons, etc., shall be in position such that they can be easily checked. Flammable condensates shall be collected by an appropriate means (e.g. piped into a container).

Valves in condensate drains shall be plugged, capped or blank-flanged with metallic parts.

5.2.1.9 Purge points

Means shall be provided to facilitate the purging of the gas system during commissioning and maintenance to prevent the build up of flammable substances. Purge points shall be installed at the furthermost appropriate point(s) of the installation and be purged into a safe discharge area to the outside atmosphere.

NOTE Because LPG is heavier than air, it should be purged into an area where no drains or depressions are found.

5.2.1.10 Blow-off and breather pipes or conduits

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

When using a discharge area, the following shall be taken into account:

a) risk of explosion;

b) risk of combustion;

c) prevention of recirculation into the combustion chamber;

d) prevention of gas discharging into drains and pits; and

e) specific gravity of the gas.

5.2.1.11 Explosion relief devices and flame arrestors

For equipment in which flashbacks could occur, flame arrestors or explosion relief devices (or both) shall be fitted.

5.2.1.12 Pressure relief devices

Pressure relief devices shall be designed to yield at a pressure below the test pressure of the burner system and shall be positioned such that the discharge flow does not constitute a hazard to the equipment, personnel or third parties. The maximum start-to-discharge pressure of the devices shall be not higher than 110 % of the design pressure. Where safety devices on the supplier's system do not protect the pipeline system, extra relief devices might be required.

5.2.1.13 Pressure oscillations

The gas system shall be designed so as to prevent the possibility of gas velocities and pressure fluctuations causing harmful oscillations in the system (e.g. by using pressure regulators and designing the correct size of pipe).

5.2.1.14 Equipment supplied with different fuel gases

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

5.2.1.15 By-passes

By-passes shall not be fitted in parallel with any item of safety equipment.

This requirement shall not apply to valve proving systems, nor to system leak-tightness monitoring devices on automatic shut-off valves.

5.2.2 Mandatory devices

5.2.2.1 General

Mandatory devices, for example, pressure switches or relief valves, shall under no circumstances be isolated from the equipment that they are designed to protect.

5.2.2.2 Manual isolation valves

A manually operated isolation valve shall be fitted upstream of the first control device in the gas circuit. Manual isolation valves shall be so designed or positioned as to prevent inadvertent operation and, where required, be lockable in the closed position. Isolation valves shall be easily accessible and capable of rapid operation when required.

Manually operated isolation valves up to 50 mm (flanged or threaded) shall comply with the requirements of SANS 50331.

5.2.2.3 Filters or strainers

Special care shall be taken to prevent the ingress of particles, either from the pipework or from the gas fuel, which could be detrimental to the operation of the equipment, by the incorporation of an acceptable filter or strainer immediately downstream of the first manual isolation valve. Additional filters or strainers might be required (e.g. immediately upstream of the automatic shut-off valve).

The filter and/or the strainer shall be positioned in such a way that it is accessible for periodic servicing and cleaning. In the event of the installation of a by-pass to the filter or the strainer, an identical filtering device shall be installed on the by-pass line.

5.2.2.4 Automatic shut-off valves

5.2.2.4.1 General

Valveclasses shall comply with EN 161. If technically applicable, only automatic shut-off valves that comply with EN 161, ISO 23551-1 or ISO 23550 shall be fitted. However,in the case of valves that are outside of the scope of EN 161, the safety requirements detailed in EN 161 shall be met, at least to an equivalent level.

Classes of valves shall comply with the requirements given in EN 161.

The automatic shut-off valves shall be of the correct type for the foreseen maximum operation pressures, back pressures and differential pressures under all process circumstances.

Low cycling applications (plants intended to operate continuously for periods longer than 1 year) shall have provisions for testing the effective closure of the valves at least once a year (e.g. double parallel automatic shut-off valve system that allows for one system to be tested while the other is in operation).

High cycling applications (e.g. over 10 000 cycles per year, or pulse firing) shall use only valves that are additionally specified ascapable of an increased number of cycles by the valve manufacturer and shall be checked at the frequency specified in the instruction handbook.

5.2.2.4.2 Single burner equipment

5.2.2.4.2.1 The gas supply to the burner shall be under the control of two class A automatic shut-off valves that comply with EN 161, in series in the gas pipework.

5.2.2.4.2.2 For a natural draught burner with controlled capacities below 70 kW, two class B automatic shut-off valves that comply with EN 161and a thermoelectric flame supervision device that complies with EN 125, are acceptable.

5.2.2.4.2.3 Automatic restart after power failure may be permitted under special circumstances. These special circumstances shall be defined in the instruction handbook.

Where the automatic shut-off valves are closed and lockout has occurred, they shall be re-opened only by manual reset through the protective system or reset manually on the valve. The capacity control functions (valves and circuitry) shall not override the automatic safety shut-off functions. The automatic shut-off valves can also be used for capacity control. However, independent sensing devices shall be used for capacity control and automatic shut off.

The automatic shut-off valves shall not open or shall shut off the fuel to the burner when the limit of any of the following safety conditions is reached:

a) minimal or maximum gas flow;

NOTE The gas flow can be determined by a correlated physical value (pressure, position of the valve, etc.).

b) maximum gas pressure;

c) minimal airflow;

d) minimal air pressure;

e) failure of power supply or other utilities (e.g. compressed air, steam), or a combination of these;

f) failure of heat transfer fluid;

g) fume extraction malfunction;

h) maximum operating temperature of IThE;

i) flame failure;

j) system leak-tightness check;

k) incorrect gas:air ratio (see 5.2.3.3); and

l) any other flame process or machine condition that could cause a risk if the burner continues to fire.

In these cases the automatic shut-off valves shall be de-energized by a protective system.

NOTE For typical examples of piping see annex A.

5.2.2.4.3 Multiple burner equipment

5.2.2.4.3.1 The gas supply to each burner or group of burners shall be under the control of two class A automatic shut-off valves that comply with EN 161, in series in the gas pipework.

For natural draught burners with controlled capacities below 70 kW, two class B automatic shut-off valves that comply with EN 161, ISO 23551-1 or ISO 23550and thermoelectric flame supervision devices that comply with EN 125, are acceptable.

For multiple burner installations, the individual burner shut-off valve may be considered as one of the automatic shut-off valves specified above, provided it is at least of the same class.

5.2.2.4.3.2 The automatic shut-off valve(s) shall not open or shall shut off the fuel to the entire IThE or independent zone when the limit of any of the following safety conditions is reached**:**

a) minimal or maximum gas flow;

NOTE The gas flow can be determined by a correlated physical value (pressure, position of the valve, etc.).

b) maximum gas pressure;

c) minimal airflow;

d) minimal air pressure;

e) failure of power supply or other utilities (e.g. compressed air, steam), or a combination of these;

f) failure of heat transfer fluid;

g) fume extraction malfunction;

h) maximum operating temperature of IThE;

i) system leak-tightness check; and

j) any other process or machine condition that could cause a risk if the burner continues to fire.

In these cases the terminals of the relevant automatic shut-off valves shall be de-energized by a protective system.

Where the automatic shut-off valves are closed and lockout has occurred, they shall be re-opened only by means of manual reset through the protective system or shall be manually reset on the valve.

Flame failure will normally cause the closing of two automatic shut-off valves piped in series.

5.2.2.4.3.3 An individual burner may be shut down by a single automatic shut-off valve in the event of flame failure or for process reasons (e.g. thermal input), providing that the following conditions are satisfied:

a) no other failure occurs (e.g. pressure or temperature fluctuations);

b) a leak-tightness test to ensure that the individual burner safety shut-off valves are closed is conducted at each start-up of the IThE or other specific test period of the burner group and this shall not be less than once per annum;

c) a specific risk analysis is documented in the technical file to prove that the levels of safety have not been compromised;

d) the results of this risk analysis (including any specific process, operational, or maintenance requirements and the number of burners permitted to operate under these conditions before two safety shut-off valves in series shall be closed to shut down the associated group of burners) will be specified in the instructions for use; and

e) if a flame signal can be detected by the automatic burner control system after a control shutdown, or if there is a flame, the burner shall go to lockout and an alarm shall occur.

The capacity control functions (valves and circuitry) shall not override the safety shut-off functions. The automatic shut-off valves can also be used for capacity control, in which case independent sensing devices shall be used.

NOTE For typical examples of piping see annex A.

5.2.2.4.4 Valve proving system

Automatic shut-off valves that control capacities greater than 1 200 kW shall be equipped with a valve proving system. If this is applicable, then the valve proving system shall comply with EN 1643, ISO 23551-4 or ISO 23550.

The signal of a leaking valve from the valve proving system shall stop the current start-up when the test takes place during start-up or prevent the next start-up when the test takes place after shutdown. This function shall comply with the requirements of a protective system or mechanical supervision device which shall operate within the limits given in table 2 after a flame disruption occurs.

5.2.2.5 Gas pressure regulators

A gas pressure regulator shall be incorporated where this is necessary for control of the pressure and the flow rate. Gas pressure regulators, when fitted, shall comply with EN 334,ISO 23551-2 or ISO 23550.Pressure adjustment on the gas pressure regulator shall only be possible with the appropriate tool.

If the outlet side of the gas pressure regulator and the following line section with equipment up to the burner is not designed for the maximum supply pressure (inlet upstream pressure to the gas pressure regulator) even under fault conditions, an over pressure cut-off device shall be applied upstream of the gas pressure regulator, shutting off the gas supply before an excessively high pressure can occur.

This over pressure cut-off device shall comply with EN 14382. Alternatively, the over pressure cut-off device can also be designed using an over pressure switch in accordance with SANS 51854 combined with a safety shut-off valve that complies with EN 161, ISO 23551-1 or ISO 23550.

A small capacity relief valve shall be installed downstream of the gas pressure regulator to vent small leakages from the high pressure cut-off device.

5.2.2.6 Airflow and gas flow and pressure detectors

5.2.2.6.1 Airflow

Equipment fitted with forced or induced draught burner(s) shall be fitted with a device for proving the determined airflow during the pre-purge, ignition and operation of the burner. Airflow failure at any time during the pre-purge, ignition or operation of the burner shall cause safety shutdown and, in the case of no operator supervision, shall cause a lockout.

This function shall comply with the requirements of the protective system (see 5.7).The air proving device shall be checked in the 'no flow' state before start-up (e.g. by stopping the combustion air supply or by interrupting the air signal to the device(s) in such a way as to simulate stopping the combustion air supply). Failure to prove the device in the "no flow" condition shall prevent start-up.

Airflow may be monitored by a differential pressure sensor or by a flow sensor. Either of these devices shall show acceptable and reliable proof of the flow for all operating conditions. This requirement shall not apply to portable gas burners, workstation burners and equipment-integrated burners with open flame, supervised continuously by trained operators, and that have a maximum burner input rating below 70 kW.

Air pressure detectors shall comply with SANS 51854.

5.2.2.6.2 Gasflow

5.2.2.6.2.1 Low gas pressure protection

Low gas pressure protection devices shall be fitted to prevent insufficient gas flow.

The low gas pressure protection device shall be located in such a position that it ensures sufficient gas will be available for correct operation of the burner(s) in all circumstances.

5.2.2.6.2.2 High gas pressure protection

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

a) the burner operates below 70 kW, and

b) the burner operates at line pressure.

Where high gas pressure protection is required, the system shall prevent start-up or cause safety shutdown or, in the case of no operator supervision, lockout in the event of a predetermined pressure being exceeded.

These functions shall comply with the requirement of the protective system (see table 2).

Gas pressure detectors shall comply with SANS 51854.

5.2.2.7 Flue gas venting

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

For IThE equipped with natural draught burners, the flue system shall be fitted with an appropriate draught break, above the height of the operator, or control damper.

If the flue gases are extracted by a fan or the draught is controlled by a damper, the system shall be fitted with a safety device to effect a safety shutdown of the burner(s) or a switching over to a backup duct system in the event of a failure in the flue venting. This function shall be part of the protective system.

For all IThE burners supplied without a flue system, in order to remove the combustion products from the workplace, the instructions for use will refer to the need for sufficient venting to ensure the correct air quality for the operator, in accordance with the requirements of the relevant national legislation (see foreword).

5.2.2.8 Ignition system

Where the gas for the ignition burner is taken from upstream of the gas pressure regulator to the main burner(s), the ignition burner shall be equipped with an appropriate gas pressure regulator that complies with 5.2.2.5.

For safety requirements, ignition burner(s) shall be treated as main burners and the requirements in 5.2.2.1 to 5.2.2.5 (inclusive) shall apply.

Any direct ignition device or combination of ignition device and ignition burner in automatic installations shall form an integral part of the main burner system.

In the case of installations for controlled manual operation, the ignition assembly shall be capable of being mounted on the main burner in one way only, and in such a way that it occupies a fixed position with respect to the burner to be ignited.

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

The ignition device shall be reliable and of sufficient capacity, so that immediate, low noise and smooth ignition is obtained.

Where use is made of a portable ignition burner or ignition device,

a) the ignition burner or ignition device shall be capable of being fitted in one way only. If necessary, fitting into the correct position shall be monitored; and

b) the connections for fuel, air and ignition energy shall be so designed that a reliable link-up is obtained, without the possibility of the connections being confused.

5.2.2.9 Individual manual shut-off valves for multiple burners

For multiple burners which are independently ignited, each individual burner shall be fitted with a manual shut-off valve.

Manually operated threaded isolation valves shall comply with the requirements of SANS 50331and flanged isolation valves shall comply with EN 13774. However, if the installation of such a manual valve affects the mixing characteristics of mixing devices (e.g. venture mixers), then the shut-off valve shall be installed upstream of any such device.

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

For multiple burners where each individual burner has < 10 kW rating and where each individual burner is installed as a single unit, the complete group of burners shall be fitted with at least one manual shut-off valve.

5.2.3 Combustion air and pre-purging of the combustion chamber and flue passages

5.2.3.1 Combustion air

The pipework design shall take into account the properties of combustion air. Special care shall be taken in the case of oxygen or oxygen-enriched air. In the latter case, provision shall be made for purging and cleaning.

All manually controlled devices (registers, valves, etc.) for combustion air shall be set in their predetermined positions and be protected against inadvertent movement. The location of the combustion air intake shall be such as to prevent entry of flue products, unless provided for by the design (e.g. for the reduction of emission of nitrogen oxides (NO_x)).

The combustion air system shall be designed in a manner that prevents the backflow of furnace atmosphere or flue gases (or both) through the combustion equipment, unless provided for by the design.

Potentially dangerous oscillations in the pipework shall be prevented (e.g. by firm anchoring or the use of flexible coupling).

5.2.3.2 Pre-purging of the combustion chamber and flue passages

5.2.3.2.1 Except where otherwise specified, start-up shall not be initiated until all safety steps have been taken to ensure that no combustible mixture is present in the combustion/processing chamber and in the flue passage (heat exchangers, dust extractors, etc.).

This safety condition shall be achieved by means of a period of pre-purging immediately before ignition.

Restart after a lockout condition shall commence with a pre-purge.

5.2.3.2.2 The pre-purge may be omitted (either during start-up or after a lockout) in the following cases:

a) in applications where the presence of free oxygen might be hazardous (e.g. flammable atmosphere) or may affect the equipment (e.g. graphite crucible) or the product quality; or

b) when the combustion chamber is proved to be at a temperature above 750 °C (as specified for high temperature equipment).

In (a), additional safety precautions shall be taken to prevent gas leakage across the safety shut-off valves by using two class A valves that comply with EN 161, and a leak-tightness device.

5.2.3.2.3 In the case of burner shutdown for control purposes, pre-purging shall not be required for recycling where

a) the burner is fitted with an independently supervised permanent or alternating pilot burner; or

b) the burner is fitted with two class A valves closing simultaneously and a leak-tightness device.

5.2.3.2.4 The leak-tightness device shall not be required for pulse-fired burners

a) in multiple burner installations; the shut-off device for each individual burner may be considered as one of the safety shut-off valves, provided it is at least of the same class;

b) if the shut-off valve is certified by the supplier as acceptable for the increased number of cycles typical of pulse firing;

c) in multiple burner systems, when one or more burners remain alight in the same zone; and

d) when the combustion chamber is at a temperature above 750 °C (as specified for high temperature equipment).

5.2.3.2.5 The pre-purging time shall be such as to ensure that the concentration of any combustible products in any part of the combustion chamber and the flue duct is below 25 % of the Lower Flammable Limit of the fuel gas. This is calculated based on the assumption that the combustion chamber and the flue duct are initially 100 % filled with flammable gases.

In general, five complete air changes of the combustion chamber and the flue duct will suffice. The airflow rate used for a pre-purge shall be at least 50 % of the airflow rate delivered to the burner at maximum heat input.

The manufacturer shall specify the resulting pre-purge time and purge procedure in the instruction handbook.

5.2.3.3 Air:gas fuel ratio

5.2.3.3.1 The air mass flow rate shall always be in a ratio with the gas fuel mass flow rate in order to ensure that, throughout the operating range, safe ignition and a stable and safe combustion are maintained at each individual burner. The ratio need not be the same value at all operational conditions.

Pneumatic gas:air ratio control systems shall comply with EN 88-1, ISO 23551-3 or ISO 23550 if applicable.

An electronic gas:air ratio control shall be designed in accordance with EN 12067-2, ISO 23552-1 or ISO 23550, if applicable.

5.2.3.3.2 In the event that an incorrect gas:air ratio would result in an unsafe condition, the system shall go to lockout.

5.2.3.3.3 In cases where electronically linked (EN 12067-2 or ISO 23552-1compliant) or mechanically linked fuel gas and combustion air capacity control valves are used for ratio control, minimum and maximum fuel gas and minimum and maximum combustion air pressure switches, differential to the combustion chamber, shall be installed.

5.2.3.3.4 The installation of the components in 5.2.3.3.3 shall be upstream of the control valves and downstream of the last pressure-controlling device to guarantee the correct fuel gas to combustion air ratio and to guarantee the capacity to be above the safe minimum and below the safe maximum during all possible operating modes of the IThE.

5.2.3.3.5 Where the combustion chamber pressure is stable, constant and identical for all operating modes of the IThE, the pressure switches do not need to be differential.

5.2.3.3.6 If the combustion chamber pressure is constant, stable and identical for all operating modes of the IThE and combustion air is supplied at its maximum possible pressure (e.g. combustion air blower at constant rotation speed) in such a way that excess combustion airflow cannot occur, the maximum combustion air pressure switch shall not be required.

5.2.3.3.7 Where a pneumatic control (EN 88-1, ISO 23551-3 or ISO 23550 compliant) is used, additional protective measures shall be applied to ensure that the protective system will go to lockout in case of defect or malfunction of the pneumatic ratio control, and that it will provide an equivalent level of safety as in 5.2.3.3.6.

NOTE In some applications, the flame sensor assures a safe lockout before incomplete combustion can occur.

5.2.3.3.8 Where other methods ortechnologies are used for ratio control, and depending on the combustion air and fuel gas properties, additional protective measures shall be required to ensure an equivalent level of safety as in 5.2.3.3.1 to 5.2.3.3.7 (e.g. the frequency control of the combustion air blower, preheated combustion air for the variable Wobbe Index of the gas).

5.2.4 Supply of pre-mixed air:gas fuel

5.2.4.1 Mixture pipework

The volume of the mixture in the pipework shall be as small as possible. The system shall be designed to provide a high mixture flow velocity such that flame propagation upstream cannot occur, and shall be fitted with a flame trap.

Alternatively, the system shall be fitted with a pressure sensor, which causes lockout in the event of the flow velocity falling below a predetermined limit, or a temperature sensor, which causes lockout in the event of flashback.

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

5.2.4.2 Air and gas supply to the mixture circuit

Where a fuel gas:air mixture in the pipework supplies either fuel gas or air to the mixing device, the installer shall ensure that no reverse flow to either supply line takes place.

If a non-return valve is used for the above and if it is not resistant to flashback, then an additional high gas pressure switch located downstream of such non-return valve shall be incorporated to shut-off the flow of fuel gas to the equipment by means of the relevant automatic shut-off valves specified in 5.2.2.4 in the event of a flame flashback.

A flashback shall at least trigger an alarm.

5.2.5 Burners

5.2.5.1 Main burners

Main burners shall be acceptable for the working conditions and shall provide operating safety for

a) the fuels used (type, pressure, etc.),

b) the operating conditions (pressure, temperature, atmosphere, etc.),

c) the nominal input rate and range of regulation (maximum and minimum capacity), and

d) ease of visual monitoring (sight glasses, sight holes, etc.).

5.2.5.2 Package burners

Package burners shall be acceptable, shall afford safe operation, andshall be in accordance with SANS 50676 or ISO 22967.

5.2.5.3 Radiant tube burners

Radiant tube burners shall be acceptable, afford safe operation, and

a) be constructed of acceptable materials for the thermal input rate, temperature and furnace atmosphere;

b) minimize the probability of combustion products coming into contact with the furnace atmosphere;

c) radiant tube burner systems shall be equipped with an automatic burner control system in accordance with 5.2.6. At temperatures above 750 °C no automatic burner control system is needed if a safe ignition of the gas:air mixture can take place. The temperature limit of 750 °C shall be detected at the coldest point designed in accordance with a protective system; and

d) if additional burners are required to operate the IThE processes above 750 °C and these are not to be fitted with automatic burner control systems, then these shall be isolated by safety shut-off valves that are controlled in accordance with the requirements of a protective system that will not permit fuel to flow until the temperature at the ignition point within the radiant tube is above 750 °C. Because the ignition point is within the radiant tube and the temperature therein might well be much lower than in the chamber in which the radiant tube is placed, this shall be taken into consideration in the design of systems operating in this prescribed manner.

5.2.5.4 Start-up and ignition

5.2.5.4.1 Start-up

Automatic start-up of the burner(s) shall be permitted only when

a) the installed air and fuel gas proving devices (e.g. airflow, gas pressure, leak-tightness) have been checked to ensure that they are in the correct operating condition for start-up (e.g. this would normally be the low fire condition); and

b) all relevant interlocks (e.g. position of burner(s), position of valve(s), flue damper(s)) have been proved to be in the correct position.

5.2.5.4.2 Start fuel flow rate

The energy released during the start fuel flame ignition period and start-up of the burners(s) shall be limited and the maximum pressure rise from a delayed ignition shall not cause any damage to the IThE (see table 4.)

The start fuel flow rate shall be controlled by a protective system.

Where the burner is ignited manually (e.g. by means of a lighting torch) and has a burner input rate in excess of 70 kW, it shall be equipped with a means of limiting the start-up gas.

5.2.5.4.3 Ignition

The ignition process shall be initiated immediatelyafter the conclusion of the pre-purging stage or within a period to be specified in the instruction manual..

Where the main burner is ignited by means of a pilot burner, the gas supply to the main burner shall be shut off during the pre-purge and ignition of the pilot burner. The automatic shut-off valve(s) of the main burner shall open only when the pilot burner flame has been proved.

Where oxygen or oxygen-enriched air is the oxidizing agent for the combustion of gas (commonly called oxy/fuel firing), then the ignition procedure and safety times for such systems require specific additional design attention to ensure the equivalent levels of safety.

5.2.5.4.4 Safety times

5.2.5.4.4.1 General

The ignition and the extinction safety times shall not vary by more than 20 % when the electrical supply voltage is between 85 % and 110 % of the nominal value or of the voltage range stated by the manufacturer.

5.2.5.4.4.2 Maximum safety times for natural draught burners

The ignition and extinction safety times for forced, induced and natural draught burners operating in open air shall not exceed the values given in tables 2 and 3.

Table 2 — Maximum safety times for natural draught burners operating in open air

1	2	3
Burner input rate kW	**Safety time** s	**Total closing time** s
Thermoelectric flame supervision device (see SANS 50125) ≤ 70	60	45
Flame supervision device that is not thermoelectric (see EN 298)		
a) ≤ 70	10	10
b) > 70; ≤ 350	10	3
c) > 350[a]	5	3
[a] Ignition at a rate of 33 % of the burner input rating with a maximum of 350 kW.		

Table 3 — Maximum safety times for natural draught burners operating in combustion chambers

1	2	3
Burner input rate kW	**Safety time** s	**Total closing time** s
Thermoelectric flame supervision device (see SANS 50125)≤ 25	60	45
Direct ignition of the burner		
a) ≤ 70	10	10
b) > 70; ≤ 350	10	3
c) > 350[a]	5	3
[a] Ignition at a rate of 33 % of the burner input rating with a maximum of 350 kW.		

For ignition rates below 33 % of the nominal heat output but with an airflow that corresponds to the normal airflow rate (i.e. lean firing), the ignition safety time may be extended to 5 s.

If required for process reasons or special cases of equipment construction, the function and values of the ignition and extinction safety times may differ from those given in tables 2 and 3, provided the safety of the IThE is not compromised.

Ignition and extinction safety times shall not exceed 10 s. In the case of long cross-ignited burners, an extension of the ignition safety time of 1,5 s/m of burner length, with a maximum of 10 s is acceptable, providing the flame is monitored at the end of the burner remote from the source of ignition.

5.2.5.4.4.3 Maximum safety times for forced and induced draught burners

The safety time and total closing time for forced and induced draught burners shall not exceed the values given in table 4.

For burners with a maximum heat input exceeding 120 kW, the start gas heat input shall not exceed 120 kW or a value given by the formula $t_S \times Q_S < 100$.

If burners are ignited by an independent ignition burner, the start gas heat input of the ignition burner shall not exceed the value given by the formula $t_S \times Q_S < 150$.

If required for process reasons or special cases of equipment construction, the function and values of the ignition safety times may differ from those given in table 4, provided the safety of the IThE is not compromised. In this case, the ignition safety times shall not exceed the values given by the following formula:

$$t_S < P_v/(B_v \times 1{,}7 \times Q_S)$$

where

t_S is the safety time in seconds (s);

P_v is the allowable combustion chamber pressure, in kilopascals (kPa), minus the combustion chamber back pressure during ignition;

B_v is the combustion chamber full load in megawatts per cubic meter (MW/m^3), with a maximum of 1 MW/m^3;

Q_S is the maximum start gas heat input expressed as a percentage of $Q_{F\,max.}$(0 < Q_S < 100).

NOTE This formula is typical for natural gas, LPG and comparable fuels (i.e. not for fuels containing high amounts of hydrogen) firing with cold combustion air with 21 % oxygen content.

Where for process reasons, burners with a nominal input exceeding 350 kW are ignited directly, the combustion chamber or process chamber, flue passages and pipework shall be designed to take account of the maximum pressure rise.

The safety time and total closing time shall not exceed 10 s. In the case of long cross-ignited burners, an extension of the safety time of 1,5 s/m of burner length, with a maximum of 10 s is acceptable, providing the flame is monitored at the end of the burner remote from the source of ignition and safe ignition always takes place.

Table 4 — Maximum safety times for forced and induced draught burners

1	2	3	4	5	6	7	8	9	10	11
Burner inputrate	**Direct main burner ignition at full rate**		**Direct main burner ignition at reduced rate**		**Direct main burner ignition at reduced rate by-pass start gas supply**		**Direct main burner ignition — Independent ignition burner**			
	Rate	**Safety time**	**Rate**	**Safety time**	**Rate**	**Safety time**	**Rate**	**First safety time**	**Rate**	**Second safety time**
kW	kW	s	kW	s	kW	s	kW	s	kW	s
< 70	$Q_{F\ max.}$	5	$Q_{ST\ max.}$	5	$Q_{ST\ max.}$	5	< 0,1 $Q_{F\ max.}$	5	$Q_{F\ max.}$	5
> 70 < 120	$Q_{F\ max.}$	3	$Q_{ST\ max.}$	3	$Q_{ST\ max.}$	3	< 0,1 $Q_{F\ max.}$	5	$Q_{F\ max.}$	3
> 120[a]	Not permitted		120 kW or t_S × Q_S < 100 (max. × t_S = 3 s)				< 0,1 $Q_{F\ max.}$	3	120 kW or t_S × Q_S < 150 (max. × t_S = 5 s)	

Q_S = maximum start gas heat input expressed as a percentage of $Q_{F\ max.}$
Q_{ST} = start gas heat in kilowatts
$Q_{ST\ max.}$ = maximum start gas heat in kilowatts
$Q_{F\ max.}$ = maximum heat input in kilowatts
t_s = safety time in seconds

[a] Burners with nominal thermal flow rate from 120 kW up to and including 350 kW may be ignited directly providing they are equipped with slow opening gas valves. In this case the safety time includes the opening time of the slow opening valve. Safety times remain as for 120 kW.

5.2.5.4.5 Flame failure

5.2.5.4.5.1 Flame failure on start-up

In the event of flame failure occurring during the safety time, the burner shall go to lockout. However, in certain cases, recycling is acceptable providing equipment safety is not compromised. The conditions and the time delay between recycles and the number of recycles, which shall not exceed three, shall be specified in the instruction handbook. The recycle(s) shall be controlled by a protective system. If there is no flame signal at the end of these recycles, the failing burner shall go to lockout.

For pulse firing burners, flame failure of a single burner may cause safety shutdown instead of lockout. Three consecutive flame failures shall cause lockout. The total number of burners subject to this provision shall be limited. The number of burners shall be specified in the instruction handbook.

5.2.5.4.5.2 Flame failure during operation

In the event of flame failure during operation, the burner shall go to lockout.

However, in certain cases, safety shutdown is acceptable providing equipment safety is not compromised(for example, the lower explosive limit (LEL)does not exceed 25 %). Not more than one recycle shall be permitted, the conditions for which shall be specified in the instruction handbook. If there is no flame signal at the end of this recycle, the failing burner shall go to lockout.

A recycle on a single burner system requires a complete recycle, including a pre-purge.

The total closing time shall not exceed 3 s. However, in the case where there is no recycle without purge and the LEL in the combustion chamber does not exceed 25 %,the total closing time shall not exceed 5 s.

The IThE shall be designed such that a recycle of a single burner system requires a complete recycle including a pre-purge .

5.2.5.5 Burner capacity control

In any combustion system, the turndown ratio shall be such that the burner(s) is fully stable at all firing conditions.

5.2.5.6 Permanent pilot burners

Permanent pilot burners used in the case of main burners supplied with gas or combustible vapours with uncertain combustion characteristics (e.g. varying calorific values), shall be independently supplied with a clean fuel gas of constant quality and be fitted with automatic burner control systems.

5.2.6 Automatic burner control systems

5.2.6.1 General

All multifunctional control devices having two or more functions, one of which is shut-off function, integratedwithin one housing and whereby the functional parts can not operate if separated. This applies to multifunctional controls of nominal connection size up to and including DN 150 with declared maximum working pressure up and including 50 kPa for use on burners or in appliances for use with one or more fuel gases of the 1st, 2ndor 3rd families in accordance with EN 126.

The main flame and, if applicable, the ignition burner flame, shall be supervised by means of an automatic burner control system. Exceptions shall only be permitted when equipment safety is not compromised (see 5.2.6.2 and 5.2.6.3).

For systems where the pilot burner remains in use during main burner operation, separate flame sensors to supervise the pilot flame and main flame shall be fitted. The main flame sensor shall be so positioned that it cannot in any circumstances detect the pilot flame. In the event that the pilot burner always ignites the main flame, it is sufficient to supervise only the pilot flame, providing the flow rate of that pilot burner is checked by a protective system (e.g. minimum gas pressure switch).

Where the ignition burner and the main burner are each provided with their own flame sensor, the ignition flame shall not influence the response of the main flame sensor.

For systems where the pilot flame is extinguished during main burner operation, a single flame sensor may suffice.

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

Automatic burner control systems shall comply with EN 298 or SANS 50125, if technically applicable. If necessary for process reasons, the characteristics of the system may differ from the requirements specified in EN 298 or SANS 50125, providing the levels of safety and reliability are not reduced.

Where a burner is required to fire continuously for periods in excess of 24 h, the automatic burner control system shall be of the self-checking type.

The detection of a flame when there shouldnot be a flame, or a defect of the automatic burner control system or the protective system, shall result in lockout.

Where manual checking of the automatic burner control system is carried out, the instruction handbook shall specify the procedures to be followed in the event of a malfunction.

5.2.6.2 Low temperature equipment

Low temperature equipment fitted with a single burner shall be equipped with an automatic burner control system in accordance with 5.2.6.1.

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

Only one of the burners shallbe equipped with an automatic burner control system that operates continuously, provided that the burners

a) guarantee stable combustion throughout the range of regulation,

b) are on the same gas:air ratio control system, and

c) are arranged adjacent to each other and in such a way that, if one of them is extinguished, it is re-ignited quickly and smoothly by the flame from the next burner.

This procedure shall not apply to burners controlled by on/off systems.

5.2.6.3 High temperature equipment

Flame supervision, either by means of an automatic burner control system or by the operator, shall be provided during the start-up period when the processing chamber wall temperature is below 750 °C. Any automatic burner control system shall comply with the requirements of 5.2.6.1.

Automatic burner control systems shall not be substituted by operator supervision unless the operator is capable of taking immediate corrective actions during the heat-up phase. The supervision procedure shall be specified in the instruction handbook.

If the design and construction of the IThE is such that, in the event of flame failure, the temperature of the processing chamber walls is likely to fall below 750 °C within 1 h, then an audible and visual alarm shall be fitted.

If automatic switchover is used, a temperature of not less than 750 °Cmay be used for the switching point. This function shall be designed in accordance with the requirements for protective systems.

5.2.6.4 Flame safeguards for open firing burners

Each burner firing in the open air with a rated heat input greater than 70 kW shall be fitted with an automatic burner control system that complies with EN 298 or SANS 50125, if technically applicable.

Where the burner heat input rating is 70 kW or less, the operator may supervise the flame, provided that the flame is visible from his workplace. If the flame cannot be observed continuously from his workplace, an automatic burner control system that complies with EN 298 or SANS 50125, if technically applicable, shall be provided.

Where an installation is equipped with several burners other than on/off burners, no automatic burner control system is required if the burners are arranged in a configuration in which the flame of an operating burner will reliably cross-light another burner in the event of flame extinction. However, in this case, at least one burner shall be equipped with spark restoration or a supervised permanent pilot flame designed so that a failure of the permanent pilot flame or the spark restoration system shall lead to safety shutdown of all the burners.

If required for, and allowed by, production operations, the flame supervision function may be integrated into a control other than a standard automatic burner control system, if such a control is capable of triggering an automatic shutdown. Any such device shall be designed to generate an alarm in the event of a safety shutdown.

If necessary for process reasons (e.g. load damaged due to lockout), and where the single burner capacity is below 100 kW, the lockout function integrated into a multiple burner installation may be replaced by an audible and a visual alarm providing the operator can react within a time that shall be specified in the instructions for use.

5.3 Liquid fuels

5.3.1 Liquid fuel distribution system

5.3.1.1 Pipework design

The pipework design shall take into account the composition and properties of the liquid fuel and the need for venting, purging and cleaning.

Potentially dangerous oscillations in the pipework shall be prevented (e.g. by firm anchoring or the use of flexible coupling).

Where excess pressure can occur in the pipework system due to the thermal expansion of the liquid fuel, means of pressure relief shall be provided.

Steel piping shall be as follows:

a) where screwed joints are used, these shall be limited to pipes of nominal bore not exceeding 40 mm. Such pipes shall comply with the requirements of SANS 62-1, or API Spec 5L (or equivalent); pipe fittings shall be of wrought steel and of a grade at least equal to that of the mating pipes;

b) pipes of nominal bore larger than 40 mm shall have welded or flanged joints and shall comply with the requirements of SANS 62-1, SANS 62-2 or API Spec 5L (or equivalent) or ISO 3183; and

c) the use of steel pipes in critical areas shall be in accordance with the following

Pipes shall not pass through the cavity of cavity walls or through lift shafts, flues, ceiling(s) or ceiling or floor voids and air ducts unless they are sleeved or welded as applicable. Where pipes pass through walls that might or might not be regarded as cavity walls, such pipes shall be sleeved. Pipes shall not be placed vertically or horizontally in the void of a cavity wall.

In cases where the pipework is within the boundaries of category II or III of SANS 347, then the additional requirements of SANS 347 shall apply. For pipework falling under category I, the requirements of SANS 347 can be used as an alternative to the requirements of 5.3.1.1.

5.3.1.2 Connections

5.3.1.2.1 Liquid fuel pipework connections shall be of the screwed, compression, flanged, brazed or welded types. Other types of connections, such as couplings for removable equipment, shall ensure a tight connection. Welded connections on pipes shall be done by a competent welder.

5.3.1.2.2 Screwed connections shall be used only for the following:

a) pressures up to 1 000 kPa;

b) temperatures up to 120 °C;

c) diameters up to DN 40.

Screwed connections may be used for higher pressures and temperatures where the connection is specifically designed to operate under those conditions without creating a risk. In such cases, the connection ratings for pressure and temperature shall be specified in the manual.

5.3.1.2.3 Cutting ring connections shall comply with the appropriate part of ISO 8434 and shall be used only for the following combinations:

a) pressures up to 4 000 kPa; and

b) diameters up to DN 40.

For other combinations of pressures and diameters, connections shall be by means of welded flanges or welded joints. The number of connections shall be kept to a minimum. The sealants used shall comply with EN 751-1 or EN 751-2, as appropriate. Solder with a melting point below 450 °C and adhesives shall not be used. In unventilated enclosures, if joints are necessary, then only welded joints shall be used. Flanges shall comply with SANS 7005-1, SANS 7005-2 and ISO 7005-3 or equivalent, as appropriate.

5.3.1.2.4 Where the equipment has a threaded connection, this thread shall comply with SANS 1306-1 or SANS 1109-1, as appropriate. In the case of parallel threads, care shall be taken to ensure an acceptable seal. Other threaded connections may be used providing they ensure tight connections and are identified.

Hemp shall not be used in threaded connections unless reinforced with an acceptable sealant.

5.3.1.2.5 The design of pipework shall be such as to avoid tensile loading of the joints. Compression fittings shall not be used on pipework larger than 40 mm in diameter.

5.3.1.3 Unconnected pipework

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

5.3.1.4 Flexible tubing

Flexible tubing shall comply with the general requirements of 5.3.1.1, and shall

a) be as short as possible;

b) be acceptable for the maximum and minimum operating temperatures;

c) be acceptable for a pressure 1,5 times the maximum operating pressure (with a minimum of 100 kPa), at the maximum and minimum operating temperatures;

d) have a directly accessible, upstream automatic shut-off device;

e) be mounted in such a way as to avoid distortion, whiplash and damage;

f) have end fittings as integral parts of the tubing;

g) be constructed from acceptable material (metallic or non-metallic (or both)), selected for the application duty and that is not easily damaged.

h) couplings for removable equipment shall ensure a tight connection. Where the equipment is disconnected there shall no leakage of the fuel.

5.3.1.5 Marking

The pipework shall be easily identifiable as liquid fuel pipework.

5.3.1.6 Testing

The liquid fuel distribution system shall be tested for leak-tightness and the ability to withstand the internal test pressure.

After assembly, the liquid fuel circuit shall be tested for leak-tightness. The test pressure shall be not less than 1,5 times the maximum working pressure at any point.

In addition to the pressure test on the pipework, all the pressure relief valves shall be tested to ensure their operation at the correct pressure. The methods and frequency of testing shall be specified in the instruction handbook (see 7.2.3).

Acceptable methods for checking leak-tightness include

a) checking for visible leaks, and

b) pressure decay monitoring, etc.

The external leakage rate shall not give rise to a dangerous condition (flammable or toxic (or both)) in the foreseen circumstances of the equipment installation. The manufacturer shall specify, in the instruction handbook, the frequency required to determine the external leakage.

5.3.1.7 Fuel pipe heating

Where the liquid fuel pipe is required to be heated and insulated to maintain the required temperature, safeguards shall be provided to prevent the temperature or pressure (or both) of the fuel from exceeding the maximum design values.

The heating system shall include all equipment, such as regulating and shut-off mechanisms. In the case of vapour or liquid heating, the heating system shall be provided with acceptable condensate outlets and shut-off valves.

5.3.1.8 By-passes

By-passes shall not be fitted parallel to any automatic shut-off valve except where the by-pass is a stand-by system equipped with an automatic shut-off valve of the same class as that being by-passed.

5.3.1.9 Purge points

Means canbe provided to purge gases safely from the liquid fuel. The venting of the purged gases shall take into account, in particular,

a) risk of explosion;

b) risk of combustion;

c) prevention of recirculation into the combustion chamber;

d) prevention of gas discharging into drains and pits;

e) specific gravity of the gas.

5.3.1.10 Equipment supplied with different liquid fuels

Where a burner is intended for use on more than one liquid fuel, means shall be provided to ensure that the supply pipe of the fuel that is not being fired, is positively isolated (e.g. by physically inserting a blank flange or disconnecting the joint).

5.3.2 Mandatory devices

5.3.2.1 Manual isolation valves

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

They shall be so designed that the open and closed positions are readily distinguishable (e.g. a 90° turn valve and lockable in closed position only).

5.3.2.2 Automatic shut-off valves

5.3.2.2.1 The liquid fuel distribution circuit shall be under the control of automatic shut-off valves. Automatic shut-off valves shall comply with ISO 23553-1, if technically applicable. In the event of damage, or failure of the electricity supply or actuating fluid (or both), the automatic shut-off valves shall shut off the fuel supply to the burner(s). The two automatic shut-off valves in series shall be acceptable for the foreseen maximum operating pressures, back pressures and differential pressures under all process circumstances.

5.3.2.2.2 Low cycling applications (plants intended to operate continuously for periods longer than 1 year) shall have provisions for testing the effective closure of the valves at least once a year (e.g. double parallel automatic shut-off valve system that allows for one system to be tested while the other is in operation).

5.3.2.2.3 High cycling applications (e.g. over 10 000 cycles per year, or pulse firing) shall use only valves that are additionally specified as capable of an increased number of cycles by the valve manufacturer and shall be checked at a frequency of twice a year or as specified in the instruction handbook.

5.3.2.2.4 Where the initial boiling point of the liquid fuel is less than 200 °C or the viscosity at 20 °C is less than 6 mm^2/s and where the burner input rating is greater than 600 kW or 2 GJ, two automatic shut-off valves shall be installed in series.

5.3.2.2.5 A single shut-off valve controlling lessthan 600 kW or 2 GJ shall be fitted with a proof of closure device to create an alarm in the event of failure to close. Where proof of closure is not possible, two automatic shut-off valves shall be installed in series.

5.3.2.2.6 Where the automatic shut-off valves are closed and lockout has occurred, they shall be re-opened only by manual intervention through the protective system after it has been reset, or reset manually on the valve.

5.3.2.2.7 Automatic restart after power failure may be permitted under special circumstances. These special circumstances shall be defined in the instruction handbook.

5.3.2.2.8 The automatic shut-off valve(s) shall shut off the fuel to the entire IThE or independent zone when the limit of any of the following safety conditions is reached:

a) minimal liquid fuel flow;

b) maximum liquid fuel pressure;

c) liquid fuel temperature outside a safe operating range;

d) minimal airflow or air pressure (or both);

e) atomizing fluid pressure outside a safe operating range;

f) failure of power supply or other utilities (e.g. compressed air, steam), or a combination of these;

g) failure of heat transfer fluid;

h) fume extraction malfunction;

i) maximum operating temperature of IThE;

j) flame failure;

k) system leak-tightness check; and

l) any other flame process or machine condition that could cause a risk if the burner continues to fire.

In these cases, the automatic shut-off valves shall be de-energized by a protective system.

5.3.2.2.9 The capacity control functions (valves and circuitry) shall not override the automatic safety shut-off functions. The automatic shut-off valves can also be used for capacity control. However, independent sensing devices shall be used for capacity control and automatic shut off.

5.3.2.3 Pressure relief valves

Where required, all the fuel circuits shall be fitted with pressure relief valves.

5.3.2.4 Liquid fuel pressure regulators

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

5.3.2.5 Pressure regulation of auxiliary fluids

Automatically operated pressure regulators shall be installed for auxiliary fluids (compressed air, steam, etc.) where this is necessary for the control of the burner system.

5.3.2.6 Combustion air, liquid fuel, atomizing and control fluid flow and pressure detectors

In order to detect deviations in the values of combustion air, fuel, atomizing and control fluid flow or pressure, as appropriate, from the limits preset for the operation of the automatic shut-off valves in 5.3.2.2, appropriate detectors shall be installed. These detectors shall be independent of the burner capacity control equipment.

5.3.2.7 Individual manual shut-off valves for multiple burners

For multiple burners which are independently ignited, each individual burner shall be fitted with a manual shut-off valve.

If fitted, the operation of the manual shut-off valve(s) shall not adversely affect the safety of the system, e.g. the atomizing fluid valve shall be proven open before the introduction of liquid fuel.

5.3.2.8 Automatic shut-off valves for multiple burners

Where individual burners are equipped with automatic shut-off valves, such valves shall comply with ISO 23553-1 and their operation shall not adversely affect the safe operation of the remaining burners.

Where two automatic shut-off valves are required (see 5.3.2.2), an individual burner may be shut down by a single automatic shut-off valve in the event of flame failure or for other process reasons (e.g. thermal input), providing that the following conditions are satisfied:

a) no other failure occurs (e.g. pressure or temperature fluctuations);

b) a proof of closure device is fitted;

c) a specific risk analysis is documented in the technical file to prove that the levels of safety have not been compromised;

d) the results of this risk analysis (including any specific process, operational or maintenance requirements and the number of burners permitted to operate under these conditions before two safety shut-off valves in series shall be closed to shut down the associated group of burners) will be specified in the instructions for use; and

e) the protective system shall check for the absence of a flame after the shut-off valve has been closed. If a flame is detected, a flame failure alarm will occur.

The capacity control functions (valves and circuitry) shall not override the automatic shut-off functions. The automatic shut-off valves can also be used for capacity control. However, independent sensing devices shall be used for capacity control and automatic shut off.

5.3.2.9 Flue gas venting

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

If the flue gases are extracted by a fan or the draught is controlled by a damper, the system shall be fitted with a safety device to effect a safety shutdown of the burner(s) or a switching over to a backup duct system in the event of a failure in the flue venting. This function shall be part of the protective system.

For all IThE burners supplied without a flue system, in order to remove the combustion products from the workplace, the instructions for use will refer to the need for sufficient venting to ensure the correct air quality for the operator in accordance with the requirements of the relevant national legislation (see foreword).

5.3.2.10 Ignition system

For safety requirements, ignition burner(s) shall be treated as main burners and the requirements in 5.3.2.1 to 5.3.2.3 (inclusive) shall apply.

Any direct ignition device or combination of ignition device and ignition burner in automatic installations shall form an integral part of the main burner system.

In the case of installations for controlled manual operation, the ignition assembly shall be capable of being mounted on the main burner in one way only, and in such a way that it occupies a fixed position with respect to the burner to be ignited.

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

The ignition device shall be reliable and of sufficient capacity, so that immediate, low noise and smooth ignition is obtained.

Where use is made of a portable ignition burner or ignition device,

a) the ignition burner or ignition device shall be capable of being fitted in one way only. If necessary, fitting into the correct position shall be monitored;

b) the connections for fuel, air and ignition energy shall be so designed that a reliable link-up is obtained, without the possibility of the connections being confused.

If the fuel used for the ignition burner is gaseous, then the requirements of the relevant sub-clauses of 5.2 shall apply.

5.3.3 Combustion air and pre-purging of the combustion chamber and flue passages

5.3.3.1 Combustion air

The pipework design shall take into account the properties of combustion air.

All manually controlled devices (registers, valves, etc.) for combustion air shall be set in their predetermined positions and be protected against inadvertent movement. The location of the combustion air intake shall be such as to prevent entry of flue products, unless provided for by the design (e.g. for the reduction of emission of nitrogen oxides (NO_X)).

The combustion air system shall be designed in a manner that prevents the backflow of furnace atmosphere or flue gases (or both) through the combustion equipment.

Potentially dangerous oscillations in the pipework shall be prevented (e.g. by firm anchoring or the use of flexible coupling).

NOTE The ventilation of the building and IThE should be such as to allow an acceptable supply of process air and combustion air to reach the burner(s) in IThE under all conditions.

5.3.3.2 Pre-purging of the combustion chamber and flue passages

5.3.3.2.1 Except where specified in 5.3.3.2.2 to 5.3.3.2.4, start-up shall not be initiated until all safety steps have been taken to ensure that no combustible mixture is present in the combustion or processing chamber, connected spaces and flue passage (heat exchangers, dust extractors, etc.).

This safety condition shall be achieved by means of a period of pre-purging immediately before ignition or within a time to be specified in the instruction handbook.

The pre-purge time and the airflow requirement during this cycle shall be controlled by a protective system.

Restart after a lockout condition shall commence with a pre-purge.

5.3.3.2.2 The pre-purge may be omitted (either during start-up or after a lockout) in the following cases:

a) in applications where the presence of free oxygen could be hazardous (e.g. flammable atmosphere) or may affect the equipment (e.g. a graphite crucible) or the product quality; or

b) when the combustion chamber is proved to be at a temperature above 750 °C (as specified for high temperature equipment).

In (a), additional precautions shall be taken to prevent combustible products from remaining in the combustion chamber, e.g. by purging with inert gas.

5.3.3.2.3 In the case of burner shutdown forcontrol purposes, pre-purging shall not be required for recycling

a) where the burner is fitted with an independently supervised permanent or alternating pilot burner, or

b) with pulse-fired burners if the burner shut-off valve is certified by the supplier as acceptable for the increased number of cycles typical of pulse firing, or

c) in multiple burner systems, where one or more burners remain alight in the same zone, even in the case of flame failure of one single burner, or

d) when the combustion chamber is at a temperature above 750 °C (as specified for high temperature equipment).

NOTE For multiple burner installations, the individual burner shut-off device may be considered as one of the shut-off valves, provided it is at least of the same class.

5.3.3.2.4 The pre-purge time shall be such as to ensure that the concentration of any combustible products in any part of the combustion chamber or processing chamber and flue duct is below 25 % of the lower fammablelimit (LFL) of the liquid fuel. This is calculated based on the assumption that the combustion chamber or processing chamber and the flue duct are initially 100 % filled with flammable gases.

In general, five complete air changes of the combustion chamber or processing chamber and flue duct volume will determine the purge time. The airflow rate used for a pre-purge shall be at least 25 % of the maximum combustion airflow rate.

In the case of natural draught, the condition to achieve the above requirements shall be defined by the manufacturer in the instruction handbook.

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

The resulting pre-purge time and purge procedure or methodology (or both) shall be specified by the manufacturer in the instruction handbook.

5.3.3.3 Air:liquid fuel ratio

The air mass flow rate shall always be in a ratio with the liquid fuel mass flow rate in order to ensure that, throughout the operating range, safe ignition and a stable and safe combustion are maintained at each individual burner. The ratio need not be the same value at all operational conditions.

Depending on the chosen technology, additional protective measures may be required (e.g. frequency control of the combustion air blower, variable combustion chamber pressure, and preheated combustion air). The failure tolerance time for CO emission shall not exceed 30 min.

5.3.4 Liquid fuel atomization

Burners for liquid fuels shall be equipped, where applicable, with fuel-atomizing systems to permit their correct combustion.

Measures shall be taken to prevent the liquid fuel from entering the atomizing fluid pipe and vice versa. If the atomized fluid is a combustible gas, then the requirements of the relevant subclauses of 5.2 shall apply.

5.3.5 Burners

5.3.5.1 Main burners

Main burners shall be acceptable for the working conditions and shall provide operating safety for

a) the fuels used (type, pressure, etc.),

b) the operating conditions (pressure, temperature, atmosphere, etc.),

c) the nominal input rate and range of regulation (maximum and minimum capacity), and

d) ease of visual monitoring (sight glasses, sight holes, etc.).

5.3.5.2 Start-up and ignition

5.3.5.2.1 Start-up

Start-up of the fuel supply and burner(s) shall be permitted only when

a) the installed air and liquid fuel proving devices (e.g. airflow, fuel pressure, atomizing-fluid pressure (when required)) have been checked to ensure that they are in the correct operating condition for start-up; and

b) all relevant interlocks (e.g. position of burner(s), position of valve(s), flue damper(s)) have been proved to be in the correct position.

5.3.5.2.2 Start fuel flow rate

The energy released during the start fuel flame ignition period and start-up of the burners(s) shall be limited and the maximum pressure rise from a delayed ignition shall not cause any damage to the plant.

Burners with an input rate of up to and including 350 kW may be ignited directly.

Where burners with an input rate exceeding 350 kW are ignited directly, the combustion chamber or process chamber, flue ways and pipework shall be designed to take account of the maximum pressure rise.

Where the burner is ignited manually (e.g. by means of a lighting torch) and has a burner input rate that exceeds 70 kW, it shall be equipped with a means of limiting the start-up fuel.

5.3.5.2.3 Ignition

The ignition process shall be initiated immediately after the conclusion of the pre-purging stage providing the requirements given in 5.3.5.2.1(a) are complied with.

Where the main burner is ignited by means of an ignition burner, the liquid fuel supply to the main burner shall be shut off during the ignition of the ignition burner. In this case, the burner input rating shall be such that maximum pressures in the combustion chamber or process chamber and in the flue passages, as well as risky situations in the pipework are prevented. The automatic shut-off safety valve(s) of the main burner shall be opened only when the ignition burner flame has been proved.

Where oxygen or oxygen-enriched air is the oxidizing agent for the combustion of a fuel (commonly called oxy/fuel firing), then the ignition procedure and safety times for such systems require specific additional design attention to ensure the equivalent levels of safety.

5.3.5.2.4 Safety times

5.3.5.2.4.1 General

The ignition and the extinction safety times shall not vary by more then 20 % when the electrical supply voltage is between 85 % and 110 % of the nominal value or of the voltage range stated by the manufacturer.

5.3.5.2.4.2 Maximum safety times

The ignition and extinction times shall not exceed the values given in table 5.

If required for process reasons or special cases of equipment construction, the function and values of the ignition and extinction safety times may differ from those given in table 5, provided the safety of the IThE is not compromised. In this case, the ignition safety time shall not exceed the value given by the following:

$$P_v/(1{,}7 \times t_s \times B_v \times Q_{s\,max.})$$

where

P_v is the allowable combustion chamber pressure, in kilopascals (kPa), minus the combustion chamber back pressure during ignition;

t_S is the safety time in seconds (s);

B_v is the combustion chamber full load in megawatts per metre cubed (MW/m^3);

$Q_{Smax.}$ is the maximum start fuel heat input expressed as a percentage of $Q_{F\,max.}$ $0 < Q_{s\,max.} < 100$).

NOTE This formula is typical for natural gas and comparable fuels (i.e. not for fuels containing high amounts of hydrogen).

5.3.5.2.5 Flame failure

5.3.5.2.5.1 Flame failure on start-up

In the event of failure occurring during ignition, the burner shall go to lockout. However, in certain cases, recycling is acceptable providing equipment safety is not compromised. The conditions and the time delay between recycles and the number of recycles, which shall not exceed two, shall be specified in the instruction handbook. The recycle(s) shall be controlled by a protective system. If there is no flame signal at the end of these recycles, the failing burner shall go to lockout.

Table 5 — Maximum safety times

1	2	3	4
Heat input kW	**Direct main burner ignition at full rate** s	**Direct main burner ignition at reduced rate**	**Reduced rate *Qs* by ignition burner**
< 300	$t_{s\ max.}$ = 10	$t_{s\ max.}$ = 10 s	$t_{s\ max.}$ = 10 s
> 300 < 1 000	$t_{s\ max.}$ = 5	$t_{s\ max.}$ = 5 s	$t_{s\ max.}$ = 5 s
> 1 000 < 5 000	Not permitted	$Q_s \leq$ 100 kW $Q_{s\ max.} \leq$ 70 % $t_{s\ max.}$ = 5 s	$Q_s \leq$ 1 000 kW $t_{s\ max.}$ = 5 s
> 5 000	Not permitted	$Q_{s\ max.} \leq$ 35 % $t_{s\ max.}$ = 5 s	$Q_{s\ max.} \leq$ 35 % $t_{s\ max.}$ = 5 s
Q_S = start fuel heat input expressed as a percentage of $Q_{F\ max.}$ $Q_{S\ max.}$ = maximum start fuel heat expressed as a percentage of $Q_{F\ max.}$ $Q_{F\ max.}$ = maximum heat input in kilowatts t_s = maximum safety time in seconds			
NOTE For liquid fuels the ignition safety time commences with the release of the fuel into the combustion chamber.			

For pulse firing burners, flame failure of a single burner to ignite may cause safety shutdown instead of lockout. Three consecutive flame failures shall cause lockout. The total number of burners subject to this provision shall be limited. The number of burners shall be specified in the instruction handbook.

5.3.5.2.5.2 Flame failure during operation

In the event of flame failure during operation, the burner shall go to lockout.

However, in certain cases, safety shutdown is acceptable, providing equipment safety is not compromised. Not more than one recycle shall be permitted, the condition for which shall be specified in the instruction handbook. If there is no flame signal at the end of this recycle, the failing burner shall go to lockout.

A recycle on a single burner system requires a complete recycle, including a pre-purge.

5.3.5.3 Burner capacity control

In any combustion system, the turndown ratio shall be such that the burner(s) is fully stable at all firing conditions.

5.3.5.4 Permanent pilot burners

Permanent pilot burners that are used in the case of main burners, shall be supplied with liquid fuel or combustible vapours with uncertain combustion characteristics shall be independently supplied with a clean fuel gas of constant quality and be fitted with automatic burner control systems.

5.3.6 Automatic burner control systems

5.3.6.1 General

The main flame and, if applicable, the ignition burner flame, shall be supervised by means of an automatic burner control system. Exceptions are only permitted when equipment safety is not compromised (see 5.3.6.2 and 5.3.6.3).

For systems where the pilot burner remains in use during main burner operation, separate flame sensors to supervise the pilot flame and the main flame shall be fitted. The main flame sensor shall be so positioned that it cannot in any circumstances detect the pilot flame. In the event that the pilot burner always ignites the main flame, it is sufficient to supervise only the pilot flame, providing the flow rate of that pilot burner is checked by a protective system (e.g. minimum gas pressure switch).

Where the ignition burner and the main burner are each provided with their own flame sensor, the ignition flame shall not influence the response of the main flame sensor.

Flame safeguards (flame failure devices) shall comply with an approved standard (for example, EN 230 and EN 298), as technically applicable.

For systems where the pilot flame is extinguished during main burner operation, a single flame sensor may suffice.

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

Where a burner is required to fire continuously for periods in excess of 24 h, the automatic burner control system shall be of the self-checking type.

The detection of a flame when there shall not be a flame, or a defect of the automatic burner control system or the protective system, shall result in lockout.

Where manual checking of the automatic burner control system is carried out, the instruction handbook shall specify the procedures to be followed in the event of a malfunction.

5.3.6.2 Low temperature equipment

Low temperature equipment fitted with a single burner shall be equipped with an automatic burner control system in accordance with 5.3.6.1.

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

5.3.6.3 High temperature equipment

Flame supervision, either by means of an automatic burner control system or by the operator, shall be provided during the start-up period when the processing chamber wall temperature is below 750 °C. Any automatic burner control system shall comply with the requirements of 5.3.6.1.

Automatic burner control systems shall not be substituted by operator supervision. However, where the operator is a competent person, he may change the settings to take immediate corrective actions during the heat-up phase. The supervision procedure shall be specified in the instruction handbook.

If the design and construction of the IThE is such that, in the event of flame failure, the temperature of the processing chamber walls is likely to fall below 750 °C within 1 h, then an audible and visual alarm shall be fitted.

If automatic switchover is used, a temperature of not less than 750 °C may be used for the switching point. This function shall be designed in accordance with the requirements for protective systems.

5.4 Solid fuels

5.4.1 Pulverized solid fuel distribution system

5.4.1.1 Pipework design

The pipework design shall take into account the composition and properties of the solid fuel and the need for venting, purging and cleaning. The creation of static electricity shall be avoided.

Potentially dangerous oscillations in the pipework shall be prevented (e.g. by firm anchoring, or the use of flexible coupling).

The pipework shall be dust-tight. The pipework shall be constructed in such a way that, due to its appropriate design and its acceptable flow rate, no deposits can occur. These requirements shall be principally complied with if the velocity in the conveyor line amounts to a minimum of 18 m/s. Depending on the material to be conveyed, higher speeds might be required.

The pipework shall be designed to be pressure-impulse resistant, which is usually achieved by using piping of the minimum pressure category PN 10.

5.4.1.2 Unconnected pipework

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

5.4.1.3 Electrical continuity

Electrical continuity shall be ensured for all pipework (e.g. fit an earth strap across two connecting flanges where a non-conductive connection is made to ensure continuity).

The pipework shall be earthed to prevent build-up of static charge.

The formation of galvanic cells shall be avoided.

5.4.1.4 Flexible tubing

Flexible tubing shall comply with the general requirements of 5.4.1.1, and shall

a) be as short as possible;

b) be acceptable for the maximum and minimum operating temperatures;

c) be acceptable for the maximum operating pressure, at the maximum and minimum operating temperatures;

d) have a directly accessible, upstream automatic shut-off device;

e) be mounted in such a way as to avoid distortion, whiplash and damage;

f) have end fittings which are acceptable for dust-tight operation, for example, heavy duty hose clamps;

g) be constructed from acceptable material (metallic or non-metallic (or both)), selected for the application duty and that is not easily damaged; and

h) be such that the creation of static electricity is avoided.

5.4.1.5 Marking

The pipework shall be easily identifiable as solid fuel pipework.

5.4.1.6 Testing

The solid fuel distribution system shall be tested for soundness (leak-tightness and the ability to withstand the internal test pressure). After assembly, the solid fuel circuit shall be tested for leak-tightness.

The test pressure shall be at the maximum operating pressure of the system.

The testing procedure and the frequency of soundness testing shall be as specified in the instruction handbook (see 7.2.3).

The external leakage rate shall not give rise to a dangerous condition (flammable or toxic (or both)) in the foreseen circumstances of the equipment installation.

The manufacturer shall specify in the instruction handbook the frequency to determine the external leakage.

5.4.1.7 Pressure relief devices and flame arrestors on pipework

For equipment in which flashbacks can occur, flame arrestors or explosion relief devices (or both) shall be fitted.

To prevent a smouldering fire from occurring in a fuel system during start-up, operation and especially during and after shutdown, special precautionary measures (e.g. an extinction system or flame-resistant stairwell feeders) shall be provided.

Explosion relief devices shall be designed to yield at a pressure of not greater than 1,5 times the maximum operating pressure of the circuit and shall be positioned such that the discharge flow does not constitute a risk to the equipment, personnel or third parties.

5.4.1.8 Pressure oscillations

The solid fuel system shall be designed (e.g. by correct sizing of pipe) so as to prevent the possibility of solid fuel velocities and pressure fluctuations causing potentially dangerous oscillations in the system.

5.4.2 Graded fuel supply systems (applicable to grate burners and fluidized beds)

Graded fuel supply systems shall be adapted to the working conditions and shall guarantee stable, safe operation for the following:

a) fuel supply (type, particle size distribution, pressure, prevention of dust leakage, prevention of ignition due to friction or overheating, etc.);

b) combustion chamber conditions (pressure, temperature, atmosphere, etc.);

c) nominal input rate and range of regulation (maximum and minimum capacity); and

d) ease of visual monitoring (sight glasses, sight holes etc.).

In the case of solid fuels with high volatile content, provision shall be made for the fitting of explosion relief devices in the fuel-handling system. These explosion relief devices shall be positioned such that the discharge flow does not constitute a hazard to the equipment, personnel or third parties.

5.4.3 Mandatory devices (for pulverized fuels and fluidized beds)

5.4.3.1 Manual isolation valve

A manually operated isolation valve shall be fitted so that the solid fuel supply may be shut off in the event of an emergency.

5.4.3.2 Airflow and air pressure detectors

Equipment fitted with forced or induced draught burner(s) shall be fitted with a device for proving predetermined airflow during the pre-purge, ignition and operation of the burner. Airflow failure at any time during the pre-purge, ignition or operation of the burner shall cause safety shutdown and, in the case of no operator supervision, shall cause a lockout.

Depending on the chosen technology, additional protective measures might be required.

5.4.3.3 Ignition system

Ignition burners fired by gaseous or liquid fuels shall comply with the safety requirements specified in 5.2 and 5.3.

5.4.4 Combustion air and pre-purging of the combustion chamber and flue passages

5.4.4.1 Combustion air

All manually controlled devices (registers, valves, etc.) for combustion air shall be set in their predetermined positions and be protected against inadvertent movement. The location of the combustion air intake shall be such as to prevent entry of flue products, unless provided for by the design (e.g. for the reduction of emission of nitrogen oxides (NO_x)).

The combustion air system shall be designed in a manner that prevents the backflow of furnace atmosphere or flue gases (or both) through the combustion equipment.

Potentially dangerous oscillations in the pipework shall be prevented (e.g. by firm anchoring or the use of flexible coupling).

NOTE The ventilation of the building and IThE should be such as to allow an acceptable supply of process air and combustion air to reach the burner(s) in IThE under all conditions.

5.4.4.2 Pre-purging of the combustion chamber and flue passages

Start-up shall not be initiated until all safety steps (e.g. pre-purging and venting) have been taken to ensure that no combustible mixture is present in the combustion or processing chamber, connected spaces and flue passages (heat exchangers, dust extractors, etc.)

The pre-purge time and the airflow requirement during this cycle shall be controlled by a protective system. These measures shall be specified in the instruction handbook.

5.4.4.3 Air:solid fuel ratio

The air mass flow rate shall always be in a ratio with the solid fuel feed rate in order to ensure that, throughout the operating range, a stable and safe combustion is maintained at each individual burner. The ratio need not be the same value at all operational conditions.

5.4.5 Burners

5.4.5.1 Main burners

Main burners shall be acceptable for the working conditions and shall provide operating safety for

a) the fuels used (type, particle size, distribution, etc.),

b) the operating conditions (pressure, temperature, atmosphere, etc.),

c) the nominal input rate and range of regulation (maximum and minimum capacity), and

d) ease of visual monitoring (sight glasses, sight holes, etc.).

5.4.5.2 Start-up and ignition

5.4.5.2.1 Start-up

Start-up of the fuel supply system(s) and the burner(s) shall be permitted only when

a) the installed air and solid fuel proving devices (e.g. airflow, solid fuel pressure) have been checked to ensure that they are in the correct operating condition for start-up; and

b) all relevant interlocks (e.g. position of burner(s), position of valve(s), flue damper(s)) have been proved to be in the correct position.

The start-up sequence shall ensure that there is no flame present before proceeding further.

5.4.5.2.2 Ignition of the pilot burner

Ignition of the pilot burner, if any, shall comply with the requirements specified in 5.3.5.2.

5.4.5.2.3 Ignition of the main combustion system

The procedure and the conditions for the safe ignition of the main combustion system shall be specified in the instruction handbook and, where appropriate, shall be incorporated into the automatic start-up sequence for pulverized fuel burners.

Where an ignition burner is used for the ignition of a pulverized fuel burner, it shall be proved stable before the introduction of the pulverized fuel. Where the process dictates, the firing chamber shall be preheated to a temperature that will ensure continuance of combustion of the pulverized fuel once the start-up burner has been extinguished.

Where oxygen or oxygen-enriched air is the oxidizing agent for the combustion of a gas (commonly called oxy/fuel firing), then the ignition procedures and safety times for such systems require specific additional design attention to ensure the equivalent levels of safety.

5.4.5.2.4 Safety times (pulverized fuel)

The ignition and total extinction times shall be such that no hazardous situation occurs. The ignition safety time shall be specified in the instruction handbook.

The extinction safety time shall not exceed 5 s except where the type of solid fuel or the design of the firing system dictates a longer time. In such cases, the extinction safety time shall be specified in the instruction handbook.

5.4.5.2.5 Flame failure (pulverized fuel)

In the event of flame failure, either during start-up or operation, the burner(s) shall go to lockout.

Manual intervention shall be necessary before any attempt is made to re-ignite the flame.

5.4.5.3 Burner capacity control (pulverized fuel)

In any combustion system, the turndown ratio shall be such that the burner(s) is fully stable at all firing conditions and no flashback condition can occur.

5.4.5.4 Permanent pilot burner (pulverized fuel)

Where the main burner is supplied with solid fuel with uncertain combustion characteristics (anthracite, petroleum coke, etc.) in a particular application, a permanent pilot burner shall be used. This pilot burner shall be supplied with a fuel of constant quality.

5.4.6 Automatic burner control systems (pulverized fuel)

Automatic burner control systems shall comply with the requirements in annex B.

5.5 Multiple fuels

5.5.1 General

Equipment heated with multiple fuels can be fitted with burners supplied with two or more types of fuel, i.e. gaseous, vapour, liquid or solid, operating either simultaneously or separately.

5.5.2 Fuel circuit

Each type of fuel shall be distributed to the burner(s) by means of an independent system. This system shall be constructed in accordance with the requirements of 5.2, 5.3 and 5.4, as appropriate.

Each burner shall be fitted with automatic shut-off valves for each type of fuel. In addition, the flame supervision system shall be chosen in such a way that it complies with the specifications appropriate to the types of fuel used.

Means shall be provided to ensure that the supply pipework of each individual fuel can be positively isolated from the other fuels whether or not non-return valves are fitted.

5.5.3 Combustion air supplies

It is acceptable to use a common combustion air system for all fuels.

5.5.4 Operation of the safety devices

Where malfunctions that affect only one type of fuel occur, the individual safety shut-off device relating to that fuel shall close.

Where a fuel supports the combustion of other fuels, the safety device of the assisted fuel shall also operate as intended.

Simultaneous closure of the safety shut-off devices installed on each type of fuel shall be guaranteed under all other circumstances given in 5.2.2.4 and 5.3.2.2 (see also annex B).

5.5.5 Air:fuel ratio

For each individual or combination fuel, the requirements specified in 5.2.3.3 and 5.3.3.3 shall apply (see also ISO 23552-1 and ISO 23551-3).

5.6 Oxygen or oxygen-enriched combustion air

5.6.1 General

The application of oxygen or oxygen-enriched combustion air requires particular consideration. Release of oxygen or oxygen-enriched air shall be in a safe area. The hazards related to the use and handling of oxygen shall be specified in the instruction handbook.

If the oxygen content exceeds 23%, the installation shall meet the requirements of EIGA 13-12/E or SANS 10260-1.

5.6.2 Suitability for oxygen service

Due to the ignition hazard of flammable material in contact with oxygen, all components coming into contact with oxygen shall be prepared, cleaned and sufficiently free of flammable substances (e.g. dust, grease, and particulates) before start-up. They shall be acceptable for oxygen systems.

NOTE EIGA 13-12/E or SANS 10260-1 provides convenient information on cleanliness for oxygen systems.

5.6.3 Sealing materials for oxygen distribution systems

Sealing materials shall be acceptable for application at the required pressure levels, installation methods and operating temperatures and shall comply with the safety requirements. Acceptable metallic sealing materials for oxygen distribution systems are given in column 2 of table 6.

5.6.4 Pipe systems

The design and material of pipe systems and their equipment and connections shall be acceptable for oxygen service and the intended pressures and temperatures. In pipe systems, right angle impingement of gaseous oxygen onto the pipe walls shall be avoided.

5.6.5 Gas velocities in pipes

5.6.5.1 Velocities shall not exceed

a) For carbon and stainless steel pipe systems:

   1) pressure below 1 200 kPa: 30 m/s (impinging or non-impinging flow);

   2) pressure above 1 200 kPa: 8 m/s (impinging or non-impinging flow);

b) For copper, nickel, and copper/nickel alloy pipe systems: pressures up to 6 500 kPa, no velocity limit.

5.6.5.2 After pressure-reducing valves or control valves, for a minimum distance of eight pipe diameters, the pipe shall be fabricated as follows:

a) pressures below 1 200 kPa: from stainless steel (wall thickness shall be greater than 3 mm), or Cu/Ni alloys where the pipe size is greater than DN 25;

b) pressures above 1 200 kPa: from copper and nickel or Cu/Ni alloys.

For operating temperatures above 200 °C and below −10 °C, the above materials shall not be used.

Filter(s) shall be fitted at the inlet of the oxygen pipe systems to prevent ingress of particulates (e.g. rust). The filter(s) shall be equipped with pressure drop indication devices.

5.6.6 Devices

The design and material of fittings for gaseous oxygen, such as safety shut-off valves, control devices and non-return valves shall be certified to be compatible with oxygen at the intended pressures and temperatures.

Acceptable materials for housings and built-in parts of fittings and their sealing materials are given in table 6.

5.6.7 Blow-off and venting lines

Venting of oxygen lines shall be channelled to a well ventilated area where the release of oxygen shall not create a hazard

5.6.8 Manual torches

Hoses, flexible pipes and connections shall be made gas-tight by means of swageing, crimping or the use of clips. Manual torches shall be equipped with a flashback arrestor (see SANS 50730-1 or equivalent) and a lockable manual shut-off valve upstream of the hose.

5.6.9 Safety devices against gas backflow

Oxygen distribution systems shall be equipped with non-return valves (see EN 730-2, EIGA 13-12/E or equivalent) that are acceptable for the operating pressure.

5.6.10 Safety devices against oxygen backflow in mixtures with other substances

If oxygen is mixed with other substances (e.g. gas or air), it shall be ensured that backflow cannot occur by using a non-return valve (see 5.6.9).

5.6.11 Material requirements

Materials in contact with oxygen shall be suitable for the intended operating pressures and temperatures. The installation method shall be selected to ensure that it is safe for oxygen service.

NOTE Regarding the selection and compatibility of materials and gases (including oxygen), see also EIGA 13-12/E

The materials given in table 6 are suitable (depending on the mounting location and the pressure) for use with oxygen or oxygen-enriched combustion air.

Table 6 — Material requirements for housings, components and seals

1	2
Pressure range kPa	**Materials for housings, built-in components and seals of fittings**
> 4 000	Copper, copper alloys with a mass proportion of at least 55 %, nickel, and nickel-wrought alloys with copper High-alloy Cr-Ni steels with a mass proportion of Cr and Ni of a total of at least 22 % High-alloy Cr-Si steels with a mass proportion of Cr of at least 22 %
0 — 4 000	Copper, copper alloys with a mass proportion of copper of at least 55 % High-alloy Cr-Ni steels with a mass proportion of Cr and Ni of a total of at least 22 % High-alloy Cr-Si steels with a mass proportion of Cr of at least 22 %
0 — 1 600	Gray cast iron, of at least quality class GG 25, and cast iron with nodular graphite, of at least quality class GGG 40
0 — 1 000	Metallic materials (except titanium, zirconium and their alloys)
Besides the metals given above, lead and tin may be used as metallic sealing materials for all pressure ranges or in accordance with ISO 15590-3.	

5.7 Power supply and design requirements for electrical and electronic equipment for control and protective systems

5.7.1 Electricity supply

Because of the very low risk of the presence of flammable concentrations of gas in the vicinity of burner pipework and control equipment, this area shall be considered as non-hazardous.

The electricity supply installations, the equipment and their earthing shall comply with SANS 10142-1 and SANS 10142-2.

The burner(s) and associated equipment shall function safely when the voltage supplies vary within the over and under percentage tolerances. Outside these tolerances the equipment shall either continue to function safely or go to safety shutdown.

Interruption or restoration (or both) of the electricity supply at any time during start-up or operation of the burner(s) and associated equipment shall result in continued safe operation, safety shutdown or safe conditions.

5.7.2 Requirements applicable to electrical and electronic equipment

Electrical and electronic equipment shall be designed in accordance with the relevant national legislation (see foreword).

5.7.3 Functional safety and protective systems

The protective system contains all the components that are required for functional safety. Control systems and protective systems (see figure 1) shall be designed in accordance with EN 50156-1.

Where a South African national standard is available for a product, it shall take precedence. However, where no South African national standard exists, the international or regional standard shall be applied.

Fault analysis shall be made in accordance with the relevant figures in EN 50156-1. Equipment

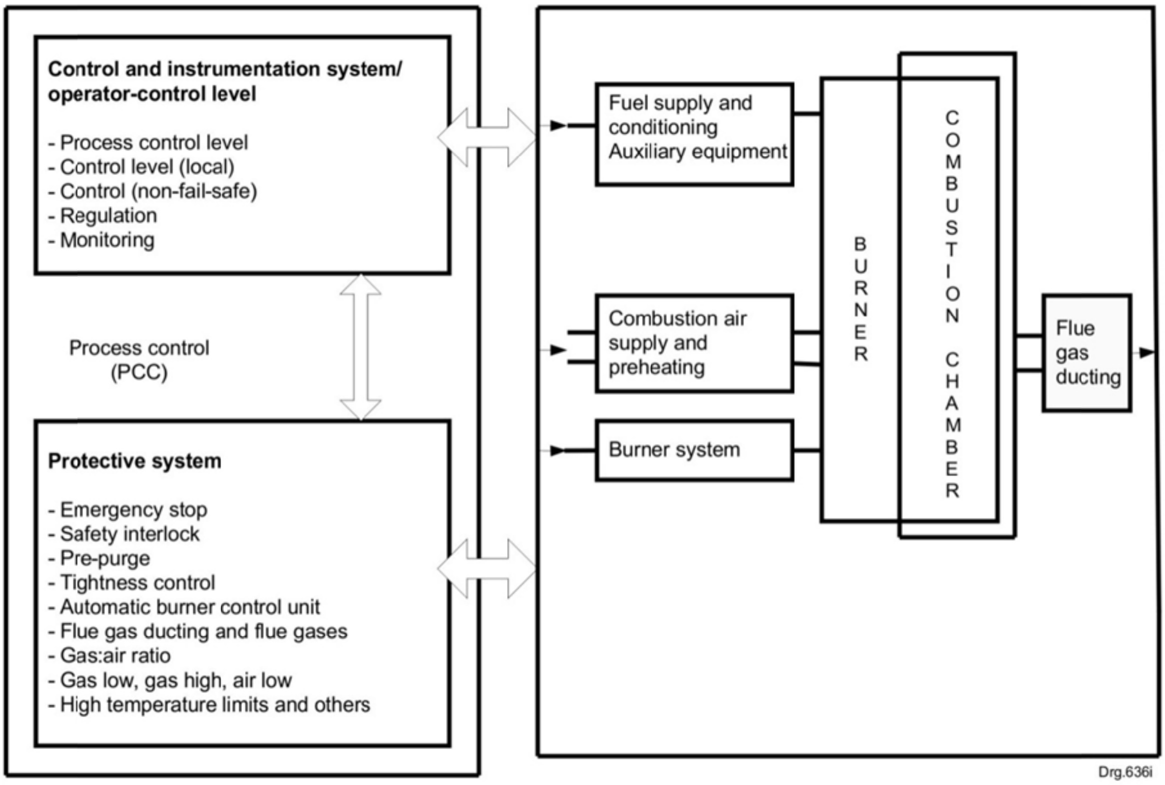


Figure 1 — Block diagram of control and protective systems

compliance with an EN standard may be used without further assessment, if the EN covers all the requirements for the proposed application.

5.7.4 Supply of utilities for instruments, monitors and capacity control

Unregulated drops in the pressure of the utilities actuating instruments and monitors (e.g. compressed air, hydraulic oil, and main fluid in the case of automatically actuated devices) shall activate an alarm while operations shall be maintained under safe conditions (see ISO 4413 and ISO 4414).

If a pressure drop can result in a dangerous situation, the safety devices shall cause shutdown of the equipment.

5.7.5 Electromagnetic compatibility (EMC)

The protective and control system shall operate correctly and undisturbed by electromagnetic emissions.

The IThE shall not give out harmful electromagnetic emissions to the environment.

Electromagnetic interference, interference pick-up and radiated interference shall not influence safe and reliable operation of the system.

Since it is difficult to test large installations as a whole, tested components shall be used. Installation and wiring shall be designed in accordance with the specifications of the equipment manufacturers according to the appropriate severity level, e.g. arrangement in respect of mutual interference, shielded lines and earthing.

5.7.6 Electrical power failure

5.7.6.1 Where an electrical power failure has occurred and the system has shut down, any restart shall only be initiated by manual intervention. The start-up and ignition sequence shall apply (see 5.2.5.4 or 5.3 or 5.4).

5.7.6.2 Manual restart by the protective system after electrical power failure shall only be initiated if all the following conditions are satisfied:

a) the IThE is in normal operating mode (not in the heating up, cooling down or starting or stopping sequence); and

b) all the requirements for the operation of the IThE were complied with immediately before the power cut occurred, e.g. all doors were closed.

5.7.6.3 If the conditions in 5.7.6.2 are satisfied,

a) a lockout shall not be generated immediately;

b) the protective system may neglect power cuts shorter than 1 s; and

c) if the power cut is of a duration that does not result in a dangerous situation if restartedautomatically (e.g. due to increased heat release after the restart), the protective system can initiate an automatic restart as for a controlled stop. The maximum allowable power cut duration to allow automatic restart shall be specified in the instruction manual.

In all other cases the protective system shall go to lockout.

5.7.7 Reset

5.7.7.1 Manual reset

On components that perform a safety function, reset after a fault lockout shall be triggered manually on the interlocked device at the site of the IThE, after the fault has been repaired.

5.7.7.2 Remote reset

If the safety of the installation is not impaired, a remote reset after a fault lockout (e.g. from the control room) may occur under the following conditions:

a) by manually operating a button that is permanently wired to the safety equipment (considered equivalent to manual reset). Resets shall be logged;

b) by manually operating a button and signal forwarding via a fail-safe PLC (considered equivalent to manual reset). Resets shall be logged; and

c) by manually operating a button if a single-channel PLC is used. In this case, additional safety measures are necessary in order to ensure a level of safety equivalent to (a) and (b).

The number of allowed resets shall be specified in the instruction handbook. The requirements of 5.2.5.4.5, 5.3.5.2.5 and 5.4.5.2.5, with respect to flame failure on start-up and during operation, shall be complied with for resetting the individual burner, i.e. gas valves shall not open an uncontrolled number of times.

5.7.8 Use of programmable logic controls

A PLC used for safety functions shall comply with the minimum SIL (safety integrity level) requirements of EN 50156-1. If the PLC does not comply with the requirements necessary to be used as a protective system in accordance with EN 50156-1, then additional measures shall be required (also specified in EN 50156-1).

NOTE Typical safety integrity level (SIL) requirements for combustion equipment in the scope of this standard are between two and three cycles, taking into account the relevant number of cycles. The total closing time shall not be exceeded if a PLC is used.

Any changes of hardware and software shall be documented and the records shall be maintained on site.

5.7.9 Software requirements

Software for safety functions shall be separate from other functions (e.g. control functions). The software for safety functions shall be designed in accordance with the requirements of IEC 61508-3 or comparable requirements for functional safety. Once the design has been commissioned, the system shall not be overridden and safety sequences shall not be altered in any way.

5.7.10 Bus system requirements

If bus systems are used to transfer safety signals, the requirements of 5.7.5 and 5.7.7 shall apply to the bus. Safety functions shall not be impaired when bus systems are used.

5.7.11 Safety function test

All safety functions shall be tested at least once during commissioning. Testing shall be documented and the records shall be maintained on site.

5.7.12 Relays

Where extra relays are put into a system, the flame-failure requirement shall not be overridden, and the power source of any safety device shall be the flame safeguard.

6 Verification of the safety requirements and measures

Annex C shall be used as a checklist by manufacturers with a view to preparing their own specific table of methods that shall be used to verify that the safety requirements and measures described in clause 5 are met and that reference is made to the relevant clauses of this standard.

7 Information for use

7.1 Marking

The equipment shall be marked with at least the following information:

a) name and address of the manufacturer;

b) year of construction;

c) designation of series or type;

d) serial number, if any;

e) minimum-maximum fuel rating (consumption) of the equipment;

f) fuel type(s); and

g) fuel calorific value.

This marking may be put directly on the equipment or on a plate attached to the equipment.

7.2 Instruction handbook

7.2.1 General

The manufacturer of the combustion and fuel-handling system shall provide an instruction handbook. This handbook shall deal with a control philosophy of the system, start-up, operation, normal shutdown and emergency shutdown of the system.

7.2.2 Description of equipment

The instruction handbook shall contain at least the following information:

a) a description of the combustion and fuel-handling system, including as-built schematic diagrams of pipework and electrical wiring;

b) a list of all safety and control equipment parts with their settings and an indication of the requirements of relevant standards;

c) a list of equipment settings or adjustments (or both) as made during final commissioning;

d) a description of any deviations from the requirements of relevant standards in the construction or function (or both) of the parts of the combustion and fuel-handling system; and

e) the requirements for handling the waste products of combustion from the IThE.

All the information given on the marking plate(s) shall be repeated together with information relevant to combustion and fuel handling.

7.2.3 Inspection procedures

The instruction handbook shall contain details of inspection intervals and periodic checking procedures for the following:

a) gas leak-tightness tests of the complete system (see 5.2.1.7, 5.3.1.6 and 5.4.1.6);

b) leak-tightness of all pipework. Periodic checking of leak-tightness shall be carried out at intervals to be determined by consideration of the operating conditions, fuel type and construction material;

c) leak-tightness of the IThE and the flue ducts in cases where pressurized combustion is used;

d) all safety equipment, especially automatic burner control systems, warning devices and safety shut-off valves;

e) combustion quality (e.g. temperature or combustion products analysis (or both)), if applicable; and

f) safety functions in order to ensure that these functions are not impaired by concealed faults or errors.

The instruction handbook shall also contain the conditions and checking intervals for automatic burner control system devices for continuously operated burners, including a description of the measures to be taken for corrective action.

A documentation form shall be included in which the date, the results and the person who carried out the checks are recorded together with the date of the next inspection.

7.2.4 Commissioning, start-up and operating procedures

7.2.4.1 The instruction handbook shall provide details of the procedures for commissioning, start-up, including preliminary checks (e.g. to check if pipework is clean), description of conditions, and a list of manually and automatically operated system checks, e.g. opening equipment doors, if applicable.

Attention shall be drawn to the necessity of ensuring that the pipework is free of debris, welding slag, etc.

a) after initial commissioning,

b) before the equipment is put into service,

c) after maintenance, or

d) after long shutdown periods.

7.2.4.2 The instruction handbook shall provide information on special allowances or requirements for

a) pre-purging, e.g. deviation of pre-purge times from standardized conditions in justified cases or waiting time between ignition attempts in the case of natural draught burners;

b) the exhausting of combustion products;

c) the conditions for automatic restart, if applicable;

d) the conditions for, and the number of, permitted recycles; and

e) any special conditions for combustion of solid fuel that concern

1) the safety limits of ignition temperature of the fuel,

2) safety times,

3) the supervision procedure of the heat-up phase, and

4) any other process-related limits.

7.2.5 Shutdown procedures

The instruction handbook shall provide information on any special requirements necessary

a) before the fuel is shut off (e.g. evacuation or combustion of flammable atmospheres),

b) after the fuel is shut off (e.g. continuous venting to avoid overheating or blocking of flue dampers in the open position), and

c) together with a description of measures to be taken in the event of a safety shutdown.

The instruction handbook shall specify any special requirements for lockout or emergency shutdown (or both) and any special measures for a subsequent restart.

An information sheet containing the above information shall be provided for display at the equipment control panel.

7.2.6 Maintenance procedures

The instruction handbook shall contain details of the maintenance intervals and procedures for repair or replacement of items of safety equipment.

It shall specify the acceptable cleaning methods and cleaning agents for the cleaning of oxygen systems (see ASTM G63 ASTM G93 and ASTM G127 or NFPA 53).

Documentation forms with the dates of the last and next maintenance, the addresses, telephone,fax numbers of maintenance and repair services shall be provided.

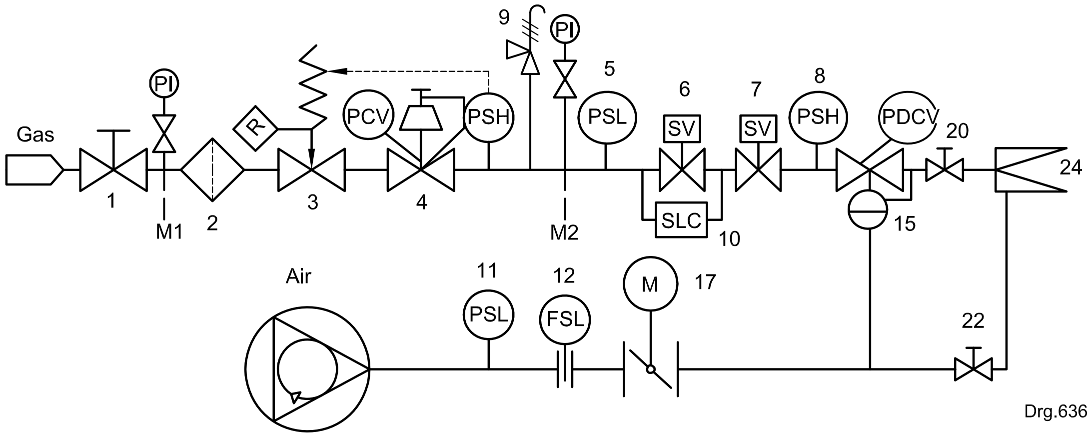
7.2.7 Documentation

Provision shall be made for recording revisions to the instruction handbook in the event of modification of the equipment (e.g. by repair, modernization or replacement of parts and change of operating conditions).

Annex A
(informative)

Typical examples of gas piping diagrams

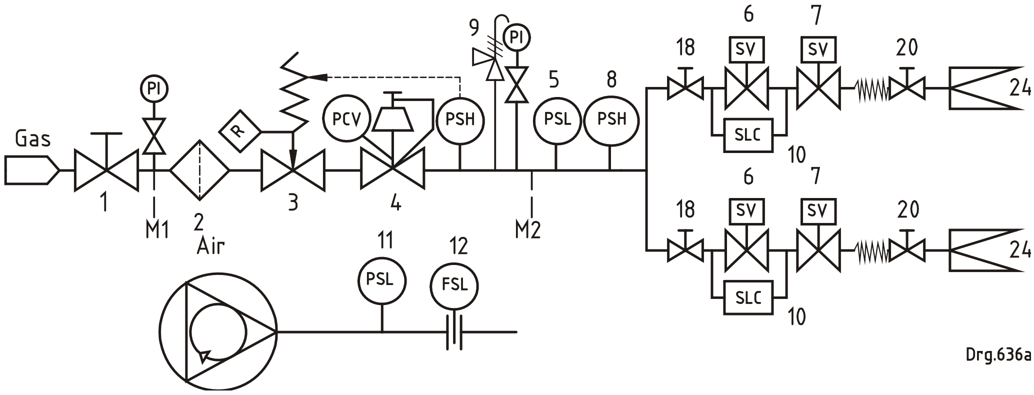
The typical types of gas piping diagrams are illustrated in figures A.1 to A.8.



Key

1	Manual isolating valve
2	Filter/strainer
3	Overpressure cut off device with manual reset (R)
4	Gas pressure regulator
5	Low gas pressure protection min. (PSL)
6	First automatic shut-off valve (SV)
7	Second automatic shut-off valve (SV)
8	High gas pressure protection max. (PSH)
9	Relief valve
10	System leak tightness check/ valve proving system (SLC)
11	Low air pressure protection min. (PSL)
12	Air flow protection max. as needed (FSL)
15	Air:gas ratio control
17	Air flow adjustment for burner
20	Gas flow control valve
22	Air flow adjustment valve for burner
24	Burner
M	Control Motor
M1	Measuring point for inlet pressure
M2	Measuring point for governor/regulator outlet pressure
PCV	Pressure control valve
PDCV	Pressure Difference Control Valve
PI	Pressure indicator
PSH	Pressure switch high
R	Manual reset

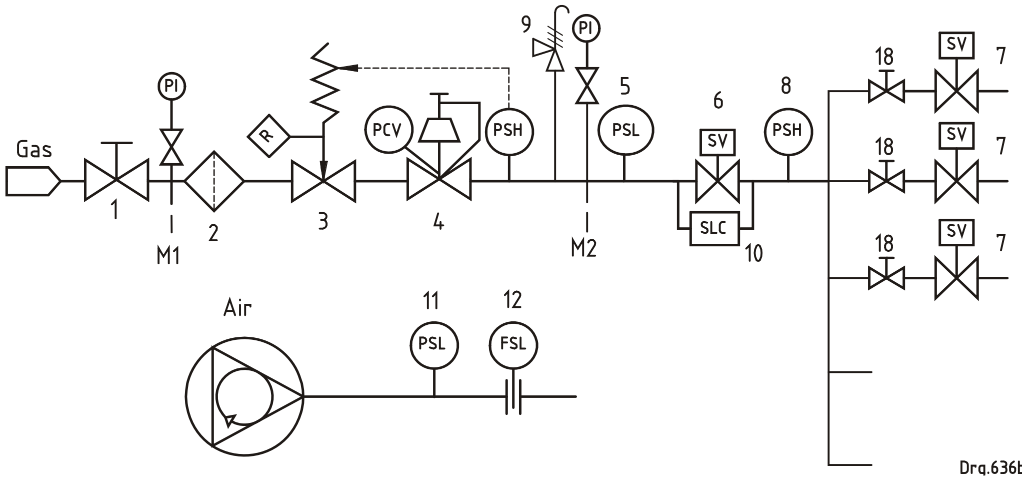
Figure A.1 — Single burner equipment



Key

1 Manual isolating valve
2 Filter/strainer
3 Overpressure cut off device with manual reset (R)
4 Gas pressure regulator
5 Low gas pressure protection min. (PSL)
6 First automatic shut-off valve (SV)
7 Second automatic shut-off valve (SV)
8 High gas pressure protection max. (PSH)
9 Relief valve
10 System leak tightness check/ valve proving system (SLC)
11 Low air pressure protection min. (PSL)
12 Air flow protection max. as needed (FSL)
18 Burner manual shut-off valve
20 Gas flow adjustment valve for burner
24 Burner
M1 Measuring point for inlet pressure
M2 Measuring point for governor/regulator outlet pressure
PCV Pressure control valve
PI Pressure indicator
PSH Pressure switch high
R Manual reset

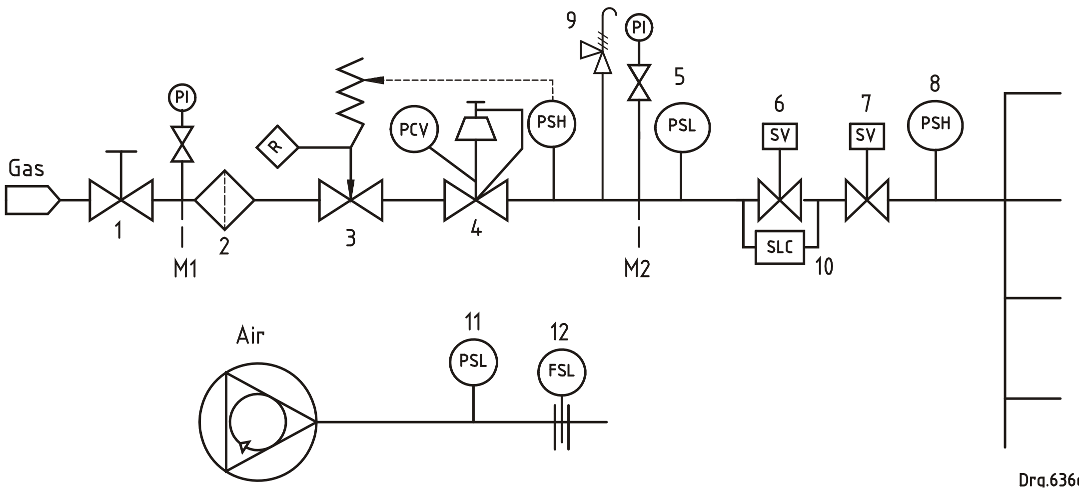
Figure A.2 — Multiple burner equipment — Central piping — Example of a two burner system



Key

1	Manual isolating valve
2	Filter/strainer
3	Overpressure cut off device with manual reset (R)
4	Gas pressure regulator
5	Low gas pressure protection min. (PSL)
6	First automatic shut-off valve (SV)
7	Second automatic shut-off valve (SV)
8	High gas pressure protection max. (PSH)
9	Relief valve
10	System leak tightness check/ valve proving system (SLC)
11	Low air pressure protection min. (PSL)
12	Air flow protection max. as needed (FSL)
18	Burner manual shut-off valve
M1	Measuring point for inlet pressure
M2	Measuring point for governor/regulator outlet pressure
PCV	Pressure control valve
PI	Pressure indicator
PSH	Pressure switch high
R	Manual reset

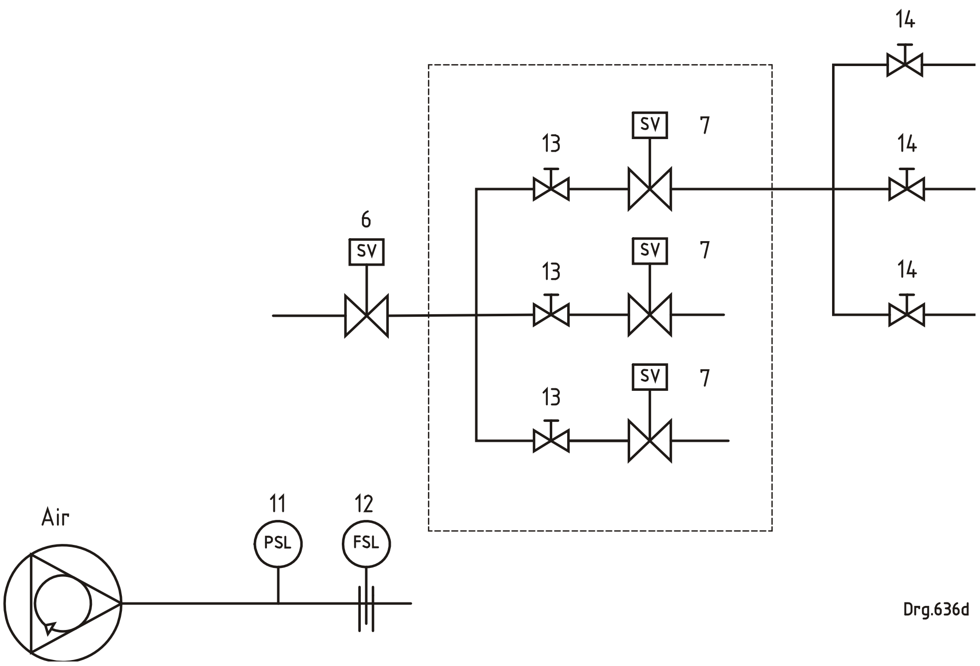
Figure A.3 — Multiple burner equipment — Central piping — Example A



Key

1	Manual isolating valve
2	Filter/strainer
3	Overpressure cut off device with manual reset (R)
4	Gas pressure regulator
5	Low gas pressure protection min. (PSL)
6	First automatic shut-off valve (SV)
7	Second automatic shut-off valve (SV)
8	High gas pressure protection max. (PSH)
9	Relief valve
10	System leak tightness check/ valve proving system (SLC)
11	Low air pressure protection min. (PSL)
12	Air flow protection max. as needed (FSL)
M1	Measuring point for inlet pressure
M2	Measuring point for Governor/regulator outlet pressure
PCV	Pressure control valve
PI	Pressure indicator
PSH	Pressure switch high
R	Manual reset

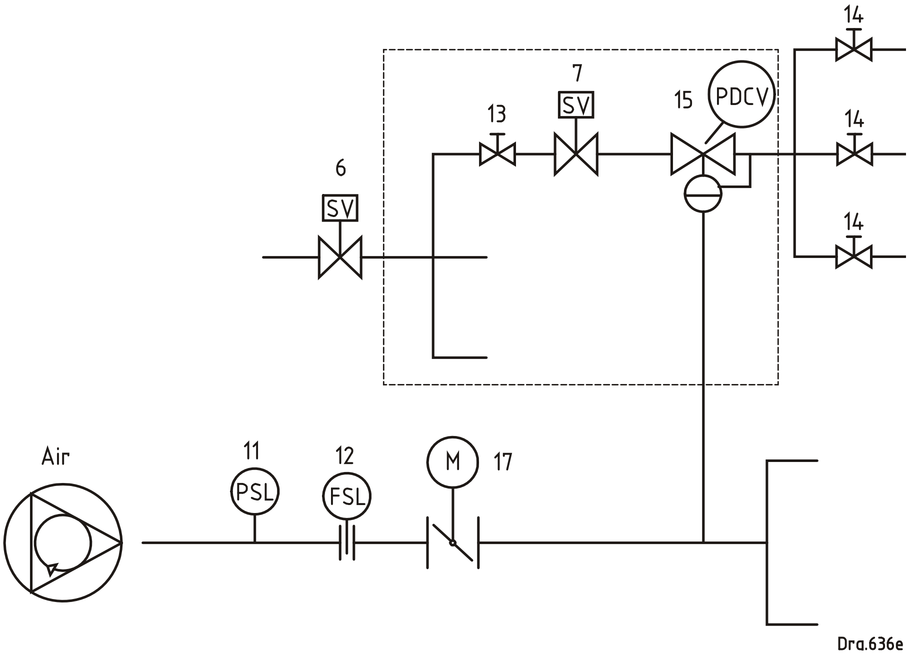
Figure A.4 — Multiple burner equipment — Central piping — Example B



Key

6 First automatic shut-off valve (SV)
7 Second automatic shut-off valve (SV)
11 Low air pressure protection min. (PSL)
12 Air flow protection max. as needed (FSL)
13 Zone isolating valve
14 Burner manual shut-off valve

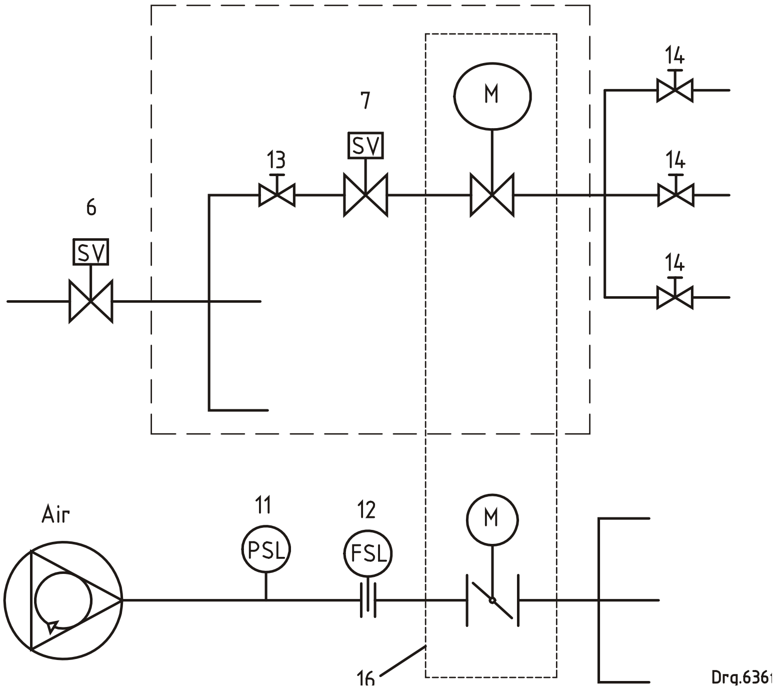
Figure A.5 — Multiple burner equipment — Zone piping — Example A



Key

6	First automatic shut-off valve (SV)
7	Second automatic shut-off valve (SV)
11	Low air pressure protection min. (PSL)
12	Air flow protection max. as needed (FSL)
13	Zone isolating valve
14	Burner manual shut-off valve
15	Air:gas ratiocontrol valve
17	Air control valve
PI	Pressure indicator
PSH	Pressure switch high
R	Manual reset

Figure A.6 — Multiple burner equipment — Zone piping — Example B

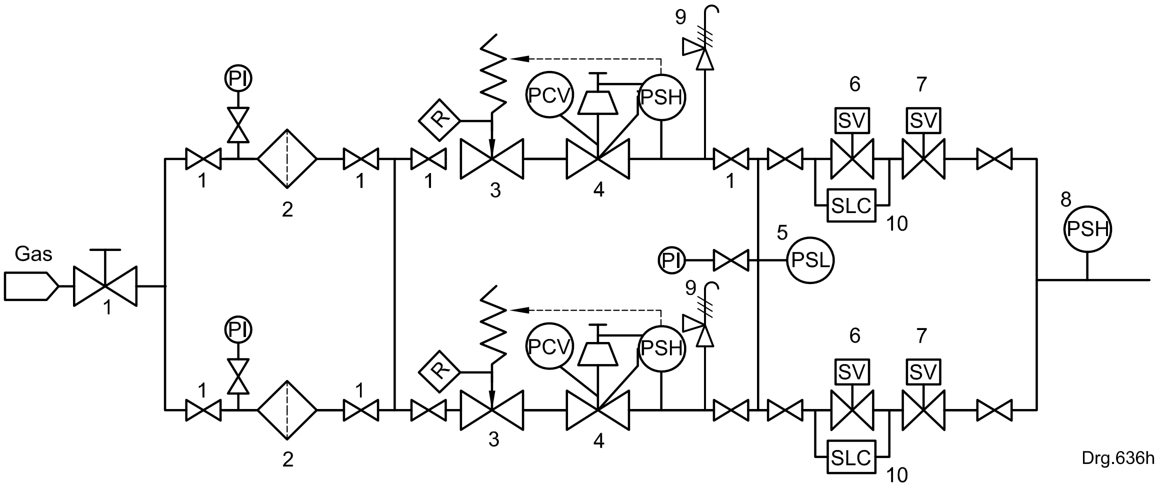


Key

6	First automatic shut-off valve (SV)
7	Second automatic shut-off valve (SV)
11	Low air pressure protection min. (PSL)
12	Air flow protection max. as needed (FSL)
13	Zone isolating valve
14	Burner manual shut-off valve
16	Electronic gas:air ratio control
M	Control Motor
M1	Measuring point for inlet pressure
M2	Measuring point for governor/regulator outlet pressure
PCV	Pressure control valve

Figure A.7 — Multiple burner equipment — Zone piping — Example C

.



Key

1	Manual isolating valve
2	Filter/strainer
3	Overpressure cut off device with manual reset (R)
4	Gas pressure regulator
5	Low gas pressure protection min. (PSL)
6	First automatic shut-off valve (SV)
7	Second automatic shut-off valve (SV)
8	High gas pressure protection max. (PSH)
9	Relief valve
10	System leak tightness check/ valve proving system (SLC)
PCV	Pressure control valve
PI	Pressure indicator
PSH	Pressure switch high
R	Manual reset

Figure A.8 — Central piping for low cycling applications

Annex B
(normative)

Automatic shut-off devices

B.1 Automatic shut-off devices (solid fuel)

The automatic shut-off devices shall shut off the solid fuel supply to the entire equipment or independent zone when a hazardous situations occurs, e.g.

a) insufficient solid fuel supply (in the case of a supply from a metering hopper equipped with low level switches, the automatic shut-off devices may be replaced by an audible or visible warning signal);

b) insufficient combustion airflow;

c) failure of power supply or other utilities (compressed air, steam, transport air, etc.) or a combination of these;

d) failure of heat transfer fluid;

e) fume extraction malfunction;

f) excessive equipment temperature; and

g) combustion chamber temperature dropping below the safe ignition temperature of the fuel that is being fired. This temperature shall be specified in the instruction handbook.

The capacity control devices and the automatic shut-off devices shall be operated through independent circuits and sensing devices.

In the case of a shut-off upon activation of the automatic shut-off device(s), any integral fine-crushing system shall reduce or cease its production.

Where safety shut-off devices are closed as a result of operation of a safety device (lockout), they shall only be re-opened by manual intervention.

Automatic restart after a power failure may be permitted under special circumstances. These special circumstances shall be specified in the instruction handbook.

B.2 Automatic burner control systems (pulverized fuel)

B.2.1 General

The main flame and, if applicable, the ignition burner flame shall be supervised by means of an automatic burner control system. Exceptions shall only be permitted when equipment safety is not compromised (see 5.4.5.2 and 5.4.5.3).

Where the ignition burner and the main burner are each provided with their own flame sensor, the ignition flame shall not influence the response of the main flame sensor.

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

For systems where the pilot burner remains in use during main burner operation, separate flame sensors to supervise the pilot flame and main flame shall be fitted. The main flame sensor shall be so positioned that it cannot in any circumstances detect the pilot flame. Where the pilot burner always ignites the main flame, it is sufficient to supervise only the pilot burner flame, providing the flow rate of that pilot burner is checked by a protective system (e.g. minimum gas pressure switch).

Where a burner is required to fire continuously for periods in excess of 24 h, the automatic burner control system shall be of the self-checking type.

The detection of a flame when there should not be a flame or a defect of the automatic burner control system or the protective system shall result in a lockout.

Where manual checking of the automatic burner control system is carried out, the instruction handbook shall specify the procedures to be followed in the event of a malfunction.

B.2.2 Low temperature equipment

Low temperature equipment shall be fitted with an automatic burner control system.

Only one of the burners need be equipped with an automatic burner control system that operates continuously, provided that the burners

a) guarantee stable combustion throughout the range of regulation,

b) are on the same gas:air ratio control system, and

c) are arranged adjacent and in such a way that, if one of them is extinguished, it is re-ignited quickly and smoothly by the flame from the next burner. This procedure shall not apply to burners controlled by on/off systems.

B.2.3 High temperature equipment

Flame supervision, either by means of an automatic burner control system or by the operator, shall be provided during the start-up period when the processing chamber wall temperature is below 750 °C.

Automatic burner control systems shall not be replaced by operator supervision unless the operator is capable of taking immediate corrective actions during the heat-up phase. The length of this heat-up phase and the supervision procedure shall be specified in the instruction handbook.

Annex C
(normative)

Table C.1 –Verification of the safety requirements and/or measures

1	2	3	4	5	6
Clause	**Safety requirements and/or measures**	**Visual Inspection[a]**	**Func-tionaltest[b]**	**Measuring[c]**	**Examination of drawings / Calculations (Note 4[d])**
5.1	General				
5.2	Gaseous fuels				
5.2.1	Gas reticulation system				
5.2.1.1	Pipework design	X			X
5.2.1.2	Pipework connections	X			X
5.2.1.3	Open-ended pipework	X			X
5.2.1.4	Galvanic cells	X			X
5.2.1.5	Flexible tubing	X			X
5.2.1.6	Marking	X			
5.2.1.7	Testing		X		X
5.2.1.8	Condensate drains	X			X
5.2.1.9	Purge points	X			
5.2.1.10	Blow-off and breather pipes or conduits	X	X		X
5.2.1.11	Explosion relief devices and flame arrestors on pipework	X	X		X
5.2.1.12	Pressure relief devices	X			
5.2.1.13	Pressure oscillations	X			
5.2.1.14	Equipment supplied with different fuel gases	X			X
5.2.1.15	By-passes	X			X
5.2.2	Mandatory devices				
5.2.2.1	General				
5.2.2.2	Manual isolating valves	X	X		X
5.2.2.3	Filter/strainers	X	X		X
5.2.2.4	Automatic shut-off valves				
5.2.2.4.1	General				
5.2.2.4.2	Single burner equipment	X	X		X
5.2.2.4.3	Multiple burner equipment	X	X		X

[a] Visual inspection is carried out in order to test the required characteristics and properties by visual study of the delivered equipment and components.

[b] The functional test shows whether the parts in question function in such a way as to satisfy the relevant requirements.

[c] Measuring instruments are used to verify compliance with the specific limitswhich are set in the requirements.

[d] Drawings and calculations are used to check whether the design characteristics of the components comply with the specificrequirements.

Table C.1 *(Continued)*

1	2	3	4	5	6
Clause	**Safety requirements and/or measures**	**Visual Inspection**[a]	**Functional test**[b]	**Measuring**[c]	**Examination of drawings / calculations Note 4** [d]
5.2.2.4.4	Valve proving system	X	X		X
5.2.2.5	Gas pressure regulators	X	X		X
5.2.2.6	Airflow and gas flow and pressure detectors				
5.2.2.6.1	Airflow	x			x
5.2.2.6.2	Gas flow	x	x		x
5.2.2.6.2.1	Low gas pressure protection		X		X
5.2.2.6.2.2	High gas pressure protection		X		X
5.2.2.7	Flue gas venting		x		x
5.2.2.8	Ignition system	X	x		X
5.2.2.9	Individual manual shut-off valves for multiple burners	X	X		X
5.2.3	Combustion air and pre-purging the combustion chamber and flue passages				
5.2.3.1	Combustion air		X		X
5.2.3.2	Pre-purging of the combustion chamber and flue	X	X		X
5.2.3.3	Air:gas fuel ratio		X		
5.2.4	Supply of pre-mixed fuel gas:airfuel				
5.2.4.1	Mixture pipework	X			X
5.2.4.2	Air and gas supply to the mixture circuit	X	X		X
5.2.5	Burners				
5.2.5.1	Main burners	X			X
5.2.5.3	Radiant tube burners	X	X		X
5.2.5.4	Start-up and ignition				
5.2.5.4.1	Start-up	x			x
5.2.5.4.2	Start fuel flow rate	X	X		X
5.2.5.4.3	Ignition	X	X		X
5.2.5.4.4	Safety times				
5.2.5.4.4.1	General	X	X		X

[a] Visual inspection is carried out in order to test the required characteristics and properties by visual study of the delivered equipment and components.

[b] The functional test shows whether the parts in question function in such a way as to satisfy the relevant requirements.

[c] Measuring instruments are used to verify compliance withthe specific limits which are set in the requirements .

[d] Drawings and calculations are used to check whether the design characteristics of the components comply withthe specific requirements.

Table C.1 *(Continued)*

1	2	3	4	5	6
Clause	**Safety requirements and/or measures**	**Visual inspection**[a]	**Functional test**[b]	**Measuring**[c]	**Examination of drawings / Calculations Note 4**[d]
5.2.5.4.4.2	Maximum safety times for natural draught burners	X	X		X
5.2.5.4.4.3	Maximum safety times for forced and induced draught burners	X	X		X
5.2.5.4.5	Flame failure				
5.2.5.4.5.1	Flame failure on start-up	X	X		X
5.2.5.4.5.2	Flame failure during operation		X		
5.2.5.5	Burner capacity control	X			X
5.2.6	Automatic burner control systems				
5.2.6.1	General	X			X
5.2.6.2	Low temperature equipment	X			X
5.2.6.3	High temperature equipment	X			X
5.2.6.4	Automatic burner control systems for burners that are used out-of-doors	X			X
5.3	Liquid fuels				
5.3.1	Liquid fuel distribution system				
5.3.1.1	Pipework design	X			X
5.3.1.2	Connections	X			X
5.3.1.3	Unconnected pipework	X			X
5.3.1.4	Flexible tubing and couplings	X			X
5.3.1.5	Marking	X			X
5.3.1.6	Soundness / tightness(testing)	X			X
5.3.1.7	Fuel pipe heating	X			X
5.3.1.8	By-passes	X			X
5.3.1.9	Purge points	X			
5.3.1.10	Equipment supplied with different liquid fuels	X			X
5.3.2	Mandatory devices				
5.3.2.1	Manual isolating valves	X			X

[a] Visual inspection is carried in order to test the required characteristics and properties by visual study of the delivered equipment and components.

[b] The functional test shows whether the parts in question function in such a way as to satisfy the relevant requirements.

[c] Measuring instruments are used to verify compliance with he specific limits which are set in the requirements

[d] Drawings and calculations are used to check whether the design characteristics of the components comply with the specific requirements.

Table C.1 *(Continued)*

1	2	3	4	5	6
Clause	**Safety requirements and/or measures**	**Visual Inspection[a]**	**Functional test[b]**	**Measuring[c]**	**Examination of drawings / calculations Note 4[d]**
5.3.2.2	Automatic shut-off valves	X	X		X
5.3.2.3	Pressure relief valves	X			X
5.3.2.4	Liquid fuel pressure regulators	X			X
5.3.2.5	Pressure regulation of auxiliary fluids	X			X
5.3.2.6	Combustion air, liquid fuel, atomizing and control fluid flow and pressure detectors	x			x
5.3.2.7	Individual manual shut-off valves for multiple burners	X			X
5.3.2.8	Automatic shut-off valves for multiple burners	X			X
5.3.2.9	Flue gas venting	X			X
5.3.2.10	Ignition system	X			X
5.3.3	Combustion air and pre-purging the combustion chamber and the flue passages				
5.3.3.1	Combustion air system	X			X
5.3.3.2	Pre-purging of the combustion chamber and flue passages	X	X		X
5.3.3.3	Air:liquid fuel ratio	X			
5.3.4	Liquid fuel atomisation	X	X		
5.3.5	Burners				
5.3.5.1	Main burners				
5.3.5.2	Start-up and ignition				
5.3.5.2.1	Start-up	X			
5.3.5.2.2	Start fuel flow rate	X	X		X
5.3.5.2.3	Ignition	X	X		X
5.3.5.2.4	Safety times				
5.3.5.2.4.1	General	X	X	X	X
5.3.5.2.4.2	Maximum safety times	X	X	X	X
5.3.5.2.5	Flame failure				
5.3.5.2.5.1	Flame failure on start-up	X			X

[a] Visual inspection is carried out in order to test the required characteristics and properties by visual study of the delivered equipment and components.

[b] The functional test shows whether the parts in question function in such a way as to satisfy the requirements.

[c] Measuring instruments are used to verify compliance with the specific limits which are set in the requirements.

[d] Drawings and calculations are used t co check whether the design characteristics of the components comply with the specific requirements.

Table C.1 *(Concluded)*

1	2	3	4	5	6
Clause	**Safety requirements and/or measures**	**Visual Inspection**[a]	**Func-tional test**[b]	**Mea-suring**[c]	**Examination of drawings / calculations Note 4**
5.3.5.2.5.2	Flame failure during operation	X			X
5.3.5.3	Burner capacity control	X			X
5.3.5.4	Permanent pilot burners	X			X
5.3.6	Automatic burner control systems				
5.3.6.1	General	X			X
5.3.6.2	Low temperature equipment	X			X
5.3.6.3	High temperature equipment	X			X
5.5	Multiple fuels				
5.5.1	General	X			
5.5.2	Fuel circuit	X			
5.5.3	Combustion air supplies	X			
5.5.4	Operation of the safety devices	X			
5.5.5	Air/fuel ratio	X			
5.6	Oxygen or oxygen-enriched combustion air				
5.6.1	General	X			X
5.6.2	Suitability for oxygen service	X			X
5.6.3	Sealing materials for oxygen distribution systems	X			X
5.6.4	Pipework	X			X
5.6.5	Gas velocities in pipes	X			X
5.6.6	Devices	X			X
5.6.7	Blow off and venting lines	X			
5.6.8	Manual torches	X			X
5.6.9	Safety devices against gas backflow	X			X
5.6.10	Safety devices against oxygen backflow in mixture with other substances	X			X

[a] Visual inspection is carried out in order to test the required characteristics and properties by visual study of the delivered equipment and components.

[b] The functional test shows whether the parts in question function in such a way as to satisfy the requirements.

[c] Measuring instruments are used to verify compliance withthe specific limits which are set in the requirements t.

[d] Drawings and calculations are used to check whether the design characteristics of the components comply with the specific requirements.

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