INTERNATIONAL STANDARD

ISO 23551-4

Second edition
2018-04

Safety and control devices for gas burners and gas-burning appliances — Particular requirements —

Part 4: Valve-proving systems for automatic shut-off valves

Dispositifs de contrôle et de sécurité pour les brûleurs à gaz et pour les appareils utilisant le gaz — Exigences particulières —

Partie 4: Systèmes de contrôle d'étanchéité pour robinets automatiques de sectionnement

Reference number
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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 161, *Controls and protective devices for gas and/or oil.*

This second edition cancels and replaces the first edition (ISO 23551-4:2005), which has been technically revised. The main changes compared to the previous edition are as follows:

— alignment to the structure of ISO 23550:2018;

— inclusion of updated references to IEC 60730-1:2013+AMD1:2015;

— inclusion of requirements for “faults during lockout or safety shutdown”;

— inclusion of software and hardware design requirements;

— inclusion of requirements for reset devices;

— updated EMC immunity requirements.

Introduction

This document is designed to be used in combination with ISO 23550. Together with ISO 23550, this document establishes the full requirements for valve-proving systems for automatic shut-off valves. Where needed, this document adapts ISO 23550 by stating in the corresponding clause:

— "with the following modification";

— "with the following addition";

— "is replaced by the following"; or

— "is not applicable".

In order to identify specific requirements that are particular to this document, that are not already covered by ISO 23550, this document may contain clauses or subclauses that are additional to the structure of ISO 23550. These subclauses are indicated by the introductory sentence: "Subclause (or Annex) specific to this document.".

To ensure global relevance of this document, the differing requirements resulting from practical experience and installation practices in various regions of the world have been taken into account. The variations in basic infrastructure associated with gas and/or oil controls and appliances have also been recognized, some of which are addressed in Annexes F, G and H. This document intends to provide a basic framework of requirements that recognize these differences.

Safety and control devices for gas burners and gas-burning appliances — Particular requirements —

Part 4:
Valve-proving systems for automatic shut-off valves

1 Scope

This document specifies safety, constructional and performance requirements of valve-proving systems (VPS), intended for use with gas burners and gas-burning appliances. It also describes the test procedures for checking compliance with these requirements and provides information necessary for the purchaser and user.

This document is applicable to all types of VPS which are used for the automatic detection of leakage in a gas burner section having at least two valves designed in accordance with ISO 23551-1 and which give a signal if the leakage of one of the valves exceeds the detection limit.

This document is applicable to VPS with a maximum working pressure up to and including 500 kPa for use in systems using fuel gases.

This document is not applicable to VPSs for use in explosive atmospheres.

NOTE Provisions for production control are not part of the ISO 23551 series.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60730-1:2013+AMD1:2015, *Automatic electrical controls — Part 1: General requirements*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23550 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
valve proving system
VPS
system to check the closure of automatic shut-off valves by detecting leakage, that often consists of a programming unit, a measuring device, valves and other functional assemblies

3.2
detecting device
device for direct or inferential detection of leakage, i.e. by measuring flow or pressure

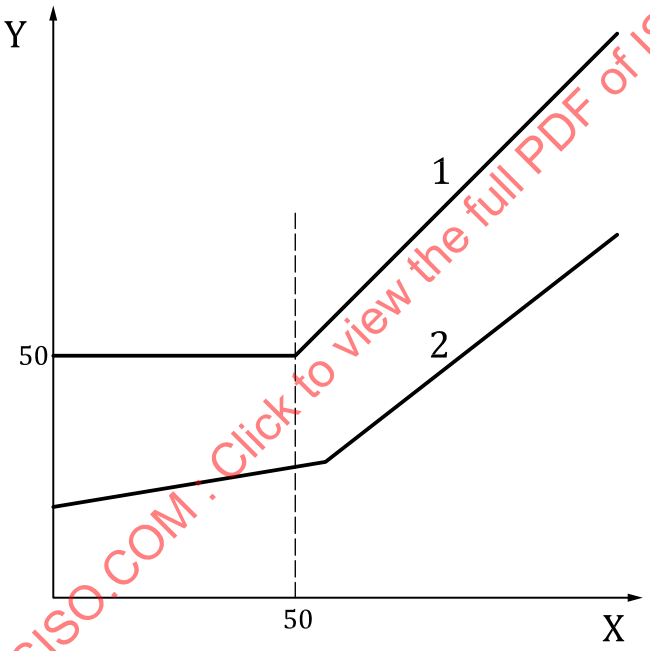
3.3
VPS operational time
time taken by the VPS to perform its entire cycle of operation

3.4
detection limit
maximum amount of leakage that can occur before the VPS is required to give a signal

Note 1 to entry: See Figure 1.

3.5
detection setting
actual leakage rate at which the VPS gives a signal

Note 1 to entry: See Figure 1.



Key

X burner heat, gas flow, expressed in m^3/h
Y detected leakage rate, expressed in dm^3/h
1 detection limit, 3.4
2 detection setting, see 3.5

Figure 1 — Illustration of detection limit and detection setting

3.6
leakage testing time
time in which the VPS monitors a gas valve for leakage

3.7
safety shut-down
process which is effected immediately following the detection of a leakage exceeding the detection limit, or detection of an internal fault, disabling energization of the ignition and of the automatic shut-off valves

3.8
volatile lock-out
safety shut-down condition of the system where a restart can only be accomplished by either the manual reset of the system, or an interruption of the main power and its subsequent restoration

3.9
non-volatile lock-out
safety shut-down condition of the system, where a restart can only be accomplished by the manual reset of the system and by no other means

4 Classification

4.1 Classes of control

Shall be according ISO 23550:2018, 4.1.

4.2 Groups of controls

Shall be according ISO 23550:2018, 4.2.

4.3 Types of DC supplied controls

Shall be according ISO 23550:2018, 4.3.

4.4 Classes of control functions

Shall be according ISO 23550:2018, 4.4 with the following addition:

VPS is a class C control function.

5 Test conditions and tolerances

Shall be according ISO 23550:2018, Clause 5.

6 Construction

6.1 General

Shall be according to ISO 23550:2018, 6.1 with the following addition.

The VPS shall be designed such that changes in critical circuit component values (such as those affecting timing or sequence) within the component manufacturer's declared worst case tolerances, including the long-term stability, shall result in the system continuing to function in accordance with this document. Compliance shall be checked by worst-case analysis.

The construction of any additional functions included in the VPS for which no provisions exist in this document shall be such that they do not degrade the safe and correct operation.

Where components are used to complete the VPS, these components shall comply with the relevant component International Standard.

6.2 Construction requirements

Shall be according to ISO 23550:2018, 6.2.

6.3 Materials

Shall be according to ISO 23550:2018, 6.3.

6.4 Gas connections

Shall be according to ISO 23550:2018, 6.4.

6.5 Gas controls employing electrical components in the gas way

Shall be according to ISO 23550:2018, 6.5.

6.6 Electronic parts of the control

Subclause specific to this document.

Shall be according to IEC 60730-1:2013/AMD1:2015.

6.7 Additional constructional requirements for VPS systems

Subclause specific to this document.

6.7.1 Signal for indication

A signal for indication, e.g. optical indication, shall be given when the leakage exceeds the detection limit.

6.7.2 VPS setting

The setting of a detecting device shall require the use of tools. If the VPS is adjustable, the installation and operating instructions shall provide information for this setting, e.g. detection setting.

7 Performance

7.1 General

Shall be according to ISO 23550:2018, 7.1 with the following addition:

Where components are used to complete the VPS, these components shall comply with the relevant component International Standard.

7.2 Leak tightness

7.2.1 General

Shall be according to ISO 23550:2018, 7.2.1.

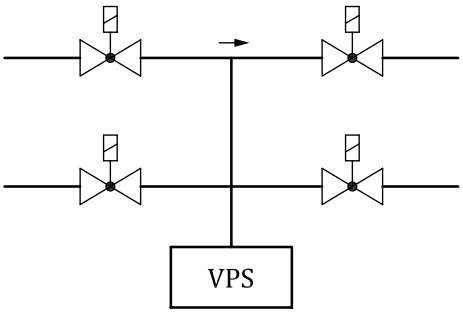
7.2.2 Requirements

Shall be according to ISO 23550:2018, 7.2.2 with the following modification.

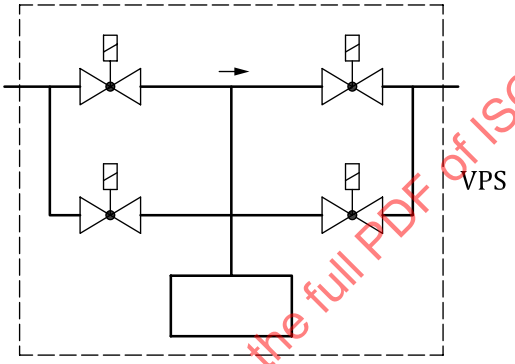
The external leak-tightness requirements are replaced by the following:

A VPS according to Figure 2 a) is considered to be externally leak tight, if no single component of a VPS has an external leakage rate higher than 60 $cm^3 \times h^{-1}$.

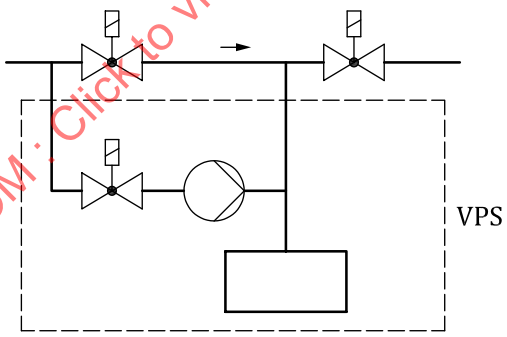
A VPS with integrated or partly integrated actuators (e.g. valves, pumps), according to Figure 2 b) and c) is considered to be a single component and shall have an external leakage rate not higher than 120 $cm^3 \cdot h^{-1}$.



a) External valves supervised by a VPS



b) VPS with integrated valves



c) VPS with partly integrated valves

Figure 2 — Examples of VPS configurations

7.2.3 Test

Shall be according to ISO 23550:2018, 7.2.3.

7.3 Torsion and bending

Shall be according to ISO 23550:2018, 7.3.

7.4 Rated flow rate

Shall be according to ISO 23550:2018, 7.4.

7.5 Durability

Shall be according to ISO 23550:2018, 7.5.

7.6 Functional requirements

Shall be according to ISO 23550:2018, 7.6 with the following addition.

NOTE Specific regional requirements are given in G.2.3.

7.6.1 Manufacturer information

The manufacturer shall declare the maximum detection limit, programme sequence and any other relevant information. The VPS shall be capable of meeting the functional tests detailed in 7.6.2 to 7.6.5.

7.6.2 Detection limit

The VPS shall prevent ignition and the opening of the burner valves at a leakage-rate limit depending on the burner heat input, starting over 50 dm^3/h and up to a minimum value of 0,1 % of the burner heat input.

Conformity is checked by measuring the actual or inferred detection limit at three values; at 50 dm^3/h, at the maximum value and at the midpoint and/or the minimum value declared by the manufacturer.

7.6.3 Programme sequence

The VPS programme sequence shall allow the gas valves to open when detection limit is at or below the manufacturers declared value, or the maximum specified in 7.6.2.

The VPS programme sequence shall prevent the gas valves to open when detection limit exceeds the manufacturers declared value, or the maximum specified in 7.6.2 followed by a lock-out.

The lock-out may be executed on the system application directly or by the VPS itself. An automatic start-up attempt by a separate control function shall not override the lock-out conditions.

Any gas necessary for the operation of the VPS may be discharged into the combustion chamber during the programme sequence if the maximum release volume, expressed in volume per switching sequence, does not exceed 0,083 % of the burner heat input referred to the nominal volume flow, expressed in cubic metres per hour.

NOTE 0,083 % is based on the quantity within 3 s.

However, when the VPS is used as an alternative for pre-purge or post-purge, the discharge of the gas necessary for the operation of the VPS into the combustion chamber shall not be allowed. The gas shall be safely vented.

If the actuating energy in the safety circuit fails, the VPS shall close the main gas valves and any ignition gas valve or give a shut-down signal to the automatic gas-burner control system.

7.6.4 Timing

The leakage testing time and the pressure pump time shall be declared by the manufacturer.

Adjustment of safety critical timing is permitted but shall be possible only by means of tools.

Where these times can be adjusted using an existing scale on the component, the scale shall be accurate to ±10 % of the indicated value. The means of adjustment shall be readily identifiable (e.g. colour-coded).

Shortening of leakage testing time, causing conflict with these requirements, shall not be allowed due to internal failures such as wear and tear, drop in accuracy of adjustments and similar causes.

Leakage testing time shall not be less than the value declared by the manufacturer.

Lengthening of valve energization time or pumping time, causing conflict with these requirements shall not be allowed due to internal failures such as wear and tear, drop in accuracy of adjustments and similar causes.

During the programme sequence, the valve shall not be energized longer than 3 s. Bypass-valves may be energized longer than 3 s, as long as the limit of 0,083 % (see 7.6.2) is not exceeded.

Pressure pump time shall not be greater than the time declared by the manufacturer.

The response time to achieve safety shut down shall not exceed 1 s after a functional failure has been detected.

The reaction time to achieve volatile lock-out or non-volatile lock-out, whenever required, shall be in accordance with the application standard. However, this time shall be achieved within 30 s of the safety shut-down.

The VPS operational time shall not change by more than ±50 % under test conditions specified in Clause 5.

7.6.5 Test of the programme sequence and timing

The test is performed on one VPS. The VPS is tested in a suitable testing unit.

With the VPS in the delivered state, the entire program sequence (7.6.2 and 7.6.3) of the VPS is started at the rated voltage and at ambient temperature.

The programme sequence shall be tested over the voltage and temperature ranges in accordance with Clause 5.

If appropriate, the programme sequence of the VPS shall be assessed with the automatic burner control system.

7.6.6 Self-checking

The VPS shall have an automatic internal self-checking function for each cycle. Where gas pressure switches are used, the contact position shall be checked. If internal faults simulate a correct function, the signal for ignition and the opening of the valves (see 8.5) shall not be given.

7.6.7 Lock-out function

A lock-out may be executed at a system-application level or by the VPS itself.

The lock-out function shall be checked for correct operation during each start-up sequence.

A lock-out caused by the VPS can be either a non-volatile or a volatile lock-out action (depending on the requirements of the application standard).

The capability of the valve proving system to store the non-volatile lock-out status shall be checked at least during each main power restoration.

The failure modes as described in IEC 60730-1:2013+AMD1:2015, Table H24 shall be taken into consideration during the analysis of the electronic circuit.

In case of a mechanical actuator, a test sequence up to the point at which switching contacts close or open is sufficient.

If the test of the lockout function fails, the system shall proceed to safety shut down.

NOTE Internal faults on components of the checking circuit are not considered.

7.6.8 Mains power interruption

Interruption of the mains supply and its restoration shall not affect the safety of the programme sequence. If mains interruption and its restoration result in automatic recycling and overriding of any interlock, the VPS shall restart from the beginning of the programme sequence.

7.7 Endurance

Shall be according ISO 23550:2018, 7.7 with the following addition.

7.7.1 General

All components of the control shall be able to withstand the tests as detailed in 7.7.2.1 and 7.7.2.2. If the control function is an integral part of an apparatus the long-term performance tests can be combined. The tests of 7.7.2.1 and 7.7.2.2 shall not be carried out on the same test sample.

In the case of the control not having a clear operating cycle, the long-term performance test shall be carried out for the minimum specified amount of time.

7.7.2 Stress test

7.7.2.1 Thermal stress test

The thermal stress test shall be carried out with the terminals loaded with the loads and power factors as declared by the manufacturer.

The purpose of the test is to expose the electronic components of the control to temperature cycles between limits likely to be reached in normal use owing to fluctuations in ambient temperature, temperature variations in the component itself, power supply fluctuation and temperature changes like from standby to operation and vice versa.

The control shall be tested as listed below:

a) 14 days at the following electrical and thermal conditions and rate of operation:

   1) Electrical conditions: The system is loaded according to the ratings declared by the manufacturer, the voltage then being increased to 110 % of maximum declared rated voltage except that for 30 min during each 24 h period of the test the voltage is reduced to 90 % of minimum declared rated voltage. The change of voltage shall not be synchronized with the change of temperature. Each 24 h period shall also include at least one period in the order of 30 s during which the supply voltage is switched off.

   2) Thermal conditions: The ambient temperature and/or the mounting surface temperature are varied between the maximum declared ambient temperature or 55 °C, whichever is higher, and the minimum declared ambient temperature or 0 °C, whichever is lower, to cause the temperature of the components of the electronic circuit to be cycled between the resulting extremes. The rate of ambient and/or mounting surface temperature change shall be in the order of 1 °K/min and the extremes of temperature maintained for approximately 1 h.Care should be taken to avoid the occurrence of condensation during this test.

   3) Rate of operation: During the test the control shall be cycled through all of its normal operational modes (e.g. stand-by, start-up, running) up to a maximum of 6 cycles per minute. The number of cycles completed during this test shall be recorded and if this number is less than 45 000 the remaining cycles shall be executed at the declared rated voltage and at ambient temperature.

b) 2 500 cycles performed, but at least 24 h through all of its normal operational modes (e.g. stand-by, start-up, running) at the maximum declared ambient temperature or 55 °C whichever is higher, and at 110 % of the maximum declared rated voltage.

c) 2 500 cycles performed, but at least 24 h through all of its normal operational modes (e.g. stand-by, start-up, running) at the minimum declared ambient temperature or 0 °C whichever is lower, and at 85 % of the minimum declared rated voltage.

d) If a control is provided with a safety relevant function that on the basis of a sensor or switch is able to initiate a safety action, 5 000 cycles of such safety actions or the number as specified in the specific control standard shall be performed for each safety relevant function individually at the ambient temperature and nominal rated voltage, by simulating the sensor or switch to initiate such safety action.

Where possible the testing of the safety relevant functions may be combined.

During the tests a), b), c) and d) as described above, the system shall be operated in such a way that the normal start-up sequence is performed. The time that the system is held in the running position and the time that the control loop is interrupted before the cycle is repeated shall be agreed between the manufacturer and the test authority.

By agreement between the manufacturer and the test authority any safety relevant times used during the above tests may be chosen to be as short as practicable so that the thermal stress test is not unnecessarily prolonged.

On completion of the thermal stress test, the test of 7.9.1 shall be repeated at rated voltage only.

NOTE Specific regional requirements are given in G.2.4.

7.7.2.2 Long-term performance test

The manufacturer shall declare that the control has completed the required duration as specified in the specific control standard or a minimum of 250 000 cycles performed through all of its normal operational modes (e.g. stand-by, start-up, running), with the terminals loaded with the loads and power factors as declared, without failure.

The control shall have been tested under the following conditions:

a) 90 % of the total number of cycles or duration of time shall be performed at the declared rated voltage and at ambient temperature.

b) 5 % of the total number of cycles or duration of time shall be performed at the maximum declared ambient temperature or 55 °C, whichever is higher, and at 110 % of the maximum declared rated voltage.

c) 5 % of the total number of cycles or duration of time shall be performed at the minimum declared ambient temperature or 0 °C, whichever is lower, and at 85 % of the minimum declared rated voltage.

On completion of this test, the test sample shall still comply with IEC 60730-1:2013+AMD1:2015, 13.2.2 to 13.2.4.

7.8 Vibration test

Shall be according to ISO 23550:2018, 7.8.

7.9 Performance tests for electronic controls

Subclause specific to this document.

7.9.1 At ambient temperature

The safety related functions (e.g. switching times and sequence of a complete programme) shall be measured in the delivered state. The system is connected and installed according to the manufacturer's instructions.

These tests shall be performed under test conditions (see Clause 5):

— at the manufacturer's declared rated voltage(s), or if this is a range, at the lowest and highest rated voltages;

— at 85 % of the lowest declared rated voltage;

— at 110 % of the highest declared rated voltage.

The results of the above measured safety related functions shall comply with the specific control standard.

7.9.2 At low temperature

The tests according to 7.9.1 shall be repeated at 0 °C or at the lowest declared ambient temperature where this is lower than 0 °C.

7.9.3 At high temperature

The tests according to 7.9.1 shall be repeated at 55 °C or at the highest declared ambient temperature where this is higher than 55 °C.

8 Electrical equipment

8.1 General

Shall be according to ISO 23550:2018, 8.1.

8.2 Requirements

Shall be according to ISO 23550:2018, 8.2.

8.3 Test

Shall be according to ISO 23550:2018, 8.3.

8.4 Protection by enclosure

Shall be according to ISO 23550:2018, 8.4.

8.5 Protection against internal faults for the purpose of functional safety

Subclause specific to this document.

8.5.1 Design and construction requirements

8.5.1.1 Fault avoidance and fault tolerance

8.5.1.1.1 General

Controls shall be designed in accordance with 6.7 (taking into account the failure modes described in IEC 60730-1:2013+AMD1:2015, Table H24) and in accordance with IEC 60730-1:2013+AMD1:2015, Annex H.11.12 for complex electronics being assemblies which use electronic components with the following characteristics:

a) The component provides more than one functional output.

b) It is impractical or impossible to represent the failure mode of such a component by stuck-at and cross-links at the pins or by other failure modes which are described in IEC 60730-1:2013+AMD1:2015, Table H24.

Components shall be dimensioned on the basis of the worst-case conditions which can arise in the control.

When making assessment, it should be considered that a component failure can cause a degradation of safety critical insulation.

Failures of complex electronics can be caused by either systematic errors (built into the design) or by random faults (component faults). Therefore, the control shall be designed in such a way that systematic errors are avoided and random faults shall be dealt with by a proper design.

8.5.1.1.2 Design

The design of the software and hardware shall be based on the functional analysis of the application resulting in a structured design explicitly incorporating the control flow, data flow and time related functions required by the application. In the case of custom-chips special attention is required with regard to measures taken to minimize systematic errors.

The result shall be a design configuration which is either inherently fail safe or in which components with direct safety-critical functions (e.g. shut-off valve drivers, microprocessors with their associated circuits, etc.) are guarded by safeguards (in accordance to IEC 60730-1:2013+AMD1:2015, Annex H, Software Class B or C). These safeguards shall be built into hardware (e.g. watch-dog, supply voltage supervision) and can be supplemented by software (e.g. ROM-test, RAM-test, etc.). It is important that these safeguards can cause a completely independent safety shutdown. Reaction times of these safeguards shall be equal or smaller than the relevant fault tolerating time.

If time slot monitoring is used, it shall be sensitive to both an upper and a lower limit of the time interval. Faults resulting in shift of the upper and/or lower limit shall be taken into account.

In case of a control that is classified as Class C, if a single fault in a primary safeguard can render the safeguard inoperative, a secondary safeguard shall be provided. The reaction time of the secondary safeguard shall be in accordance with 8.5.4.

NOTE The secondary safeguard can be realized by:

a) physically separate circuit monitoring the primary safeguard; or

b) mutual action between the circuit being safeguarded and the primary safeguard (e.g. a watch-dog guarded by the microprocessor); or

c) action between primary safeguards (e.g. a ROM-test guarding a RAM-test).

For lock-out function with a mechanical actuator a test up to, but not including the switching contacts, is sufficient. If the test of the lock-out function fails, the system shall proceed to safety shut-down.

Frequency of test is given in the specific control standard. Internal faults on components of the checking circuit are not considered.

Components shall be dimensioned on the basis of the worst-case conditions which can arise in the control, as stated by the manufacturer.

When making assessment, it should be considered that a component failure could cause a degradation of safety critical insulation.

8.5.1.2 Reset device

The control shall be so constructed that a restart attempt following non-volatile lock-out shall only be possible following a manual reset, e.g. with an integrally or remotely mounted reset button.

Misuse or tampering with the reset device, whether integrally or remotely mounted (e.g. continuous pressing of the manual reset button or an internal fault of the reset device) or shorting of the connecting cables to the reset device, or between the connecting cables and earth, shall not cause the control to operate outside the requirements of this standard or prevent it from going to shutdown or lock-out.

For remote reset functions, IEC 60730-1:2013+AMD1:2015, Annex H11.12.4.3 applies.

8.5.1.3 Documentation

The functional analysis of the control and the safety related programme under its control shall be documented in a clear hierarchical way in accordance with the safety concept and the programme requirements.

As a minimum the following documentation shall be provided with any system submitted for assessment:

a) description of the system concept, the control flow, data flow and timings;

b) clear description of the safety concept of the system with all safeguards and safety functions clearly indicated. Sufficient design information shall be provided to enable the safety functions or safeguards to be assessed;

c) documentation for any software within the system.

A documentation of design programming shall be supplied in a programming language declared by the manufacturer.

Safety related data and safety related segments of the operating sequence shall be identified and classified according to IEC 60730-1:2013+AMD1:2015, Annex H.

There shall be a clear relationship between the various parts of the documentation, for example the interconnections of process, hardware and the labelling used in software documentation.

If a manufacturer provides documentation of the analytical measures taken during the development stage of the hardware and software, this documentation shall be used by the test authority as part of the assessment procedure.

8.5.2 Class A

IEC 60730-1+AMD1:2015, Annex H, Software Class A is not applicable.

8.5.3 Class B

IEC 60730-1+AMD1:2015, Annex H, Software Class B is not applicable.

8.5.4 Class C

8.5.4.1 Design and construction requirements

A Class C control function shall be designed such that under first and second fault conditions it remains in or proceeds to the defined state. A third independent fault is not considered.

Software shall conform to software class according to IEC 60730-1:2013+AMD1:2015,Annex H.

At least the following states are defined as unsafe states:

a) if during burner shut-down, the gas flow through a valve or by-passing valve is higher than the detection limit value of that valve except for the function of the VPS;

b) if a test for leakage is outside the limits defined in 3.4 or 3.5;

c) overriding the VPS sequence control of the safety shut-off valves by the burner control unit, except for the normal function of the VPS;

d) preventing the VPS from going to a defined fault response.

VPS or safety-related (hardware) parts of the VPS that are not powered during the stand-by and the running state of the appliance shall execute all relevant internal tests during powering-up of the VPS. Once the VPS is operational, the required internal test to detect the first faults leading to one of the unsafe states as mentioned in above shall be executed every 3 s.

For this type of VPS system, the second fault shall only be considered to occur when a start-up sequence has been performed between the first and the second fault.

VPS systems that are powered during stand-by or running state of the appliance shall comply with the following:

— reaction time to detect the first faults leading to one of the unsafe states as mentioned in above are ≤3 s;

— reaction time to detect second independent fault ≤24 h.

The VPS shall be fail-safe. Systems which meet these requirements and, if applicable, those in 8.5.1.1, are considered to be inherently fail-safe.

The circuitry and the construction of the system shall be such that they meet the requirements of 7.9 and shall be appraised according to the requirements to 8.5.4.2, 8.5.4.3 and 8.5.4.4 and under the test conditions and criteria of 8.5.5.

Components shall be dimensioned on the basis of the worst-case conditions which can arise in the system, as stated within the design documentation.

8.5.4.2 First fault

Any first fault (see IEC 60730-1:2013+AMD1:2015, Table H24) in any one component or any one fault together with any other fault arising from that first fault shall result in either:

a) the VPS becoming inoperative with all valve terminals de-energized;

b) the system proceeding to safety shut-down within 3 s followed by a non-volatile or volatile lock-out. The lock-out may be executed by the VPS, or by another control within the appliance preventing the burner start up. During subsequent reset action, the VPS shall not operate any valves or the pressurizing pump belonging to the valve. Subsequent reset from the lock-out condition under the same fault condition results in the VPS returning to the volatile or non-volatile lock-out condition; continue with fault assessment during lock-out or safety shut-down according to 8.5.4.4.3;

c) the VPS continuing to operate, the fault being identified during the next start-up sequence, the result being a) or b);

d) the VPS remaining operational in accordance with all the other requirements of this document (see 7.9).

For VPS designed for use on non-permanent operating appliances, c) is applicable. However, c) is not applicable for VPS designed for use on permanent operating appliances.

8.5.4.3 Second fault

If the assessment of the first fault results in the control remaining operational in accordance with the safety related functional requirements of the specific control standard [see 8.5.4.2 d)], any further independent fault considered together with the first fault shall result in either 8.5.4.2 a), b), c) or d).

During assessment, the second fault shall only be considered to occur:

a) Either when a start-up sequence has been performed between the first and the second fault, or

b) 24 h after the first fault.

For VPS designed for use on non-permanent operating appliances, a) is applicable. However, b) is applicable for VPS designed for use on permanent operating appliances.

8.5.4.4 Faults during lock-out or safety- shut-down

8.5.4.4.1 General

Whenever the control is in lock-out or safety shut down without an internal fault, an assessment according to 8.5.4.4.2 and 8.5.4.4.3 shall be performed.

Whenever the control is inoperative with all safety related output terminals de-energized or in a status in which they ensure a safe situation, in lock-out or in safety shut down with an internal fault, an additional single fault assessment according to 8.5.4.4.3 shall be performed.

NOTE Safety related output terminal as used in 8.5.4.4.2 and 8.5.4.4.3 are terminals which are safety related even in the safety shut-down or lock-out position, e.g. gas valve terminals, but not a terminal for an actuator driving the controlling element of a gas air ratio control (see ISO 23552-1).

8.5.4.4.2 First fault introduced during lock-out or safety- shut-down

During assessment, the first fault shall not be considered to occur within 24 h after lock-out or safety shut-down is reached without an internal fault.

Any first fault (together with any other fault arising from that fault) in any one component (see IEC 60730-1:2013+AMD1:2015, Table H24), induced while the VPS is in the safety shut-down or lock-out position, shall result in either:

a) the system remaining in safety shut-down or lock-out, with the shut-off valves remaining de-energized;

b) the system becoming inoperative with the shut-off valves remaining de- energized;

c) the system coming into operation again resulting in a) or b) under the condition that the shut-off valve terminals are energized not longer than the 3 s. If the cause of the original safety shut-down or lock-out condition is no longer present and the valve proving system resumes operation, it shall operate in accordance with the safety related functional requirements of this document and the second fault assessment shall be carried out in accordance with 8.5.4.3.

While conducting this test, the fault can be applied at any time during the lock-out or safety shut-down condition. It is not necessary to wait 24 h before applying the fault. If the fault was applied before 24 h

and unacceptable results were obtained, the fault should be applied 24 h after reaching lock-out or safety shut-down.

8.5.4.4.3 Second fault introduced during lock-out or safety shut-down

Any second fault (together with any other fault arising from that fault) in any one component (see IEC 60730-1:2013+AMD1:2015, Table H24), induced while the control is staying in the safety shut-down or lock-out position, shall result in either 8.5.4.4.2 a), b) or c).

During assessment, the second fault shall not be considered to occur within 24 h after the first fault.

While conducting this test, the second fault can be applied at any time during the lock-out or safety shut-down condition. It is not necessary to wait 24 h before applying the second fault. If the second fault was applied before 24 h and unacceptable results were obtained, the initial fault should be applied and then wait 24 h before applying the second fault.

8.5.5 Circuit and construction evaluation

8.5.5.1 Test conditions

The effect of internal faults shall be assessed by simulation and/or by an examination of the circuit design.

The fault shall be considered to have occurred at any stage in the control programme sequence.

The control shall be operated or considered to operate under the following conditions:

a) at the most unfavourable voltage in the range 85 % to 110 % of the rated supply voltage;

b) loaded with the most unfavourable load declared by the manufacturer;

c) in an ambient temperature of (20 ± 5) °C, unless there are significant reasons for conducting the test at another temperature within the manufacturer's declared range;

d) with any actuating member placed in the most unfavourable position;

e) with tissue paper placed on the supporting surface(s) of the control;

f) with sparks of about 3 mm in length and having an energy of not less than 0,5 J applied to those components which are likely to liberate flammable gases during the test.

8.5.5.2 Test criteria

During the appraisal, it shall be verified that under the conditions described in 8.5.5.1, the following criteria are satisfied.

a) The control shall not emit flames, hot metal or hot plastics, the tissue paper shall not ignite, no explosion shall result from the liberation of flammable gases and any flame produced shall not continue to burn for more than 10 s after switching off the spark generator. When a control is incorporated with any appliance, any enclosure afforded by the appliance is taken into consideration.

b) If the control continues to function, it shall conform to IEC 60730-1:2013+AMD1:2015, Clauses 8 and 13. If it ceases to function, it shall still continue to conform to IEC 60730-1:2013+AMD1:2015, Clause 8.

After the tests there shall be no deterioration of the various parts of the control that would result in failure to comply with IEC 60730-1:2013+AMD1:2015, Clause 20.

NOTE Heating elements consisting of wire-wound resistors are considered to be short-circuit proof (see IEC 60730-1:2013+AMD1:2015, Table H24).

8.5.5.3 Assessment

A thorough appraisal of the circuit shall be carried out to determine its performance under the specified fault conditions. This appraisal shall take the form of a theoretical analysis and a component failure simulation test. Fault simulations may also be carried out to simulate faults within complex devices, e.g. EPROM emulation tests.

Only the safety related software (Software class B and C) as identified according to 8.5.1.3 shall be subjected to further assessment. For the identification, a fault tree analysis may be used.

9 Electromagnetic compatibility (EMC)

9.1 Protection against environmental influences

Shall be according to ISO 23550:2018, 9.1.

9.2 Harmonics and inter harmonics including mains signalling at a.c. power port, low frequency immunity

Shall be according to ISO 23550:2018, 9.2.

9.3 Voltage dips, voltage interruptions and voltage variations in the power supply network

9.3.1 Voltage dips and voltage interruptions

9.3.1.1 General

Shall be according to ISO 23550:2018, 9.3.1.1.

9.3.1.2 Requirements

Shall be according to ISO 23550:2018, 9.3.1.2 with the following addition.

The VPS shall either perform as in Criteria I or it may proceed to safety shut down followed by an automatic restart, or if in volatile lock-out it may proceed to an automatic restart. If in non-volatile lock out it shall remain in that condition.

9.3.2 Test

Shall be according to ISO 23550:2018, 9.3.2.

9.3.3 Voltage variation

Shall be according to ISO 23550:2018, 9.3.3.

9.4 Test of influence of voltage unbalance

ISO 23550:2018, 9.4 is not applicable.

9.5 Surge immunity tests

9.5.1 General

Shall be according to ISO 23550:2018, 9.5.1.

9.5.2 Requirements

Shall be according to ISO 23550:2018, 9.5.2.

9.5.3 Test

Shall be according to ISO 23550:2018, 9.5.3, is replaced by the following:

The control is supplied with rated voltage. Test instrumentation, test set-up and test procedure shall be in accordance with IEC 61000-4-5. The severity levels being those specified in Table 1. Five pulses of each polarity (-, +) and each phase angle as described in IEC 61000-4-5 are delivered under the test conditions specified in the specific control standard.

Table 1 — Surge test levels

	Open-circuit test voltage for power supply ports connected to AC or DC power supply systems[1]		**Open-circuit test voltage for DC power supply ports not connected to DC power supply systems[1] and interconnection ports for process measurement and control lines (Sensors and actuators)[2]**	
Installation situation	**Installation class 3**	**Installation class 3**	**Supply lines and interconnection cables are well-separated, even at short runs[3]**	**Supply lines and interconnection cables run in parallel[4]**
Coupling mode **Severity level**	**Line-to-Line**	**Line-to-Ground**	**Line-to-Ground**	**Line-to-Ground**
2	0,5 kV	1,0 kV	0,5 kV	1,0 kV
3	1,0 kV	2,0 kV	1,0 kV	2,0 kV
4	not tested	4,0 kV	not tested	not tested
NOTE 1 a.c. and d.c. power supply systems are fixed installations. Their topology and other electrical loads are unknown.				
NOTE 2 The tests on d.c. power ports and interconnection cables are not carried out if the manufacturer explicitly specifies that the length of that cables shall not exceed 10 m.				
NOTE 3 Installation class 2 according to IEC 61000-4-5.				
NOTE 4 Installation class 3 according to IEC 61000-4-5.				

— When tested at severity level 2 the control shall conform to Assessment Criterion I as specified in 9.1.

— When tested at severity level 3 and 4 the control shall conform to Assessment Criterion II as specified in 9.1.

For controls having surge protective devices incorporating spark gaps, the tests at severity level 3 and 4 is repeated at a level that is 95 % of the flashover voltage.

If surge protective devices are used they shall comply with IEC 61643-1. Additionally they shall be selected to withstand the impulses corresponding to installation class 3.

Test conditions:

The five pulses of each polarity (+, -) and each phase angle are delivered in the following order:

— 2 pulses with the system in the lock-out position;

— 1 pulse with the system in start position (if applicable);

— 2 pulses randomly applied during the VPS sequence.

The Assessment Criteria I and II as specified in 9.1 are applicable.

9.6 Electrical fast transient/burst

9.6.1 General

Shall be according to ISO 23550:2018, 9.6.1.

9.6.2 Requirements

Shall be according to ISO 23550:2018, 9.6.2.

9.6.3 Test

Shall be according to ISO 23550:2018, 9.6.3. with the following modification and addition:

Test conditions:

The test shall be performed for 20 cycles during the VPS sequence. Remaining for a minimum of 30 s each cycle in the position which is reached after successful completion of the VPS sequence. The test shall also be performed for a minimum of 2 min with the system in the lock-out position and with the system in the start position (if applicable).

The Assessment Criteria I and II as specified in 9.1 are applicable.

9.7 Ring wave immunity

Shall be according to ISO 23550:2018, 9.7.

9.8 Electrostatic discharge

9.8.1 General

Shall be according to ISO 23550:2018, 9.8.1.

9.8.2 Requirements

Shall be according to ISO 23550:2018, 9.8.2.

9.8.3 Test

Shall be according to ISO 23550:2018, 9.8.3 with the following modification and addition:

Modification:

The test voltages for direct and indirect electrostatic discharges given in Table 2 apply.

Table 2 — Test voltages for direct and indirect electrostatic discharges

Severity level	Contact discharge kV	Air discharge kV
2	4	4
4	8	15

Addition:

This requirement applies to controls having their own protective enclosure. For control not having their own protective enclosure, the test applies only to touchable points declared by the manufacturer, (see Selection of test points in IEC 61000-4-2).

If the test at the highest severity level complies with the Assessment Criterion I tests at lower severity levels need not be performed.

Test conditions:

The system shall be tested in each of the operating phases as given in 9.1 whereas the discharges during the VPS sequence are randomly applied.

The Assessment Criteria I and II as specified in 9.1 are applicable.

9.9 Radio-frequency electromagnetic field immunity

Shall be according to ISO 23550:2018, 9.9.

9.10 Test of influence of supply frequency variations

Shall be according to ISO23550:2018, 9.10.

9.11 Power frequency magnetic field immunity

Shall be according to ISO 23550:2018, 9.11.

10 Marking, installation and operating instructions

10.1 Marking

Shall be according to ISO 23550:2018, 10.1 with the following addition.

The VPS and/or its components shall be durably marked in a clear and visible position with the following:

a) name of manufacturer and/or registered trademark;

b) type reference;

c) maximum working pressure, expressed in Pa or KPa;

d) nature of supply and frequency;

e) rated voltage or rated voltage range;

f) degree of protection;

g) maximum load rating of outputs;

h) date of manufacture (at least the year), which may be in code.

10.2 Installation and operating instructions

Shall be according to ISO 23550:2018, 10.2 with the following addition:

One set of instructions shall be supplied with each consignment, written in the language(s) of the countries into which the VPS will be delivered. They shall include all relevant information on use, installation, operation and maintenance, in particular, the following:

a) type reference;

b) electrical data, including maximum ratings of loads on output terminals;

c) maximum and minimum permissible ambient temperature;

d) wiring diagram with clear terminal markings for the connection of the mains and/or battery supply and external wiring;

e) information on interlocks and how to reset them when the mains supply is interrupted;

f) permissible installation position;

g) diagram of the programme-sequence;

h) all adjustment and setting information;

i) length and the type of cable for the connection of external components.

10.3 Warning notice

Shall be according to ISO 23550:2018, 10.3.

Annex A
(informative)

Leak-tightness test — Volumetric method

Shall be according to ISO 23550:2018, Annex A.

Annex B
(informative)

Leak-tightness test — Pressure-loss method

Shall be according to ISO 23550:2018, Annex B.

Annex C
(normative)

Conversion of pressure loss into leakage rate

Shall be according to ISO 23550:2018, Annex C.

Annex D
(informative)

Gas quick connector (GQC)

ISO 23550:2018, Annex D is not applicable.