

INTERNATIONAL STANDARD

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**Automatic electrical controls –
Part 2-23: Particular requirements for electrical sensors and sensing elements**

**Dispositifs de commande électrique automatiques –
Partie 2-23: Exigences particulières pour les capteurs électriques et les éléments sensibles**



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IEC 60730-2-23 has been prepared by IEC technical Committee 72: Automatic electrical controls. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
72/1477/FDIS	72/1481/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 60730 series, under the general title: *Automatic electrical controls*, can be found on the IEC website.

This part 2-23 is intended to be used in conjunction with IEC 60730-1. It was established on the basis of the publication of the sixth edition of IEC 60730-1:2022.

This part 2-23 supplements or modifies the corresponding clauses in 60730-1:2022, so as to convert that publication into the IEC standards: Safety requirements for electrical sensors and sensing elements.

When a particular subclause of Part 1 is not mentioned in this Part 2, that subclause applies.

Where no change is necessary, this part 2-23 indicates that the relevant clause or subclass in IEC 60730-1 applies.

In this publication:

- 1) The following print types are used:
 - *test specifications: in italic type;*
- 2) Subclauses, notes or items which are additional to those in Part 1 are numbered starting from 101, additional annexes are lettered AA, BB, etc.
- 3) Words in **bold** in the text are defined in Clause 3.

Sensor manufacturers may refer to this Part 2 as a template to understand how to apply the relevant clauses in IEC 60730-1 and to begin designing sensors and sensing elements and apply these requirements for their devices.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

AUTOMATIC ELECTRICAL CONTROLS –

Part 2-23: Particular requirements for electrical sensors and sensing elements

1 Scope

This clause of Part 1 is applicable except as follows.

Replacement:

This part of IEC 60730 applies to the safety of electrical, electro-mechanical and electronic **sensors** including **sensing elements** and any conditioning circuitry. **Sensors** covered under the scope of this document serve only to transform an activating quantity into a usable output and do not perform a control **operation** as defined in IEC 60730-1.

This document applies to **sensors** in so far as defining the reliability and accuracy of their inherent operating characteristics and corresponding response under normal and abnormal conditions within the **sensor**. **Sensors**, as defined herein, are used in or as part of an automatic electrical control or as independently mounted devices in connection with controls and control systems.

The use of this document for other applications in which **sensors** are used is possible provided that the appropriate safety is maintained as defined by the end product standard. This document applies to discrete **sensors** constructed of, but not limited to, conductive or semiconductive substrate, for the detection of activating quantities such as voltage, current, temperature, pressure, **humidity**, light (e.g. optical), gasoline vapours, and the like.

NOTE 1 Future consideration will be given to other **sensor** technologies such as chemical, mechanical and micro-electromechanical systems (MEMS), along with other activating quantities like mass flow, liquid, movement, weight, vibration, or other as needed.

This document applies to **sensing element(s)** as well as any electronic hardware, software, or other conditioning circuits that are inherent to the **sensor** and relied upon to reliably transform the input **signal** into a useable response **signal** (output) for functional safety purposes. Conditioning circuits that are inseparable from the control for which the **sensing element** relies upon to perform its desired function are evaluated by the requirements of the relevant control Part 2 standard and/or IEC 60730-1.

NOTE 2 Additional requirements can be also applied by the application standard in which the **sensor** is used.

Throughout this document, whenever it is indicated that the IEC 60730-1 requirements are applicable, the term "control(s)", is replaced by the term "**sensor(s)**", and the term "equipment" is replaced by the term "control", as they are used in IEC 60730-1, respectively, unless otherwise specified herein.

This document does not apply to **sensors** explicitly described in another relevant part 2 of the IEC 60730 series.

NOTE 3 For example, a flame **sensor** as described in IEC 60730-2-5.

2 Normative references

This clause of Part 1 is applicable except as follows.

Addition:

IEC 60730-1:2022, *Automatic electrical controls – Part 1: General requirements*

IEC 60751:2022, *Industrial platinum resistance thermometers and platinum temperature sensors*

3 Terms and definitions

This clause of Part 1 is applicable except as follows.

3.1 Definitions relating to ratings, voltages, currents, frequencies, and wattages

Additional definition:

3.1.101

signal

physical variable quantity one or more parameters of which carry information about one or more variable quantities

Note 1 to entry: These parameters are designated "information parameters".

Note 2 to entry: This entry was numbered 351-21-51 in IEC 60050-351:2006.

[SOURCE: IEC 60050-351:2013, 351-41-17]

3.2 Definitions of types of control according to purpose

Additional definitions:

3.2.101

sensor

device that embodies a **sensing element**, which is directly affected by the activating quantity, and which generates a **signal** related to the value of the activating quantity and can also include an auxiliary **sensor** circuit, and/or **signal** conditioner

Note 1 to entry: When the term "**sensor**" is used throughout this document in a general way, it refers to all types of **sensors** unless otherwise noted. See example in Figure 101.

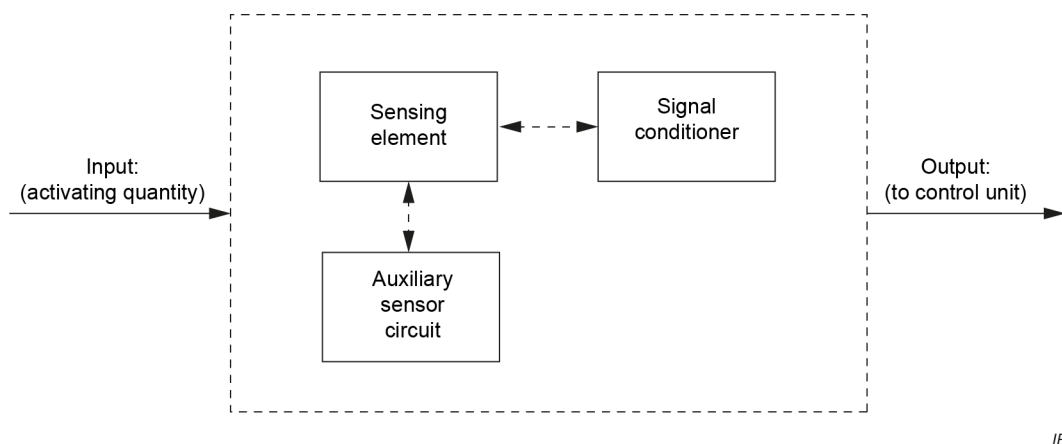


Figure 101 – Schematic diagram of a typical sensor

3.2.102

temperature sensor

device designed to respond to temperature providing a usable **signal**

Note 1 to entry: Example include thermocouples, resistance temperature detector (RTD), etc.

[SOURCE: IEC 60050-426:2020, 426-20-44, modified – "an electrical signal or mechanical operation" has been replaced with "a usable signal", a Note to entry has been added.]

3.2.103

gasoline vapour sensor

device designed to respond to the presence of a specific concentration of gasoline vapour(s) providing a usable **signal**

Note 1 to entry: **Gasoline vapour sensors** can detect flammable or non-flammable gasoline vapours.

3.2.104

pressure sensor

device designed to respond to pressure of gas(es) or liquid(s) providing a usable **signal**

3.2.105

optical sensor

device designed to respond to light providing a usable **signal**

3.2.106

humidity sensor

device designed to respond to **humidity** providing a usable **signal**

Note 1 to entry: **Humidity sensors** usually have two **sensing elements** within the **sensor**. One to measure the moisture and the other to measure temperature.

3.2.107

current sensor

device designed to respond to the electrical current providing a usable **signal**

3.2.108

voltage sensor

device designed to respond to voltage providing a usable **signal**

Note 1 to entry: A **voltage sensor** can perform other integral functions as part of the output **signal** such as to calculate and/or monitor the voltage of an object.

3.3 Definitions relating to the function of controls

3.3.4 to 3.3.9 Not applicable.

3.3.15 Not applicable.

3.3.24 Not applicable.

3.3.29 *Modification:*

Replace "**switch head**" with "**sensing element or sensor**".

3.3.31 Not applicable.

3.4 Definitions relating to disconnection and interruption

Not applicable.

3.5 Definitions of types of control according to construction

3.5.3 and 3.5.4 Not applicable.

3.5.6 to 3.5.12 Not applicable.

3.8 Definitions relating to component parts of controls

Replacement:

3.8.1 **sensing element**

functional device that senses the effect of a measurand at its input and places a corresponding measurement (electrical) **signal** at its output

Note 1 to entry: In general, a **sensing element** does not include an enclosure, or any **signal** conditioning circuits.

[SOURCE: IEC 60050-351:2013, 351-56-26, modified – "unit" has been replaced by "device", "(electrical)" has been added after "measurement".]

3.13 Miscellaneous definitions

Additional definition:

3.13.101 **humidity**

quantity representing the amount of water vapour in the atmosphere, or in a gas, relative to the temperature of the air or gas

3.15 Definitions pertaining to thermistors

Replacement of definitions in Part 1, Annex J:

J.3.15.2

PTC thermistor

thermally sensitive semiconductor resistor that exhibits a non-linear change in its electrical resistance with a change in temperature resulting in an increase in resistance with increasing temperature over the useful portion of the resistance/temperature (R/T) characteristic

Note 1 to entry: **PTC thermistors** also exhibit a decreasing resistance with applied voltage as a secondary effect.

Note 2 to entry: For a **PTC thermistor**, the significant portion of the resistance/temperature characteristic is usually the portion in which a step-like increase in resistance occurs in a temperature increment, usually preceded by a gradual change in resistance at lower temperatures, and a similar gradual change at temperatures above the step-like increase. The resistance/temperature characteristic of some **PTC thermistors** can take on a negative slope after a slight gradual increase following the step-like increase.

J.3.15.3

NTC thermistor

thermally sensitive semiconductor resistor that exhibits a non-linear change in its electrical resistance with a change in temperature resulting in a decrease in resistance with increasing temperature over the useful portion of the resistance/temperature characteristic

J.3.15.7

beta value

β value

NTC thermistor's index, which expresses the degree of resistance change when calculated from any two points specified by the manufacturer on the resistance/temperature (R/T) curve

J.3.15.14

resistance

$R_{\min}$

for a ceramic **PTC thermistor**, point of minimum resistance on the R/T curve

J.3.15.15

rated resistance

R_x or R_{25}

resistance at a temperature specified by the manufacturer for R_x or at $25\text{ °C} \pm 2\text{ K}$ for R_{25}

J.3.15.16

switching resistance

R_{sw}

for a **PTC thermistor**, **resistance** value at which the **resistance** begins to increase sharply with temperature increase

Note 1 to entry: For this standard, R_{sw} is the value where the **resistance** is twice $R_{\min}$, unless the manufacturer specifies R_{sw} with reference to $R_{\min}$ with a multiplying factor other than two, or with reference to R_x

J.3.15.18

switching temperature

T_{sw}

for a **PTC thermistor**, temperature at which the **resistance** is at R_{sw}

J.3.15.21

thermal runaway temperature

T_R

high temperature point on the R/T curve at which a **PTC thermistor's** resistance no longer increases with increasing temperature

Additional definitions:

3.15.101

ceramic PTC

CPTC

PTC thermistor made of doped polycrystalline ceramic material

3.15.102

polymeric PTC

PPTC

PTC thermistor made of non-conductive crystalline organic polymer matrix impregnated with carbon black particles

Additional subclause:

3.101 Definitions relating to resistance temperature detector (RTD) sensors**3.101.1**

temperature coefficient of resistance

α value

relative change in resistance over the temperature range of 0° to 100 °C

Note 1 to entry: The alpha value is the temperature coefficient for the specific material and composition of the RTD element.

4 General

This clause of Part 1 is applicable

4.3 General notes on tests

This clause of Part 1 is applicable except as follows.

4.3.2.7 Replacement:

Unless otherwise specified in this standard, the minimum and/or maximum rates of change in activating quantity shall be declared in requirement 31 of Table 1. The rates shall be used in Clause 19 of this document.

4.3.3 Samples required

Replacement:

Unless otherwise specified, representative samples as indicated in Table 101 shall be subjected to the relevant tests based on the technology used for the **sensing element**. New samples shall be used for all tests other than the overload and endurance tests.

Table 101 – Samples and test sequence for sensors

Conditioning tests	Ageing	HCH	O/L	END	CTC	Vib ^f	TC	EMC	Other	
Number of samples per test	3	3	3 ^a	3 ^a	3	3	3	1		
Technology and type of sensors	Semiconductor technology									
	Gasoline vapour	X	X	n/a	X ^c	X	X	X	X ^b	d
	Thermistor:									
	Polymeric PTC (PPTC)	X	X	X	X	X	X	n/a	n/a	n/a
	Ceramic PTC (CPTC)	X	X	X	X	X	X	n/a	n/a	n/a
	NTC	X	X	X	X	X	X	n/a	n/a	n/a
	Pure/doped metal technology									
	RTD (Pt, Cu, Ni)	X	X	X	X	X	X	n/a	n/a	n/a
	Electronic technology ^e									
	Current	X	X	d	d	X	X	X	X	d
	Voltage	X	X	d	d	X	X	X	X	d
	Pressure	X	X	X	X	X	X	X	X	d
	Humidity	X	X	X	X	X	X	X	X	d
	Optical technology									
	Infrared ^d									
Explanation of abbreviations:										
Ageing – Ageing test, see 19.101.2										
HCH Heat-cold- humidity test, see 19.101.3										
O/L Overload test, see 19.101.4.1										
END Endurance test, see 19.101.4.2										
CTC Cold thermal cycling test, see .101.5										
Vib Vibration test, see 19.101.6										
TC Thermal cycling test, see 19.101.7										
EMC Electromagnetic compatibility (EMC) requirements– Immunity. Applicable to electronic sensors and integrated electronic components, see Clause H.25										
OTHER Tests described in Clause 19 that are specific to the type of sensor , as applicable.										
The calibration tests of Clause H.17 shall be conducted before and after each of the above tests.										
^a The same three samples shall be used for both the overload and endurance tests.										
^b Electrical fast transient/burst immunity test (see H.25.9) and electrostatic discharge test (see H.26.10) are applicable. Additional EMC testing can be applicable depending on the technology and as agreed between the test house and manufacturer.										
^c For gasoline vapour sensors , see also 19.101.8.										
^d Under consideration.										
^e Excludes nano-technologies (MEMS).										
^f Vibration only applies to sensors declared as Type 2 action.										

4.3.4 Instructions for test

4.3.4.1 According to submission

4.3.4.1.4 Replacement:

Sensors not submitted in or with a control are tested separately in accordance with the manufacturer's specifications and declarations of Table 1.

4.3.4.1.5 Not applicable.

4.3.4.2 According to rating

4.3.4.2.1 Not applicable.

4.3.4.2.11 Replacement:

The electrical and thermal ratings of a **sensor** shall be in accordance with Table 102 and based on its intended application.

Table 102 – Electrical and thermal ratings of a sensor

Characteristic	Semiconductors		Pure/doped metal		Electronic sensors			
	PTC sensor	NTC sensor	RTD sensors	Thermo meters	Current	voltage	Pressure	Humidity
Beta value (β)	-	R	-	-				
Calibration class number	R	R	R	-	R	R		
Rated resistance – R_{25} and tolerance, ohms	R	R	-	-				
Maximum sensing range of activating quantity	R	R	R	R	R	R	R	R
Switching temperature (T_{sw}), °C	R	-	-	-				
Resistance – R_0 °C and tolerance, ohms	-	-	-					
Alpha value (α)	-	-	R	R				
RTD tolerance class and tolerance			X	X				
Rated I/O current (A)					R		R	R
Rated I/O voltage (V_r)	R	R	R			R	R	R
The "R" designation indicates ratings for the device that are required to be provided by the manufacturer.								
The "X" designates ratings that are declared by the manufacturer and verified.								

4.3.4.5 According to purpose

4.3.4.5.4 Replacement:

Based on the type of **sensors** and the particular application, **sensors** shall be subjected to the applicable tests noted in Table 101 and the calibration tests of Clause H.17, whichever applies.

Additional subclauses:

4.101 According to chemical composition

When necessary, **sensors** shall be classified according to the chemical composition and make-up.

5 Required technical information

This clause of Part 1 is applicable except as follows.

Table 1 – Required technical information and methods of providing these information

Information		Clause or subclause	Method
<i>Modifications:</i>			
6	Purpose of sensor	3.2, 4.3.4.2, 4.3.4.5	D or E
8	Not applicable		
15	Not applicable		
19	Not applicable		
20	Not applicable		
21	Not applicable		
22	Not applicable		
30	Not applicable		
37	Not applicable		
47	Not applicable		
53	Not applicable		
68	Not applicable		
70	Not applicable		
72	Not applicable		
73	Not applicable		
86	Not applicable		
87	Not applicable		
<i>Additional items:</i>			
101	According to the type of sensor technology ¹⁰³ a) semiconductor b) pure/doped metal c) electronic d) optical	Table 101	X
102	Calibration specifications ¹⁰¹	17, H.17	X
103	Calibration specifications, drift ¹⁰²	17, 19, H.17	X
104	Number of cycles	19.101.4.2, Table 103	X
105	Method of measurement	17	X
106	Declared for non-safety operation in the application	17	X
107	Declared for exposure to water	19.101.3.1	D or E
108	Vibration ¹⁰⁴	19.101.6	D or E
109	Drop test	20.101	X