

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals**

**Transducteurs électriques de mesure convertissant les grandeurs électriques alternatives ou continues en signaux analogiques ou numériques**



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ELECTROTECHNICAL  
COMMISSION

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ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS**

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IEC 60688 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2021. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) updating normative references;
- b) updating definitions;
- c) updating structure;
- d) adding DC power measurement.

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

|             |                  |
|-------------|------------------|
| Draft       | Report on voting |
| 85/921/FDIS | 85/932/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

In this document, the following print types are used:

- requirements and definitions: in roman type;
- NOTES: in smaller roman type;
- *compliance*: in italic type.

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- reconfirmed,
- withdrawn, or
- revised.

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## INTRODUCTION

Energy distribution systems need to guarantee energy efficiency, availability, and network performance to address the following challenges:

- meet sustainable development requirements, where energy measurement is necessary to identify sources of energy savings, and to improve the energy performance of manufacturing, commercial organisations, and public services;
- adjust to technological evolutions (electronic loads, electronic measuring methods, etc.);
- address end-user needs (cost saving, compliance building regulations, etc.) regarding electrical energy management;
- ensure safety and continuity of service;
- adjust to the evolution of installation standards;
- meet the needs of new applications for DC systems (photovoltaic, electrical vehicle, DC distribution, etc.).

Monitoring electrical quantities in internal networks contributes to addressing these challenges.

To set up this monitoring, transducers:

- perform the measurement of different types of electrical quantities,
- convert AC and DC electrical quantities to analogue or digital signals,
- can be combined with measuring equipment to monitor and analyse electrical quantities.

NOTE Some of the terms used in this document are different from those used in IEC 60051 (all parts) due to the fundamental differences between indicating instruments and measuring transducers.

# ELECTRICAL MEASURING TRANSDUCERS FOR CONVERTING AC AND DC ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS

## 1 Scope

This document applies to transducers (TRD) with electrical inputs and outputs for making measurements of AC or DC electrical quantities. The output signal can be in the form of an analogue or digital signal.

This document applies to measuring transducers used for converting electrical quantities such as:

- current,
- voltage,
- active power,
- reactive power,
- power factor,
- phase angle,
- frequency,
- harmonics or total harmonic distortion,
- apparent power, and
- DC power

to an output signal.

NOTE The above electrical quantities include AC and/or DC components.

This document applies

- a) if the fundamental frequency of the input(s) lies between 0 Hz and 1 500 Hz,
- b) to the electrical measuring transducer if it is part of a system for the measurement of an electrical or non-electrical quantity,
- c) to transducers for use in a variety of applications such as telemetry and process control and in one of a number of defined environments.

This document is not applicable for:

- instrument transformers that comply with IEC 61869 (all parts),
- transmitters for use in an industrial process application that comply with IEC 60770 (all parts),
- power metering and monitoring devices (PMD) that comply with IEC 61557-12,
- meters that comply with the IEC 62053 series,
- handheld sensors,
- residual current monitoring devices (RCMs) that comply with IEC 62020-1,
- residual current detecting devices (RDC-DD) that comply with IEC 62955,
- in-cable control and protection devices (IC-CPDs) that comply with IEC 62752,
- modular residual current devices (MRCDs) that comply with IEC 60947-2:2016/AMD1:2019, Annex M.

Within the measuring range, the output signal is a function of the measurand. An auxiliary supply can be required.

This document is intended:

- to specify the terminology and definitions relating to transducers whose main application is in industry,
- to unify the test methods used in evaluating transducer performance,
- to specify accuracy limits and output values for transducers.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-11, *Environmental testing – Part 2-11: Tests – Test Ka: Salt mist*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-52:2017, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60228:2023, *Conductors of insulated cables*

IEC TR 61000-2-3, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 3: Description of the environment – Radiated and non-network-frequency-related conducted phenomena*

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2023, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61326-1:2020, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61557-12:2018, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 12: Power metering and monitoring devices (PMD)*

IEC 61557-12:2018/AMD1:2021

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 62586-1:2017, *Power quality measurement in power supply systems – Part 1: Power quality instruments (PQI)*

ISO 4628-3:2016, *Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 3: Assessment of degree of rusting*

### 3 Terms and definitions

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

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

NOTE Some of the terms used in this document are different from those used in IEC 60051 (all parts) due to the fundamental differences between indicating instruments and measuring transducers.

#### 3.1 General terms

##### 3.1.1

##### **alternating current**

electric current that is a periodic function of time with a zero direct component or, by extension, a negligible direct component

Note 1 to entry: For the qualifier AC, see IEC 60050-151:2001, 151-15-01.

[SOURCE: IEC 60050-131:2002, 131-11-24]

##### 3.1.2

##### **alternating voltage**

##### **alternating tension**

voltage that is a periodic function of time with a zero direct component or, by extension, a negligible direct component

Note 1 to entry: For the qualifier AC, see IEC 60050-151:2001, 151-15-01.

[SOURCE: IEC 60050-131:2002, 131-11-25]

##### 3.1.3

##### **direct current system**

##### **DC system**

electrical system fed by unidirectional voltage

[SOURCE: IEC 60050-601:1985, 601-01-04]

##### 3.1.4

##### **direct current**

electrical current that is time-independent or, by extension, periodic current the direct component of which is of primary importance

Note 1 to entry: For the qualifier DC, see IEC 60050-151:2001, 151-15-02.

[SOURCE: IEC 60050-131:2002, 131-11-22]

**3.1.5****direct voltage**

voltage that is time-independent or, by extension, periodic voltage the direct component of which is of primary importance

[SOURCE: IEC 60050-131:2002, 131-11-23, modified – The term "direct tension" has been omitted.]

**3.1.6****DC power**

product of the direct voltage and the direct current (mean values)

[SOURCE: IEC 60050-551:1998, 551-17-09]

**3.1.7****SELV**

electric system in which the voltage cannot exceed the value of extra-low voltage:

- under normal conditions and
- under single fault conditions, including earth faults in other electric circuits

Note 1 to entry: SELV is the abbreviation for safety extra-low voltage.

[SOURCE: IEC 60050-195:2021, 195-06-28, modified – The word "system" has been omitted from the term.]

**3.2 Terms describing transducers****3.2.1****electrical measuring transducer  
transducer****TRD**

device for converting an AC or DC measurand to a direct or alternating current, a direct or alternating voltage or a digital signal for measurement purposes

**3.2.2****electrical measuring transducer type 1  
transducer type 1****TRD1**

conventional transducer

**3.2.3****electrical measuring transducer type 2  
transducer type 2****TRD2**

single-function transducer used in low voltage (LV) monitoring applications

**3.2.4****single-function transducer**

transducer performing the measurement of a single electrical quantity (e.g. current, power factor, THD) in a single form (e.g. RMS or peak or average) but not both

**3.2.5****analogue transducer**

transducer for converting an AC or DC measurand to a direct or alternating current, a direct or alternating voltage for measurement purposes

### 3.2.6

#### **digital transducer**

transducer for converting an AC or DC measurand to a digital signal for measurement purposes

### 3.2.7

#### **auxiliary supply**

AC or DC electrical supply, other than the measurand, which is necessary for the correct operation of the transducer

### 3.2.8

#### **auxiliary circuit**

circuit which is usually energized by the auxiliary supply

Note 1 to entry: The auxiliary circuit is sometimes energized by one of the input quantities.

### 3.2.9

#### **transducer with suppressed zero**

transducer for which zero output signal corresponds to a measurand greater than zero

### 3.2.10

#### **output load burden**

<analogue signal> total resistance of the circuits and apparatus connected externally across the output terminals of the transducer

### 3.2.11

#### **ripple content**

<analogue output signal> ratio of the peak-to-peak value of the fluctuating component of an analogue output signal, expressed in percentage, to the fiducial value, with steady-state input conditions

### 3.2.12

#### **output signal secondary signal**

analogue or digital representation of the measurand

### 3.2.13

#### **output current secondary current**

current produced by the transducer which is an analogue function of the measurand

### 3.2.14

#### **output voltage secondary voltage**

voltage produced by the transducer which is an analogue function of the measurand

### 3.2.15

#### **measuring element**

unit or module of a transducer that converts the measurand, or part of the measurand, into a corresponding signal

### 3.2.16

#### **multi-element transducer**

transducer having two or more measuring elements

Note 1 to entry: The signals from the individual elements are combined to produce an output signal corresponding to the measurand.

**3.2.17****response time**

time from the instant of application of a specified change of the measurand until the output signal reaches and remains at its final steady value or within a specified interval centred on this value

**3.2.18****compliance voltage**

accuracy limiting output voltage

<variable output load transducers having a current output> value of the voltage appearing across the output terminals up to which the transducer complies with the requirements of this document

**3.2.19****stability**

ability of a transducer to keep its performance characteristics unchanged during a specified time, all influence quantities remaining within their specified ranges

**3.2.20****usage group**

group of transducers capable of operating under a specified set of environmental conditions

**3.2.21****pulse density output**

digital representation of the measurand, where the relative density of the output pulses corresponds to the analogue signal amplitude

**3.3 Terms describing transducers according to the measurand****3.3.1****voltage transducer**

transducer used for the measurement of AC or DC voltage

**3.3.2****current transducer**

transducer used for the measurement of AC or DC current

**3.3.3****apparent power transducer**

transducer that is used for the measurement of the apparent power

**3.3.4****active power transducer**

transducer used for the measurement of active electrical power

**3.3.5****reactive power transducer**

transducer used for the measurement of reactive electrical power

**3.3.6****frequency transducer**

transducer used for the measurement of the frequency of an AC electrical quantity

**3.3.7****phase angle transducer**

transducer for the measurement of the phase angle between two AC electrical quantities having the same frequency

### **3.3.8**

#### **power factor transducer**

transducer used for the measurement of the power factor of an AC circuit

### **3.3.9**

#### **harmonics transducer**

transducer that is used for the measurement of the harmonics or the total harmonic distortion of an AC circuit

### **3.3.10**

#### **TRD2-PFA**

power factor (arithmetic method) transducer for LV monitoring applications

### **3.3.11**

#### **TRD2-PFV**

power factor (vector method) transducer for LV monitoring applications

### **3.3.12**

#### **TRD2-THDU**

voltage THD transducer for LV monitoring applications

### **3.3.13**

#### **TRD2-THDI**

current THD transducer for LV monitoring applications

### **3.3.14**

#### **TRD2-UAC**

voltage transducer for LV monitoring applications that is used for the measurement of AC voltage

### **3.3.15**

#### **TRD2-UDC**

voltage transducer for LV monitoring applications that is used for the measurement of DC voltage

### **3.3.16**

#### **TRD2-IAC**

current transducer for LV monitoring applications that is used for the measurement of AC current

### **3.3.17**

#### **TRD2-IDC**

current transducer for LV monitoring applications that is used for the measurement of DC current

## **3.4 Terms describing transducers according to their output load**

### **3.4.1**

#### **fixed output load transducer**

transducer that complies with this document only when the output load is at its nominal value, within specified limits

### **3.4.2**

#### **variable output load transducer**

transducer that complies with this document when the output load has any value within a given range

### 3.5 Nominal values

#### 3.5.1

##### **nominal value**

value, or one of the values, indicating the intended use of a transducer

Note 1 to entry: The lower and upper nominal values of the measurand are those which correspond to the lower and upper nominal values of the output signal.

#### 3.5.2

##### **span**

##### **output span**

algebraic difference between the upper and lower nominal values of the output signal

#### 3.5.3

##### **fiducial value**

value to which reference is made in order to specify the accuracy of a transducer

Note 1 to entry: The fiducial value is the span, except for transducers having a reversible and symmetrical output signal when the fiducial value may be half the span if specified by the manufacturer.

#### 3.5.4

##### **nominal power factor**

factor by which it is necessary to multiply the product of the nominal voltage and nominal current to obtain the nominal power

Note 1 to entry: When the current and voltage are sinusoidal quantities, the nominal power factor is  $\cos \varphi$  where  $\varphi$  is the phase difference between the current and the voltage. For reactive power transducers, the nominal power factor is  $\sin \varphi$ .

#### 3.5.5

##### **limiting value of the output signal**

##### **limiting value of the secondary signal**

upper limit of output signal which cannot, by design, be exceeded under any conditions

#### 3.5.6

##### **measuring range**

range defined by two values of the measurand within which the performance complies with the requirements of this document

Note 1 to entry: See 3.4.3 of IEC 60051-1:2016.

#### 3.5.7

##### **nominal value of the measured voltage**

nominal value of the voltage of the external circuit (e.g. the secondary winding of a voltage transformer) to which the voltage input circuit of the transducer is to be connected

#### 3.5.8

##### **nominal value of the measured current**

nominal value of the current in the external circuit (e.g. the secondary winding of a current transformer) to which the current input circuit of the transducer is to be connected

### 3.6 Terms describing transducers with provisions to be adjusted by users

#### 3.6.1

##### **calibration value**

value of a quantity to which the nominal value is changed by user adjustment for a specific application

### 3.6.2

#### **adjustment range**

possible range of adjustment values of the measured current or voltage

## 3.7 Influence quantities and reference conditions

### 3.7.1

#### **influence quantity**

quantity (other than the measurand) that may affect the performance of a transducer

### 3.7.2

#### **reference conditions**

specified conditions under which the transducer complies with the requirements concerning intrinsic errors

Note 1 to entry: These conditions may be defined by either a reference value or a reference range.

#### 3.7.2.1

##### **reference value**

specified single value of an influence quantity at which the transducer complies with the requirements concerning intrinsic errors

#### 3.7.2.2

##### **reference range**

specified range of values of an influence quantity within which the transducer complies with the requirements concerning intrinsic errors

### 3.7.3

#### **nominal range of use**

specified range of values over which it is intended that an influence quantity can assume without the output signal of the transducer changing by amounts in excess of those specified

## 3.8 Errors and variations

### 3.8.1

#### **error**

##### **absolute error**

actual value of the output signal minus the intended value of the output signal, expressed algebraically

### 3.8.2

#### **relative error**

$\varepsilon$

relative difference between the output signal and the intended value of the output signal, typically expressed as a percentage or ppm

$$\varepsilon = \frac{E_m - E_t}{E_t} \times 100 \%$$

with

$E_m$  Measured output value

$E_t$  Intended (expected) output value

### 3.8.3

#### **intrinsic error**

error determined when the transducer is under reference conditions

**3.8.4****variation due to an influence quantity**

difference between the two values of the output signal for the same value of the measurand when an influence quantity assumes successively two different specified values

**3.9 Accuracy, accuracy class, class index****3.9.1****accuracy**

quality that characterizes the ability of a transducer to minimize the measurement error

**3.9.2****accuracy class****class index**

class of transducers for which the accuracy of all can be designated by the same number if they comply with all the requirements of this document

**3.10 Terms related to primary of transducers****3.10.1****rated input voltage****rated primary voltage** $U_{pr}$ 

value of the primary voltage on which the performance of the transducer is based

**3.10.2****rated frequency** $f_r$ 

value of the frequency at which the equipment is designed to operate and on which the requirements are based

**3.10.3****rated input current****rated primary current** $I_{n-low}$ 

value of the primary current which the performance of the transducer is based

Note 1 to entry:  $I_{n-low}$  is also called  $I_{pr}$  in other standards.

**3.10.4****rated extended input current****rated extended primary current** $I_{n-high}$ 

Value of the primary current up to which the accuracy defined at the rated primary current is guaranteed

Note 1 to entry:  $I_{n-low}$  and  $I_{n-high}$  define a range of rated currents for which the TRD2 can be used.  $I_{n-low}$  and  $I_{n-high}$  may have the same value.

**3.10.5****rated maximum primary current** $I_{max}$ 

highest value of the primary current up to which the accuracy of a TRD2 is guaranteed in overload conditions

**3.10.6****rated maximum current factor** $K_{max}$ 

ratio of the rated maximum primary current to the rated extended primary current

**3.10.7**  
**rated continuous thermal current**

$I_{cth}$

value of the current which can be permitted to flow continuously in the primary of the transducer

**3.10.8**  
**rated short time thermal current**

$I_{th}$

value of the current which can be permitted to flow for a specified short time in the primary of the transducer

**3.10.9**  
**rated dynamic current**

$I_{dyn}$

maximum peak value of the primary current which a transducer will withstand without being damaged electrically or mechanically by the resulting electromagnetic forces

**3.11 Terms related to secondary output of transducers**

**3.11.1**  
**rated output current**  
**rated secondary current**

$I_{sr}$

value of the secondary current on which the performance of the transducer is based

**3.11.2**  
**rated output voltage**  
**rated secondary voltage**

$U_{sr}$

value of the secondary voltage on which the performance of the transducer is based

**3.11.3**  
**rated output frequency**  
**rated secondary frequency**

$f_{sr}$

value of the secondary frequency on which the performance of the transducer is based

**3.11.4**  
**rated burden**

$Z_{br}$

value of the burden on which the accuracy requirements of a specification are based

**4 Environmental conditions**

No requirements.

**5 Ratings**

No requirements.

## 6 Requirements for design and construction

### 6.1 General

#### 6.1.1 Transducer general architecture

The electrical quantity to be measured may be either directly accessible, as it is generally the case in low-voltage systems, or accessible via measurement sensors like voltage sensors (VS) or current sensors (CS).

Figure 1 shows an example of architecture of a transducer (TRD), with dotted line blocks being optional. The implementation may be analogue or include digital parts.

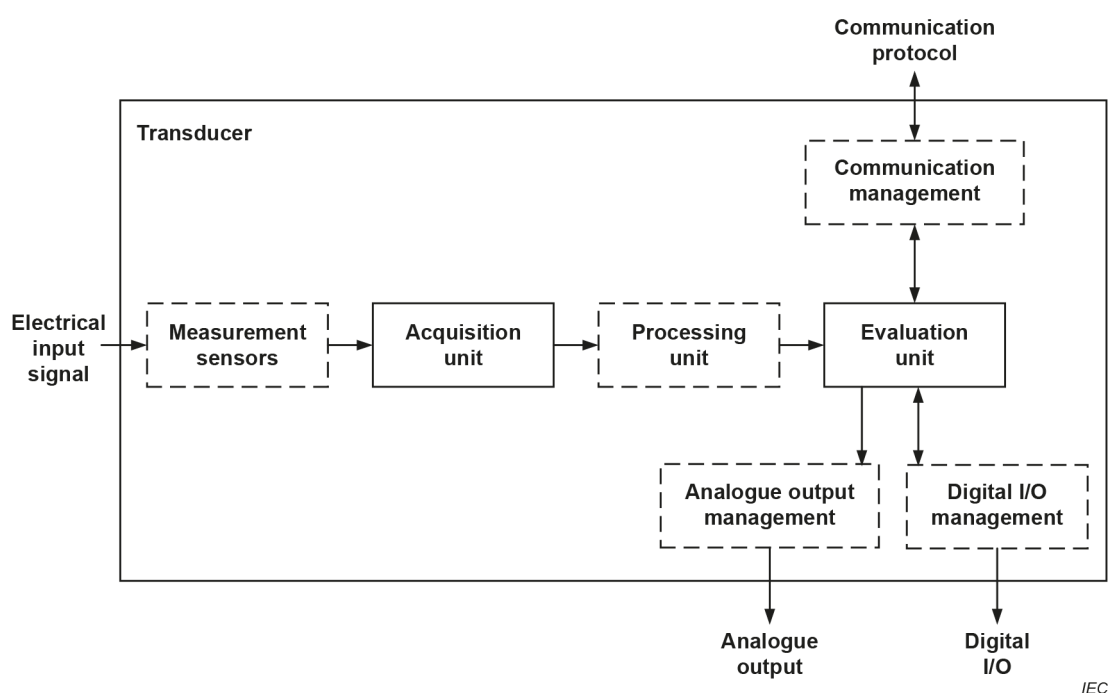


Figure 1 – Transducer (TRD) architecture example

#### 6.1.2 Classification of transducers (TRD)

This document describes two different types of transducers, transducer type 1 (TRD1), and transducer type 2 (TRD2).

- TRD1 are conventional transducers, use conventional interface outputs and are generally single-function devices.
- TRD2 are single-function transducers used in low voltage (LV) applications. TRD2 use specific interface outputs and are generally more accurate than TRD1.

Transducers are classified according to the applications as defined in Table 1.

Table 1 – Functional classification of transducers with minimal required functions

| Requirements                                                                            | Transducers type         |                          |
|-----------------------------------------------------------------------------------------|--------------------------|--------------------------|
|                                                                                         | Transducer type 1 (TRD1) | transducer type 2 (TRD2) |
| See Annex A                                                                             | ■                        |                          |
| See Annex B                                                                             |                          | ■                        |
| NOTE For more information about classification between TRD1 and TRD2, see also Annex C. |                          |                          |

## 6.2 Safety requirements

### 6.2.1 General

This Subclause 6.2 is applicable to transducers in applications with nominal voltage up to 1 000 V AC or 1 500 V DC.

NOTE For higher voltage applications, see relevant safety standards.

Two classes of TRD are defined.

- Class F:
  - Safety and insulation requirements: TRD shall comply with the safety requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and IEC 61010-2-030:2023 with additional requirements specified in the subsequent subclauses of 6.2 of this document.
  - Class F is recommended for new designs.
- Class D:
  - Safety requirements: TRD shall comply with the safety requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and IEC 61010-2-030:2023 except for insulation requirements.
  - Insulation requirements: TRD shall comply with IEC 60664-1:2020, and with additional requirements specified in the subsequent subclauses of 6.2 of this document.

### 6.2.2 Protection against electric shocks

#### 6.2.2.1 General insulation requirements

For TRD class F, clearances and creepage distances as well as solid insulation shall be selected at least in accordance with

- pollution degree 2,
- measurement category III, for measuring circuits, and
- overvoltage category III, for other circuits.

For TRD class D, clearances and creepage distances as well as solid insulation shall be selected at least in accordance with

- pollution degree 2, and
- overvoltage category III.

See Annex H for guidance related to overvoltage categories and measurement categories.

#### 6.2.2.2 Accessible parts

##### 6.2.2.2.1 Output terminals of TRD

Output terminals of transducers to be connected to the measuring equipment shall generally be considered as accessible parts.

This is especially true for terminals equipped with an information technology connector (e.g. RJ45, DB9, or similar plugin connectors) or with stranded wire, where skilled or unskilled people do not expect a hazardous voltage.

Some exemptions may apply on the condition that they are based on a risk analysis, in which case the related mitigation measures shall be documented.

#### **6.2.2.2.2 Outer surfaces of TRD**

Outer surfaces of transducers intended to be installed outside a cabinet, a panel or a cubicle shall generally be considered as accessible parts.

Some exemptions may apply on the condition that they are based on a risk analysis, in which case the related mitigation measures shall be documented.

#### **6.2.2.3 Insulation provided by cables, busbars and bushings**

Manufacturers shall specify in the technical documentation:

- the kind of insulation requested on the cables or busbars or bare conductors, and
- the kind of bushings to use, if any.

NOTE Guidance on insulation of cables or bushings is provided in Annex G.

#### **6.2.2.4 Insulation within a panel**

Manufacturers shall specify in the technical documentation if a minimum distance should be maintained between outer surfaces of the TRD (or its output circuits) and other equipment such as metallic parts or another TRD in its proximity.

#### **6.2.2.5 Automatic disconnection**

TRD class F, when automatic disconnection is implemented, shall comply with the requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 related to automatic disconnection.

TRD class D, when automatic disconnection is implemented, shall either comply class F requirements or comply with the requirements of Clause 15 of IEC 61558-1:2017 related to automatic disconnection.

#### **6.2.3 Protection against mechanical hazards**

IEC 61010-1:2010, Clause 7 and IEC 61010-1:2010/AMD1:2016, Clause 7 applies.

#### **6.2.4 Resistance to mechanical stress**

Clause 8 of IEC 61010-1:2010 applies with the below additional requirements.

Outer surfaces of transducers intended to be installed exclusively inside a cabinet, a panel or a cubicle shall meet, except terminals and cords, at least IK02 (0,2 J) requirements.

#### **6.2.5 Protection against the spread of fire**

IEC 61010-1:2010, Clause 9 and IEC 61010-1:2010/AMD1:2016, Clause 9 apply.

#### **6.2.6 Equipment temperature limits and resistance to heat**

IEC 61010-1:2010, Clause 10 and IEC 61010-1:2010/AMD1:2016, Clause 10 apply with the below additional requirements.

Manufacturers shall declare for TRD measuring current:

- if the TRD is intended to be used with integral means to avoid any (thermal) contact with conductor (cable or busbar) or if it is intended to be used in (thermal) contact with the conductor,
- if two TRD, put side by side, can be continuously in (thermal) contact during service, and

- if a TRD can be continuously in (thermal) contact during service with another cable or busbar in the vicinity.
- if minimum distances should be retained to prevent contacts with the conductors, cables or busbars.

NOTE Guidance on temperature of cables and busbars is provided in Annex G.

## **6.2.7 Protection against hazards from fluids**

### **6.2.7.1 General**

IEC 61010-1:2010, 11.6 and IEC 61010-1:2010/AMD1:2016, 11.6 apply with the additional requirements of 6.2.7.2 and 6.2.7.3.

### **6.2.7.2 Degrees of protection for indoor use**

For indoor use, outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall meet IP40 requirements.

For indoor use, outer surface of transducers intended to be installed inside a cabinet, a panel or a cubicle shall meet IP2X requirements.

This requirement is not applicable to installations where personnel cannot gain access to the transducer without firstly de-energising the transducer and making it safe through some controlled means (i.e. interlocking, documented operating instructions, etc.). In this case, the need for such external safety measures to the transducer should be clearly stated in the product documentation.

### **6.2.7.3 Degrees of protection for outdoor use**

The recommended minimum degree of protection for enclosures for outdoor TRD is IP44 according to IEC 60529.

For TRD with lower IP index or for higher installation needs, additional protection features against rain and other weather conditions shall be specified by means of the supplementary letter W placed after the second characteristic numeral, or after the additional letter, if any.

## **6.2.8 Protection against radiation, including laser sources, and against sonic and ultrasonic pressure**

IEC 61010-1:2010, Clause 12 and IEC 61010-1:2010/AMD1:2016, Clause 12 if relevant, apply.

## **6.2.9 Protection against liberated gases and substances, explosion and implosion**

IEC 61010-1:2010, Clause 13 and IEC 61010-1:2010/AMD1:2016, Clause 13 if relevant, apply.

## **6.2.10 Components and subassemblies**

IEC 61010-1:2010, Clause 14 and IEC 61010-1:2010/AMD1:2016, Clause 14 apply.

## **6.2.11 Protection by interlocks**

Clause 15 of IEC 61010-1:2010 applies.

## **6.2.12 Hazards resulting from application**

Clause 16 of IEC 61010-1:2010 applies.

### 6.2.13 Risk assessment

Clause 17 of IEC 61010-1:2010 applies.

## 6.3 EMC requirements

### 6.3.1 General

This Subclause 6.3 applies only to TRD with active electronic components.

This Subclause 6.3 is applicable to transducers in applications with nominal voltage up to 1 000 V AC or 1 500 V DC.

NOTE For higher voltage applications, see relevant EMC standards.

TRD shall comply with the immunity requirements of 6.3.2 and the emission requirements of 6.3.3.

They shall also comply with the requirements of IEC 61326-1:2020 in regard to

- test plan,
- test,
- test report, and
- instructions of use.

### 6.3.2 Immunity requirements

TRD covered by 6.3.1 shall comply with IEC 61326-1:2020, Table 2, with:

- the ports as defined in the below Table 2,
- the performance criteria of 6.4 of IEC 61326-1:2020 are replaced by those defined in the below Table 3, and
- the recommendation that devices are tested at 5 kHz for IEC 61000-4-4, instead of 100 kHz.

**Table 2 – Definition of ports**

| Port                                                                                                                                                                                                                                                                                                                   | Items related to transducers                                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Enclosure                                                                                                                                                                                                                                                                                                              | Inner surface and outer surface of the transducer, including outer surface of connection cable and connectors.                                                                                                                                                                           |
| I/O signal/control                                                                                                                                                                                                                                                                                                     | Output terminals<br>Auxiliary power supply port when provided by the measuring equipment connected to the TRD2 output via the connector.<br>Memory management port when provided by the measuring equipment connected to the TRD2 output via the connector.<br>Functional earth, if any. |
| DC power <sup>a</sup>                                                                                                                                                                                                                                                                                                  | Protective earth.<br>Auxiliary power supply port, when supplied from an external power supply source.                                                                                                                                                                                    |
| AC power                                                                                                                                                                                                                                                                                                               | Protective earth.<br>Auxiliary power supply port, when supplied from an external power supply source.                                                                                                                                                                                    |
| <sup>a</sup> Power supply terminal intended to be connected to a low voltage DC supply ( $\leq 60$ V) where the power ports isolated from the AC mains are not subject to transient overvoltages (i.e. reliably grounded, capacitively filtered DC output circuits) and shall be regarded as I/O signal/control ports. |                                                                                                                                                                                                                                                                                          |

**Table 3 – Performance criteria for EMC immunity tests**

| Assessment criteria | Conditions for acceptance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A                   | <p>Normal performance within the accuracy specification limits during and after the test.</p> <p>No change in the operating state is allowed nor is loss of data.</p> <p>For transducers with digital output signal, this includes the state of quality and sync bits.</p> <p>During the tests, no individual sampled value error shall exceed 10 % of the rated value.</p> <p>A reset or restart is not allowed.</p>                                                                                                                                                                                                               |
| B                   | <p>Normal performance after the tests, within the accuracy specification limits for transducers.</p> <p>An unintended change of the operating state is allowed if self-recoverable. A temporary degradation of the performance is permitted during the tests, provided the function is self-recoverable, i.e. without user intervention, if this is described in the EMC test plan and if the information is provided to the end user.</p> <p>During the tests, no loss of stored data is allowed, and no individual sampled value error shall exceed 100 % of the nominal RMS value.</p> <p>A reset or restart is not allowed.</p> |
| C                   | <p>Temporary loss of function is permitted, provided the function is self-recoverable or can be restored by the operation of controls.</p> <p>A reset or restart is allowed, provided that, during this cycle, the output signal is either zeroed or the validity bit is set to invalid until the transducer is again within the normal performance limits.</p> <p>The recovery procedure shall be provided to the end user.</p> <p>No permanent damage to the equipment is allowed.</p> <p>After a reset or restart: normal performance within the accuracy specification limits</p>                                               |

### 6.3.3 Emission requirements

TRD covered by 6.3.1 shall comply with the requirements of 7.2 of IEC 61326-1:2020 for class A or class B equipment.

### 6.4 Climatic requirements

No general requirements.

### 6.5 Mechanical requirements

No general requirements.

### 6.6 Functional requirements

No general requirements

### 6.7 Marking requirements

No general requirements.

### 6.8 Documentation requirements

No general requirements.

## **7 Type tests**

No general requirements.

## **8 Routine tests**

No general requirements.

## Annex A (normative)

### Requirements for TRD1

#### A.1 General

Clause 1 of this document applies.

#### A.2 References for the purposes of this Annex A

Clause 2 of this document applies.

#### A.3 Terminology for the purposes of this Annex A

Clause 3 of this document applies.

#### A.4 Environmental conditions

The conditions of temperature and humidity are classified according to the severity dictated by the usage group in accordance with Table A.1.

**Table A.1 – Usage groups**

|                                                                                    | K55 class of transducer | K70 class of transducer | Kx <sup>b</sup> class of transducer                  |
|------------------------------------------------------------------------------------|-------------------------|-------------------------|------------------------------------------------------|
| <b>Usage group</b>                                                                 | I                       | II                      | III                                                  |
| <b>Rated operating range<br/>(with specified uncertainty)</b>                      | –5 °C to +55 °C         | –25 °C to +70 °C        | Above +70 °C and/or under –25 °C <sup>a</sup>        |
| <b>Limit range of operation<br/>(no hardware failures)</b>                         | –5 °C to +55 °C         | –25 °C to +70 °C        | Above +70 °C and/or under –25 °C <sup>a</sup>        |
| <b>Limit range for storage and transport</b>                                       | –25 °C to +70 °C        | –40 °C to +85 °C        | According to manufacturer specification <sup>a</sup> |
| <sup>a</sup> Limits shall be defined by manufacturer according to the application. |                         |                         |                                                      |
| <sup>b</sup> Kx stands for extended conditions.                                    |                         |                         |                                                      |

For the purpose of this document, ambient temperature shall be the temperature measured at a single representative point with the transducer operating normally. This measuring point shall be adjacent to the transducer, exposed to free air circulation and not significantly affected by heat from the transducer or by direct solar radiation and other sources of heat.

Humidity is not considered to be an influence quantity provided that the environmental conditions are within the limits specified.

#### A.5 Ratings

No ratings.

## A.6 Requirements for design and construction of TRD1

### A.6.1 General

Subclause 6.1 of this document applies.

Compliance with requirements of Clause A.6 shall be verified by all applicable tests in accordance with Clause A.7.

### A.6.2 Safety requirements

Subclause 6.2 of this document applies.

### A.6.3 EMC requirements

Subclause 6.3 of this document applies.

### A.6.4 Climatic requirements

Subclause 6.4 of this document applies.

### A.6.5 Mechanical requirements

Subclause 6.5 of this document applies.

### A.6.6 Functional requirements

#### A.6.6.1 Class index requirements

##### A.6.6.1.1 Class index

The class index for a transducer shall be chosen from those given in Table A.2.

This class index definition applies only for the analogue secondary output of the transducers.

**Table A.2 – Relationship between the limits of intrinsic error, expressed as a percentage of the fiducial value, and the class index**

| Class index                                                        | 0,2    | 0,5    | 1    | 2    | 2,5    | 3    | 5    | 10    | 20    |
|--------------------------------------------------------------------|--------|--------|------|------|--------|------|------|-------|-------|
| Limits of error                                                    | ±0,2 % | ±0,5 % | ±1 % | ±2 % | ±2,5 % | ±3 % | ±5 % | ±10 % | ±20 % |
| Class indices of 0,3 and 1,5, although non-preferred, may be used. |        |        |      |      |        |      |      |       |       |

##### A.6.6.1.2 Class index for transducer used with sensors

If the transducers are used with sensors, the manufacturer shall specify the accuracy class of the whole system transducer and sensor.

In some cases when a transducer does not include the sensors, their associated uncertainties are not considered. When a transducer includes the sensors, their associated uncertainties are considered.

##### A.6.6.1.3 Intrinsic error

When the transducer is under reference conditions, the error at any point between the upper and lower nominal values of the output signal shall not exceed the limits of the intrinsic error given in Table A.2 expressed as a percentage of the fiducial value.

Values stated in a table of corrections, if any, supplied with the transducer shall not be taken into account in determining the errors.

#### A.6.6.2 Conditions for the determination of intrinsic error

Prior to pre-conditioning and before determination of the intrinsic error, preliminary adjustments shall be carried out in accordance with the manufacturer's instructions. The transducer shall be at the reference temperature.

The transducer shall be left in circuit under the conditions specified in Table A.3.

**Table A.3 – Pre-conditioning**

| Conditions                                                                | Values          |
|---------------------------------------------------------------------------|-----------------|
| Voltage (including any auxiliary supply)                                  | Nominal value   |
| Current                                                                   | Nominal value   |
| Frequency                                                                 | Reference value |
| Power factor                                                              | Reference value |
| Time between connection into circuit and start of determination of errors | 30 min          |

After the specified pre-conditioning, transducers having adjustments available to the user shall be adjusted in accordance with the manufacturer's instructions.

The reference conditions relative to each of the influence quantities are given in Table A.4. The reference conditions relative to the measurand are given in Table A.5.

**Table A.4 – Reference conditions of the influence quantities and tolerances for testing purposes**

| Influence quantity                                                                                                                                                                                                    | Reference conditions unless otherwise marked | Tolerances permitted for testing purposes applicable to a single reference value <sup>a</sup>                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Ambient temperature                                                                                                                                                                                                   | To be marked in the type test report         | ±1 °C                                                                                                        |
| Usage group (see A.4)                                                                                                                                                                                                 |                                              |                                                                                                              |
| I                                                                                                                                                                                                                     | K55                                          | –                                                                                                            |
| II                                                                                                                                                                                                                    | K70                                          | –                                                                                                            |
| III                                                                                                                                                                                                                   | Kx <sup>b</sup>                              | –                                                                                                            |
| Frequency of the input quantity                                                                                                                                                                                       |                                              |                                                                                                              |
| Non-frequency sensitive                                                                                                                                                                                               | Nominal value                                | ±2 %                                                                                                         |
| Frequency sensitive                                                                                                                                                                                                   | To be marked in the type test report         | ±0,1 %                                                                                                       |
| Waveform of the input quantity                                                                                                                                                                                        | Sinusoidal, except for harmonics transducers | The distortion factor × 100 shall not exceed the class index, unless otherwise specified by the manufacturer |
| Output load                                                                                                                                                                                                           |                                              |                                                                                                              |
| Fixed output load transducers                                                                                                                                                                                         | Nominal value                                | ±1 %                                                                                                         |
| Variable output load transducers                                                                                                                                                                                      | Mean value of the nominal range              | ±1 %                                                                                                         |
| Auxiliary supply                                                                                                                                                                                                      |                                              |                                                                                                              |
| Voltage AC                                                                                                                                                                                                            | Nominal value                                | ±2 %                                                                                                         |
| Voltage DC                                                                                                                                                                                                            | Nominal value                                | ±1 %                                                                                                         |
| Frequency                                                                                                                                                                                                             | Nominal value                                | ±1 %                                                                                                         |
| Distortion factor                                                                                                                                                                                                     | 0,05 maximum                                 | –                                                                                                            |
| Magnetic field of external origin                                                                                                                                                                                     | Total absence                                | 40 A/m at frequencies from DC to 65 Hz in any direction <sup>c</sup>                                         |
| <sup>a</sup> When a reference range is marked, no tolerance is allowed.<br><sup>b</sup> "Kx" stands for extended conditions.<br><sup>c</sup> 40 A/m is approximately the highest value of the earth's magnetic field. |                                              |                                                                                                              |

**Table A.5 – Reference conditions relative to the measurand**

| Measurand                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Reference conditions              |                                       |                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|---------------------------------------|---------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Voltage                           | Current                               | Power factor, active or reactive                                          |
| Apparent power                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Nominal voltage $\pm 2\%$         | Any current up to the nominal current | $ \cos \varphi $ or $ \sin \varphi  = 1,0$ to $0,8$<br>lagging or leading |
| Active power                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Nominal voltage $\pm 2\%$         | Any current up to the nominal current | $ \cos \varphi  = 1,0$ to $0,8$<br>lagging or leading                     |
| Reactive power                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Nominal voltage $\pm 2\%$         | Any current up to the nominal current | $ \sin \varphi  = 1,0$ to $0,8$<br>lagging or leading <sup>a</sup>        |
| Phase angle or power factor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Nominal voltage $\pm 2\%$         | 40 % to 100 % of the nominal current  | –                                                                         |
| Frequency                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Nominal voltage $\pm 2\%$         | –                                     | –                                                                         |
| Polyphase quantities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Symmetrical voltages <sup>b</sup> | Symmetrical currents <sup>b</sup>     | –                                                                         |
| <sup>a</sup> Apparent, active power and reactive power transducers are normally used together and are connected to the same current and voltage transformers.<br><sup>b</sup> The difference between any two line-to-line voltages and between any two line-to-neutral voltages shall not exceed 1 % of the average (line-to-line and line-to-neutral voltages respectively). Each of the currents in the phases shall differ by not more than 1 % from the average of the currents.<br>The angles between each of the currents and the corresponding phase-to-neutral (star) voltages shall differ by not more than $2^\circ$ .<br>Where interactions between the separate measuring elements of a multi-element transducer are adequately characterized, single-phase testing of the transducer is acceptable. |                                   |                                       |                                                                           |

### A.6.6.3 Power supply

#### A.6.6.3.1 General

Some transducers dealt with in this document may need an auxiliary supply. This is specified in two separate categories, DC and AC supplies.

The power supply may be provided by a separate auxiliary supply or may be derived from the measured voltage or current.

#### A.6.6.3.2 DC supply

- The value of the voltage of the DC supply shall be as specified in A.6.6.4.3.
- The battery supply may be earthed or floating. Suitable means shall be provided in the transducer to ensure isolation between the power supply and the input/output circuits of the transducer (for details of voltage tests, see A.7.19.1.4).
- The transducer shall withstand any voltage ripple up to a maximum of 10 % peak to peak superimposed on the DC power supply.
- The noise fed back to the battery from the transducer shall be limited to 100 mV peak to peak when measured with a specified source resistance at all frequencies up to 100 MHz.

In addition, when the battery feeding the transducer is also used for telephone equipment, the noise shall not exceed 2 mV psophometric.

NOTE The psophometric weighting characteristic is specified in ITU-T Recommendation O.41.

#### A.6.6.3.3 AC supply

There is no requirement on the nominal value of the voltage of the AC power supply.

#### **A.6.6.4 Input values**

##### **A.6.6.4.1 General**

The nominal values of voltage, current, frequency and auxiliary supply shall be specified by the manufacturer.

##### **A.6.6.4.2 Adjustment ranges**

Adjustment range for transducers that can be adjusted by the user:

- a) for the input voltage: 80 % to 120 % of the nominal value;
- b) for the input current: 60 % to 130 % of the nominal value.

This means that the nominal value of the output signal can be obtained for any calibration value of the measurand within the ranges given above.

##### **A.6.6.4.3 Preferred nominal values**

The preferred nominal value of DC auxiliary supplies shall be 24 V, 48 V, 110 V or 220 V.

#### **A.6.6.5 Analogue output values**

##### **A.6.6.5.1 General**

The lower and upper nominal values of the output signal and the compliance voltage shall be chosen from those given in A.6.6.5.2 and A.6.6.5.3 or A.6.6.5.6.

##### **A.6.6.5.2 Output current**

The signal 4 mA to 20 mA is preferred.

NOTE The condition "0 mA" has a special meaning (IEC 60381-1).

Other permissible values are

- 0 mA to 20 mA,
- 0 mA to 1 mA,
- 0 mA to 10 mA,
- –1 mA to 1 mA,
- –5 mA to 5 mA,
- –10 mA to 10 mA, and
- –20 mA to 20 mA.

##### **A.6.6.5.3 Compliance voltage**

Permissible values are:

- 10 V;
- 15 V.

##### **A.6.6.5.4 Maximum output voltage**

The manufacturer shall state the maximum value of the output voltage occurring under any conditions of output load and input. This voltage shall not exceed the limit of safety extra-low voltage (SELV).

#### A.6.6.5.5 Interference risk of output current

Attention is drawn to the interference problems which may result if the output current has a low value.

#### A.6.6.5.6 Output voltage

Permissible values are:

- 0 V to 1 V;
- 0 V to 5 V;
- 0 V to 10 V;
- –1 V to 1 V;
- –10 V to 10 V;
- –5 V to 5 V.

NOTE Transducers having a voltage output are non-preferred.

#### A.6.6.6 Output transfer function

For analogue transducers, the used transfer function shall be one of the following curves.

For analogue transducers, variables  $x$ ,  $y$  can be adjustable.

Curve A is described in Figure A.1

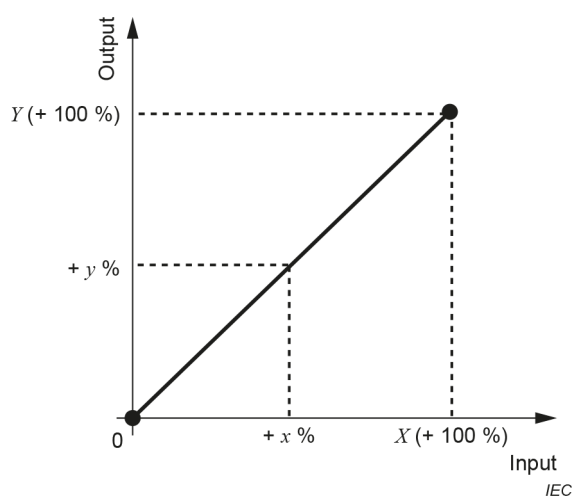


Figure A.1 – Transfer function curve A

Curve B is described in Figure A.2.

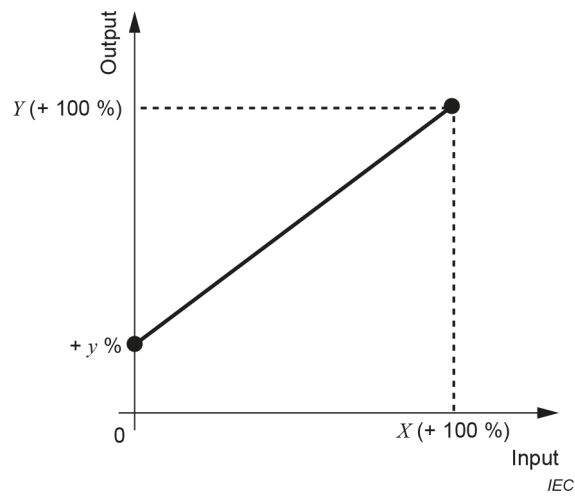


**Figure A.2 – Transfer function curve B**

Curve C is described in Figure A.3.

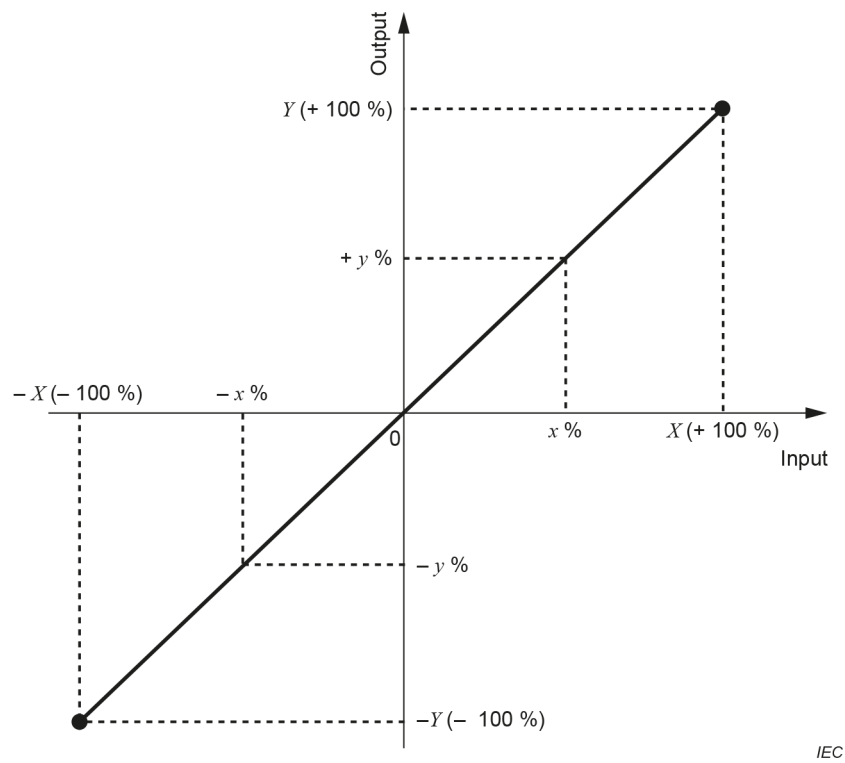


**Figure A.3 – Transfer function curve C**

Curve D is described in Figure A.4.

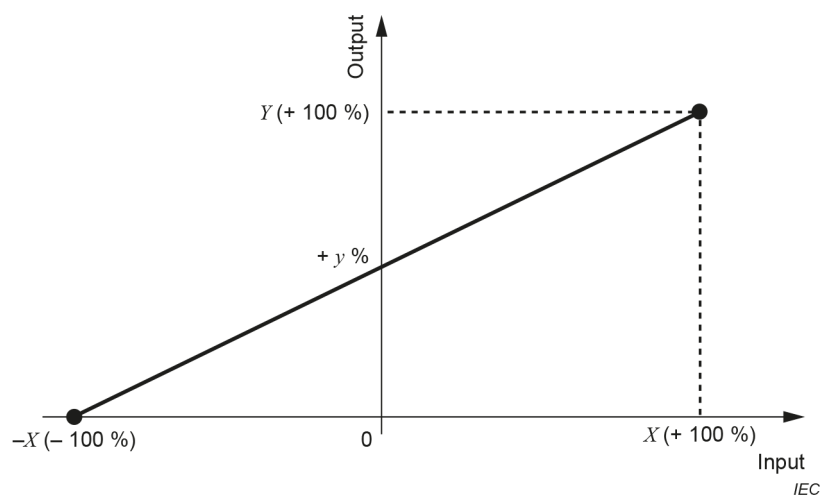


**Figure A.4 – Transfer function curve D**

Curve E is described in Figure A.5.

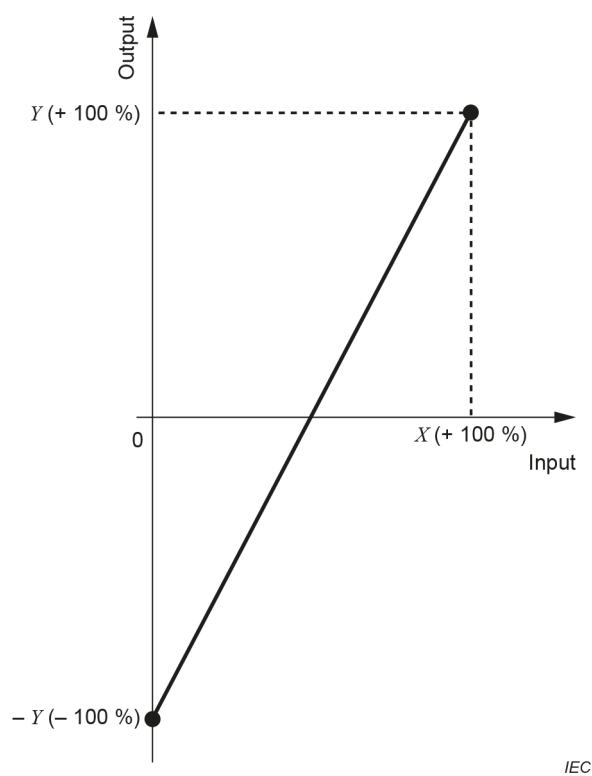


**Figure A.5 – Transfer function curve E**

Curve F is all other kinds of curves.

The accuracy class shall be checked for each point of the transfer function according to the formula:

$$\frac{Y - R}{R} \times 100$$

where

$R$  is the value of the output signal under reference conditions;

$Y$  is the value of the output signal measured at one extreme of the influence quantity.

For the curves  $F$ ,  $F$  shall be replaced by  $R$  in the calculations in A.7.2 to A.7.18.

#### **A.6.6.7 Pulse output signals**

The digital output signals chosen shall correspond with the requirements for transducers concerning accuracy and response time as well as with the requirements of the communication system.

#### **A.6.6.8 Ripple (for analogue outputs)**

The maximum ripple content in the output signal shall not exceed twice the class index.

#### **A.6.6.9 Response time**

Before determining the response time, the transducer shall be under reference conditions and the auxiliary circuit shall be energized for at least the pre-conditioning time unless it is energized from one of the input quantities and is not separately accessible.

The response time shall be stated by the manufacturer and shall be determined for an input step such that it would produce a change in output signal from 0 % to 90 % of the fiducial value.

If a test for decreasing input is required, the input step should produce a change in output signal from 100 % to 10 % of the fiducial value.

The interval (see 3.2.18) shall be  $\pm 1$  % of the upper nominal value of the output signal.

Methods of test for frequency transducers and transducers with suppressed zero shall be stated by the manufacturer.

#### **A.6.6.10 Variation due to over-range of the measurand**

If, by agreement, a transducer is required to operate with an input up to 150 % of the nominal value, the difference between the intrinsic error at 100 % and the error at 150 % (under reference conditions) of the nominal value of the input shall not exceed 50 % of the class index.

For active power and reactive power transducers, 150 % of the nominal value is achieved by increasing the current while retaining the voltage at the nominal value.

#### **A.6.6.11 Limiting value of the output signal**

The output signal shall be limited to a maximum of twice the upper nominal value.

When the measurand is not between its lower and upper nominal values, the transducer shall not, under any conditions, for example over-current or under-voltage, produce an output having a value between its lower and upper nominal values.

#### **A.6.6.12 Limiting conditions of operation**

The limits of the nominal ranges of use given in A.6.7 are those within which the transducer will comply with the requirements of this document. It is possible to operate transducers beyond these limits, but the user should note that it is possible that:

- the accuracy will not be maintained, and/or
- the designed operational lifetime will be reduced.

As an example, many transducers will operate in ambient temperatures as low as  $-25\text{ }^{\circ}\text{C}$  and as high as  $+70\text{ }^{\circ}\text{C}$  but the manufacturer should be consulted as to the degradation to be expected in both accuracy and operational lifetime.

#### **A.6.6.13 Limits of the measuring range**

When the limits of the measuring range do not coincide with the lower and upper nominal values of the output, the limits of the measuring range shall be marked – see A.6.7.2.

#### **A.6.6.14 Limiting conditions for storage and transport**

Unless otherwise stated by the manufacturer, transducers shall be capable of withstanding, without damage, exposure to temperatures within the range specified in Table A.1 for storage and transport.

After returning to reference conditions, they shall meet the requirements of this document.

The manufacturer shall specify any additional limiting condition required to ensure the integrity of the transducer.

#### **A.6.6.15 Sealing**

When the transducer is sealed to prevent unauthorized adjustment, access to the internal circuit and to the components within the case shall not be possible without destroying the seal.

#### **A.6.6.16 Stability**

Transducers shall comply with the relevant limits of intrinsic error specified for their respective accuracy classes for a period specified by the manufacturer, provided that the conditions of use, transport and storage specified by the manufacturer are complied with.

NOTE Usually, the period will be below one year.

### **A.6.7 Marking requirements**

#### **A.6.7.1 General**

Subclause 6.7 applies in addition to the below requirements.

#### **A.6.7.2 Marking on the case**

Transducers shall bear, in addition to markings required by IEC 61010-1 and IEC 61010-2-030, on (or visible through) one of the external surfaces of the case, the markings listed below. The markings shall be legible and indelible. The symbols referred to below are specified in Table A.7.

- a) Class index (symbol E-10 or E-11).
- b) Nature of the measurand and number of circuits (symbol B-2, B-4 or B-6 to B-10).
- c) Lower and upper nominal values (RMS values if AC) of the measurand.
- d) Ratios of current transformers and voltage transformers, if any, with which the transducer is intended to be used.

- e) Range of values of the output current (voltage) and output load within which specified operation is obtained (analogue signals only).
- f) Limits of the measuring range, if appropriate (see A.6.6.13).
- g) Symbol showing that some other essential information is given in a separate document (symbol F-33).
- h) Space for adjustment data (if appropriate).
- i) Nominal range of use for temperature, according to usage group I, II or III.
- j) Common mode voltage.

TRD1 should be marked with the reference of this document.

If the markings and symbols are on an easily removable part, such as a cover, the transducer shall have a serial number which shall also be marked on the body of the transducer.

Transducers having a non-linear relationship between input and output shall be marked with the symbol F-33, and actual relationship between input and output shall be given in a separate document.

#### A.6.7.3 Markings relating to the reference conditions and nominal ranges of use for transducers

The reference values (or ranges) and nominal ranges of use, if different from those given in Table A.4 and Table A.5 and A.6.6, shall be marked on the transducer or given in a separate document.

When a reference value or a reference range is marked, it shall be identified by underlining.

Table A.6 shows the significance of the various markings, for example for temperature.

**Table A.6 – Examples of marking relating to the reference conditions and nominal range of use for temperature**

| Example                                                                                             | Meaning                                                                 |
|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| –5 ... <u>23</u> ... 55 °C                                                                          | Conforms to group I                                                     |
| –25 ... <u>15</u> ... <u>30</u> ... 70 °C                                                           | Conforms to group II                                                    |
| –35 ... <u>0</u> ... <u>45</u> ... 75 °C                                                            | Conforms to group III                                                   |
| 0 ... <u>25</u> ... 40 °C                                                                           | Reference value: 25 °C<br>Nominal range of use: 0 °C to 40 °C           |
| –5 ... <u>20</u> ... <u>30</u> ... 35 °C                                                            | Reference range: 20 °C to 30 °C<br>Nominal range of use: –5 °C to 35 °C |
| Three or four numbers shall always be used, and the reference conditions range shall be underlined. |                                                                         |

#### A.6.7.4 Identification of connections and terminals

If so required for the correct use of the transducer, a diagram or table of connections shall be supplied, and the terminals shall be clearly marked to show the proper method of connection.

If a terminal of a measuring circuit is intended to be kept at, or near to earth (ground) potential (for example, for safety or functional reasons), it shall either be marked with a capital N if it is intended to be connected to the neutral conductor of an AC supply circuit, or it shall be marked with symbol F-45 (see Table A.7) in all other circumstances.

The earthing terminal(s) shall be marked using symbol(s) F-31 and/or F-42 to F-45, as appropriate.

**Table A.7 – Symbols for marking transducers**

| No.                                                                     | Item                                                                        |                                                            | Symbol    |
|-------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------------------------------------------------------|-----------|
| <b>B Nature of input quantity(ies) and number of measuring circuits</b> |                                                                             |                                                            |           |
| B-1                                                                     | DC circuit (for auxiliary supply only)                                      | IEC 60417-5031 (2002-10)                                   |           |
| B-2                                                                     | AC circuit (single phase)                                                   | IEC 60417-5032 (2002-10)                                   |           |
| B-3                                                                     | DC and AC circuit                                                           | IEC 60417-5033 (2002-10)                                   |           |
| B-4                                                                     | Three-phase AC circuit (general symbol)                                     | IEC 60417-5032-1 (2002-10)                                 | 3         |
| B-6                                                                     | One measuring element for three-wire network                                | IEC 60417-5032-1 (2002-10), modified – "1E" has been added | 3  1E     |
| B-7                                                                     | One measuring element for four-wire network                                 | IEC 60417-5032-2 (2002-10), modified – "1E" has been added | 3N  1E    |
| B-8                                                                     | Two measuring elements for three-wire network with unbalanced load          | IEC 60417-5032-1 (2002-10), modified – "2E" has been added | 3  2E     |
| B-9                                                                     | Two measuring elements for four-wire network with unbalanced load           | IEC 60417-5032-2 (2002-10), modified – "2E" has been added | 3N  2E    |
| B-10                                                                    | Three measuring elements for four-wire network with unbalanced load         | IEC 60417-5032-2 (2002-10), modified – "3E" has been added | 3N  3E    |
| <b>C Safety (see IEC 61010-1:2010)</b>                                  |                                                                             |                                                            |           |
| <b>E Accuracy class</b>                                                 |                                                                             |                                                            |           |
| E-10                                                                    | Class index (e.g. 1) when the fiducial value corresponds to the span        | ---                                                        | 1         |
| E-11                                                                    | Class index (e.g. 0,5) when the fiducial value corresponds to half the span | ---                                                        | 0,5 / 0,5 |
| <b>F General symbols</b>                                                |                                                                             |                                                            |           |
| F-31                                                                    | Earth (ground) terminal (general symbol)                                    | IEC 60417-5017 (2006-08)                                   |           |
| F-33                                                                    | Caution, (refer to a separate document)                                     | ISO 7000-0434B (2004-01)                                   |           |
| F-42                                                                    | Frame or chassis terminal                                                   | IEC 60417-5020 (2002-10)                                   |           |
| F-43                                                                    | Protective earth (ground) terminal                                          | IEC 60417-5019 (2006-08)                                   |           |
| F-44                                                                    | Functional earth terminal                                                   | IEC 60417-5018 (2011-07)                                   |           |

| No.                                                                     | Item                                      |                          | Symbol                                                                              |
|-------------------------------------------------------------------------|-------------------------------------------|--------------------------|-------------------------------------------------------------------------------------|
| <b>B Nature of input quantity(ies) and number of measuring circuits</b> |                                           |                          |                                                                                     |
| F-45                                                                    | Measuring circuit earth (ground) terminal | IEC 60417-5017 (2006-08) |  |
| F-46                                                                    | Positive terminal                         | IEC 60417-5005 (2002-10) |  |
| F-47                                                                    | Negative terminal                         | IEC 60417-5006 (2002-10) |  |

### A.6.8 Documentation requirements

The following information shall be given in the document supplied with the transducer, in addition to documentation elements specified in IEC 61010-1 and IEC 61010-2-030:

- response time;
- the variation due to a magnetic field of external origin;
- the actual relationship between input and output (see required indications according to type of curves given in A.6.6.1 for output current transfer functions);
- EMC emission class A or class B;
- safety class: class F or class D;
- type of use: outdoor and/or indoor;
- any information from A.6.7.2 that could not fit onto the transducer.

## A.7 Type tests for TRD1

### A.7.1 General

Clause 7 of this document applies in addition to the below requirements.

### A.7.2 General additional requirements for type tests for TRD1

#### A.7.2.1 Determination of variations

The variation due to an influence quantity shall be determined for each influence quantity. During the tests, all other influence quantities shall be maintained at reference conditions.

All the influence quantities are given in A.7.3 to A.7.23, together with the appropriate testing procedure, computations and the permissible variations for each usage group expressed as a percentage of the class index. None of the variations determined shall exceed the permissible values.

Variations shall be determined at the upper nominal value of the output and, at least, at one other point.

For apparent power, active power and reactive power transducers, these values shall be obtained by maintaining the voltage and power factor at their reference conditions and varying the value of the current.

For DC power transducers, these values shall be obtained by maintaining the voltage at its reference conditions and varying the value of the current.

When a reference range is specified, the influence quantity shall be varied between each of the limits of the reference range and any value in that part of the nominal range of use which is adjacent to the chosen limit of the reference range.

### A.7.2.2 Computations

In A.7.2.2 to A.7.23, a computation is required according to a formula. The terms in the formulae follow a general principle:

- $R$  is the value of the output signal under reference conditions;
- $X$  (or  $Y$ ) is the value of the output signal measured at one extreme of the influence quantity;
- $F$  is the fiducial value.

NOTE For curves F (see A.6.6.6) replace in all the following formulae  $F$  with  $R$ .

## A.7.3 Variations due to auxiliary supply voltage

### A.7.3.1 Application

All transducers requiring a DC or an AC auxiliary supply except where this is obtained from the input voltage or current and the connections cannot be separated for testing purposes.

### A.7.3.2 Procedure

Apply the nominal value of auxiliary supply voltage and record the value of the output signal ( $R$ ).

At a constant value of the measurand, reduce the auxiliary supply voltage to the lower limit given in A.7.3.4 and record the value of the output signal ( $X$ ). Increase the auxiliary supply voltage to the upper limit given in A.7.3.4 and record the value of the output signal ( $Y$ ).

### A.7.3.3 Computation

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

### A.7.3.4 Permissible variations

For AC auxiliary supplies, Table A.8 applies.

**Table A.8 – Permissible variations due to AC auxiliary supply**

| Usage group | Nominal range of use<br>% | Variation<br>% of class index |
|-------------|---------------------------|-------------------------------|
| I           | 90 to 110                 | 50                            |
| II          | 80 to 120                 | 50                            |
| III         | 80 to 120                 | 50                            |

For DC auxiliary supplies, Table A.9 applies.

**Table A.9 – Permissible variations due to DC auxiliary supply**

| Usage group | Nominal range of use<br>% | Variation<br>% of class index |
|-------------|---------------------------|-------------------------------|
| I           | 85 to 125                 | 50                            |
| II          | 85 to 125                 | 50                            |
| III         | 85 to 125                 | 50                            |

**A.7.4 Variations due to auxiliary supply frequency****A.7.4.1 Application**

All transducers requiring an AC auxiliary supply except where this is obtained from the input voltage or current and the connections cannot be separated for testing purposes.

**A.7.4.2 Procedure**

Apply the nominal value of auxiliary supply frequency and record the value of the output signal ( $R$ ). At a constant value of the measurand, reduce the auxiliary supply frequency to the lower limit given in A.7.4.4 and record the value of the output signal ( $X$ ).

Increase the auxiliary supply frequency to the upper limit given in A.7.4.4 and record the value of the output signal ( $Y$ ).

**A.7.4.3 Computation**

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

**A.7.4.4 Permissible variations**

Table A.10 applies.

**Table A.10 – Permissible variations due to auxiliary supply frequency**

| Usage group | Nominal range of use<br>% | Variation<br>% of class index |
|-------------|---------------------------|-------------------------------|
| I           | 90 to 110                 | 50                            |
| II          | 90 to 110                 | 50                            |
| III         | 90 to 110                 | 50                            |

**A.7.5 Variations due to ambient temperature****A.7.5.1 Application**

All transducers.

**A.7.5.2 Procedure**

At a constant value of the measurand and at reference temperature, record the value of the output signal ( $R$ ).

Increase the ambient temperature to the upper limit given in A.7.5.4 and allow sufficient time for conditions to stabilize (30 min is usually adequate). Record the value of the output signal ( $X$ ).

Reduce the ambient temperature to the lower limit given in A.7.5.4 and allow the same stabilization to take place. Record the stabilization time and the value of the output signal ( $Y$ ).

### A.7.5.3 Computation

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

### A.7.5.4 Permissible variations

Table A.11 applies.

**Table A.11 – Permissible variations due to ambient temperature**

| Usage group | Nominal range of use<br>°C | Variation<br>% of class index |
|-------------|----------------------------|-------------------------------|
| I           | 10 to 35                   | 100                           |
| II          | 0 to 45                    | 100                           |
| III         | –10 to 55                  | 100                           |

## A.7.6 Variations due to the frequency of the input quantity(ies)

### A.7.6.1 Application

All transducers except frequency transducers and DC transducers. Frequency sensitive transducers (e.g. those employing phase shifting circuits) are exceptions and the nominal range of use shall always be marked.

### A.7.6.2 Procedure

Apply the nominal value of the input frequency and record the value of the output signal ( $R$ ).

At a constant value of the measurand, reduce the frequency to the lower limit given in A.7.6.4 and record the value of the output signal ( $X$ ).

Increase the frequency to the upper limit given in A.7.6.4 and record the value of the output signal ( $Y$ ).

### A.7.6.3 Computation

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

#### A.7.6.4 Permissible variations

Table A.12 applies.

**Table A.12 – Permissible variations due to the frequency of input quantity**

| Usage group         | Nominal frequency range of use<br>% | Variation<br>% of class index |
|---------------------|-------------------------------------|-------------------------------|
| I                   | 90 to 110                           | 100                           |
| II                  | 90 to 110                           | 100                           |
| III                 | 90 to 110                           | 100                           |
| Frequency sensitive | As marked                           | 100                           |

#### A.7.7 Variations due to the input voltage

##### A.7.7.1 Application

Subclause A.7.7 applies to all transducers except voltage and current transducers.

##### A.7.7.2 Procedure

Apply the nominal value of the input voltage and record the value of the output signal ( $R$ ).

At a constant value of the measurand, reduce the voltage to the lower limit given in A.7.7.4 and record the value of the output signal ( $X$ ).

Increase the voltage to the upper limit given in A.7.7.4 and record the value of the output signal ( $Y$ ).

##### A.7.7.3 Computation

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

##### A.7.7.4 Permissible variations

Table A.13 applies.

**Table A.13 – Permissible variations due to the input voltage**

| Usage group | Nominal range of use<br>% | Variation<br>% of class index |
|-------------|---------------------------|-------------------------------|
| I           | 80 to 110                 | 50                            |
| II          | 80 to 120                 | 50                            |
| III         | 80 to 120                 | 50                            |

#### A.7.8 Variations due to the input current

##### A.7.8.1 Application

Subclause A.7.8 applies to phase angle transducers and power factor transducers.

**A.7.8.2 Procedure**

Apply the nominal value of the input current and record the value of the output signal ( $R$ ).

At a constant value of the measurand, reduce the input current to the lower limit given in A.7.8.4 and record the value of the output signal ( $X$ ).

Increase the input current to the upper limit given in A.7.8.4 and record the value of the output signal ( $Y$ ).

**A.7.8.3 Computation**

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

**A.7.8.4 Permissible variations**

Table A.14 applies.

**Table A.14 – Permissible variations due to the input current**

| Usage group | Nominal range of use<br>% | Variation<br>% of class index |
|-------------|---------------------------|-------------------------------|
| I           | 20 to 120                 | 100                           |
| II          | 20 to 120                 | 100                           |
| III         | 20 to 120                 | 100                           |

**A.7.9 Variations due to power factor****A.7.9.1 Application**

Subclause A.7.9 applies to apparent, active and reactive power transducers.

**A.7.9.2 Procedure**

Apply respectively 50 % (5 %) of the nominal value of the input current at a power factor of 1,0 and record the two values of the output signal ( $R$ ). At a constant value of the measurand, increase the input current to 100 % (10 %) of the nominal value and reduce the power factor to 0,5 lag/lead, respectively. Record the two values of the output signal ( $X$ ).

For convenience, when testing the reactive power transducers, it is usual to apply the equivalent values of  $\sin \varphi$ .

Active power transducers shall also be tested for error at a power factor of zero and reactive power transducers at a  $\sin \varphi = 0$ .

### A.7.9.3 Computation

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

### A.7.9.4 Permissible variations

Table A.15 applies.

**Table A.15 – Permissible variations due to power factor**

| Usage group | Nominal range of use                        | Variation<br>% of class index |
|-------------|---------------------------------------------|-------------------------------|
| I           | Cos (sin) $\varphi = 0,5 \dots 1 \dots 0,5$ | 50                            |
| II          | Cos (sin) $\varphi = 0,5 \dots 1 \dots 0,5$ | 50                            |
| III         | Cos (sin) $\varphi = 0,5 \dots 1 \dots 0,5$ | 50                            |

For all transducers, the error at a power factor of zero (or  $\sin \varphi = 0$ ) shall not exceed 100 % of the class index.

### A.7.10 Variation due to output load

#### A.7.10.1 Application

Subclause A.7.10 applies to all variable output load transducers.

#### A.7.10.2 Procedure

Apply a value of output load equal to the mean value of the nominal range and record the value of the output signal ( $R$ ).

At a constant value of the measurand, reduce the resistance of the output load to the lower limit given in A.7.10.4 and record the value of the output signal ( $X$ ).

Increase the resistance of the output load to the upper limit given in A.7.10.4 and record the value of the output signal ( $Y$ ).

#### A.7.10.3 Computation

The variations are:  $\frac{X - R}{F} \times 100$

and:  $\frac{Y - R}{F} \times 100$

#### A.7.10.4 Permissible variations

Table A.16 applies.