

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Reference conditions and procedures for testing industrial and process measurement transmitters –

Part 1: General procedures for all types of transmitters

Conditions de référence et procédures pour l'essai des transmetteurs de mesure industrielle et de processus –

Partie 1: Procédures générales pour tous les types de transmetteurs



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INTERNATIONAL STANDARD

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**Reference conditions and procedures for testing industrial and process
measurement transmitters –**

Part 1: General procedures for all types of transmitters

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mesure industrielle et de processus –**

Partie 1: Procédures générales pour tous les types de transmetteurs

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

REFERENCE CONDITIONS AND PROCEDURES FOR TESTING INDUSTRIAL
AND PROCESS MEASUREMENT TRANSMITTERS –

Part 1: General procedures for all types of transmitters

FOREWORD

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International Standard IEC 62828-1 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

The IEC 62828 series cancels and replaces the IEC 60770 series and proposes revisions for the IEC 61298 series.

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

FDIS	Report on voting
65B/1100/FDIS	65B/1107/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62828 series, published under the general title *Reference conditions and procedures for testing industrial and process measurement transmitters*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Most of the current IEC standards on industrial and process measurement transmitters are rather old and were developed having in mind devices based on analogue technologies. Today's digital industrial and process measurement transmitters are quite different from those analogue transmitters: they include more functions and newer interfaces, both towards the computing section (mostly digital electronic) and towards the measuring section (mostly mechanical). Even if some standards dealing with digital process measurement transmitters already exist, they are not sufficient, since some aspects of the performance are not covered by appropriate test methods.

In addition, existing IEC test standards for industrial and process measurement transmitters are spread over many documents, so that for manufacturers and users it is difficult, impractical and time-consuming to identify and select all the standards to be applied to a device measuring a specific process quantity (pressure, temperature, flow, level, etc.).

To help manufacturers and users, it was decided to review, complete and reorganize the relevant IEC standards and to create a more suitable, effective and comprehensive standard series that provides in a systematic way all the necessary specifications and tests required for different industrial and process measurement transmitters.

To solve the issues mentioned above and to provide an added value for the stakeholders, the new standard series on industrial and process measurement transmitters covers the following main aspects:

- Applicable normative references
- Specific terms and definitions
- Typical configurations and architectures for the various types of industrial and process measurement transmitters
- Hardware and software aspects
- Interfaces (to the process, to the operator, to the other measurement and control devices)
- Physical, mechanical and electrical requirements and relevant tests; clear definition of the test categories: type tests, acceptance tests and routine tests
- Performance (its specification, tests and verification)
- Environmental protection, hazardous areas application, functional safety, etc.
- Structure of the technical documentation.

To cover in a systematic way all the topics to be addressed, the standard series is organized in several parts. At the moment of the publication of this document, IEC 62828 consists of the following parts:

- *Part 1: General procedures for all types of transmitters*
- *Part 2: Specific procedures for pressure transmitters*
- *Part 3: Specific procedures for temperature transmitters*
- *Part 4: Specific procedures for level transmitters*
- *Part 5: Specific procedures for flow transmitters*

In preparing the IEC 62828 series many test procedures were taken, with the necessary improvements, from the IEC 61298 series. As the actual IEC 61298 series is applicable to all process measurement and control devices, when the IEC 62828 series is completed the IEC 61298 series will be revised to harmonise it with the IEC 62828 series, taking out from its scope the industrial and process measurement transmitters. During the time when 61298 scope is being updated, the new series IEC 62828 takes precedence for industrial and process measurement transmitters.

When the IEC 62828 series is published, the IEC 60770 series will be withdrawn.

REFERENCE CONDITIONS AND PROCEDURES FOR TESTING INDUSTRIAL AND PROCESS MEASUREMENT TRANSMITTERS –

Part 1: General procedures for all types of transmitters

1 Scope

This Part of IEC 62828 establishes a general framework for defining reference conditions and test procedures applicable to all types of industrial and process measurement transmitters (PMTs) used in measuring and control systems for industrial process and machinery. These reference test conditions are divided into “standard reference conditions”, which apply when determining the accuracy of measurement, and “ambient and process reference conditions”, which are used to assess the influence of external quantities on the measurement.

For the purpose of this document, an analogue PMT is a process measurement transmitter with an analogue current or voltage output, irrespective of the technology adopted and the complexity of the circuitry. All the other process measurement transmitters, with digital output only or with hybrid analogue and digital output (e.g. HART®), are considered to be digital PMTs.

For general test procedures, reference is made to IEC 62828-1, which is applicable to all types of industrial and process measurement transmitters.

Additional specific test procedures for given types of PMTs (pressure, temperature, level, flow) are covered by other parts of this series.

NOTE 1 In industrial and process applications, to indicate the process measurement transmitters it is common also to use the terms “industrial transmitters”, or “process transmitters”.

NOTE 2 For better clarity, when the complete definition “industrial and process measurement transmitter” makes the sentence too long in this document, the short term “transmitter” is used instead.

Proximity devices with analogue output are excluded from the scope of this document.

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 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

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

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60079-10 (all parts), *Explosive atmospheres – Part 10: Classification of areas*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 60654-1:1993, *Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic conditions*

IEC 60654-3:1983, *Operating conditions for industrial-process measurement and control equipment – Part 3: Mechanical influences*

IEC 60654-4:1987, *Operating conditions for industrial-process measurement and control equipment – Part 4: Corrosive and erosive influences*

IEC 60721-3-1, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 1: Storage*

IEC 60721-3-2, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

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

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61298-1:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 1: General considerations*

IEC 61298-4:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 4: Evaluation report content*

IEC 61499 (all parts), *Function blocks*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

IEC 61784-1, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61784-2, *Industrial communication networks – Profiles – Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3*

IEC 61784-5 (all parts), *Industrial communication networks – Profiles – Part 5: Installation of fieldbuses*

IEC 61804-2, *Function blocks (FB) for process control – Part 2: Specification of FB concept*

IEC 61918, *Industrial communication networks – Installation of communication networks in industrial premises*

IEC 61987-11:2016, *Industrial-process measurement and control – Data structures and elements in process equipment catalogues – Part 11: List of properties (LOPs) of measuring equipment for electronic data exchange – Generic structures*

IEC 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62262:2002, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK Code)*

IEC 62381:2012, *Automation systems in the process industry – Factory acceptance test (FAT), site acceptance test (SAT) and site integration test (SIT)*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM:2007)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

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

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

3.1.1 Terms related to accuracy

3.1.1.1

accuracy (of a measuring instrument)

quality which characterizes the ability of a measuring instrument to provide an indicated value close to a true value of the measurand

Note 1 to entry: This term is used in the "true value" approach.

Note 2 to entry: Accuracy is all the better when the indicated value is closer to the corresponding true value.

[SOURCE: IEC 60050-311:2001, 311-06-08]

3.1.1.2

conformity

ability of a measuring instrument to provide an indication having a specified characteristic curve which can be linear, logarithmic, parabolic, etc.

3.1.1.3

dead band (dead zone)

finite range of values within which a variation of the input variable does not produce any measurable change in the output variable

Note 1 to entry: When this type of characteristic is intentional, it is sometimes called neutral zone.

Note 2 to entry: This entry was numbered 351-24-14 in IEC 60050-351:2006.

Note 3 to entry: This value is usually insignificant for the actual instruments.

[SOURCE: IEC 60050-351:2013, 351-45-15, modified: Note 3 added]

3.1.1.4

error

discrepancy between a computed, observed or measured value or condition, and the true, specified or theoretically correct value or condition

Note 1 to entry: An error within a system may be caused by failure of one or more of its components, or by activation of a systematic fault.

[SOURCE: IEC 60050-192:2015, 192-03-02]

3.1.1.5

hysteresis

phenomenon represented by a characteristic curve which has a branch, called ascending branch, for increasing values of the input variable, and a different branch, called descending branch, for decreasing values of the input variable

Note 1 to entry: The CDD code of this entry for Electronic Data Exchange is ABB661 and the hysteresis is defined as the difference between consecutive upscale and downscale outputs for any single test cycle at the same input test point.

[SOURCE: IEC 60050-351:2013, 351-45-16, modified: Note to entry added]

3.1.1.6

inaccuracy

maximum positive and negative deviation from the specified characteristic curve observed in testing a device under specified conditions and by a specified procedure

Note 1 to entry: Accuracy is defined in IEC 60050-300, definition 311-06-08.

[SOURCE: IEC 61298-1:2008]

3.1.1.7

linearity

ability of a measuring instrument to provide an indication having a linear relationship with a defined quantity other than an influence quantity

Note 1 to entry: The method of expression of lack of linearity is different for different kinds of instrument and is established in each particular instance.

[SOURCE: IEC 60050-311:2001, 311-06-05]

3.1.1.8

long term drift

drift in output monitored for 30 days at 90 % of span

[SOURCE: IEC 61987-1:2008, 3.22]

3.1.1.9

long term stability

drift of zero output signal in percent of full scale limit after a given period of normal operating conditions

Note 1 to entry: The long term stability can be evaluated over a different period of time, e.g. 6 months, 1, 2 or 5 years. Sometime manufacturers declare a life-time stability.

Note 2 to entry: Depending the type of PMT, the drift can be referred to an upper range limit (e.g. digital pressure PMTs), a fixed value (e.g. certain level PMTs), a full scale (e.g. some analogue PMTs), etc.

Note 3 to entry: The CDD code of this entry for Electronic Data Exchange is ABB551, modified (time period).

3.1.1.10**measured error**

largest positive or negative value of errors of the average upscale or downscale values at each point of measurement

[SOURCE: IEC 61298-1:2008]

3.1.1.11**measuring range**

range defined by two values of the measurand, or quantity to be supplied, within which the limits of uncertainty of the measuring instrument are specified

Note 1 to entry: An instrument can have several measuring ranges

[SOURCE: IEC 60050-311:2001, 311-03-12]

3.1.1.12**non-conformity**

deviation from ideal behavior for devices that have a non-linear input/output relationship, determined from the curve plotted using the overall average of corresponding upscale and downscale errors

Note 1 to entry: Non-conformity can be calculated and expressed in one of three ways:

- independent: line positioned so as to minimize the maximum deviation;
- terminal-based: line positioned so as to coincide with the actual characteristic curve at the upper and lower range-values;
- zero-based: line positioned so as to coincide with the actual characteristic curve at the lower range-value.

Note 2 to entry: The corresponding properties are to be found in the CDD.

Note 3 to entry: in IEC 61298-2:2011 the non conformity is defined as the closeness with which a calibration curve approximates to a specified characteristic curve (which can be linear, logarithmic, parabolic, etc.).

Note 4 to entry: Non-conformity does not include hysteresis.

[SOURCE: IEC 61987-13:2016, modified: Note 3 and Note 4 added]

3.1.1.13**non-linearity**

deviation from ideal behavior for devices that have a linear input/out relationship, determined from the curve plotted using the overall average of corresponding upscale and downscale errors

Note 1 to entry: Non-linearity can be calculated and expressed in one of three ways:

- independent: line positioned so as to minimize the maximum deviation;
- terminal-based: line positioned so as to coincide with the actual characteristic curve at the upper and lower range-values;
- zero-based: line positioned so as to coincide with the actual characteristic curve at the lower range-value.

Note 2 to entry: The corresponding properties can be found in the CDD.

Note 3 to entry: Linearity is defined in IEC 60050(300). definition 311-06-06.

Note 4 to entry: Non-linearity does not include hysteresis.

[SOURCE: IEC 61987-13:2016, modified: Notes added]

3.1.1.14

overshoot

for a step response, the maximum transient deviation from the final steady-state value of the output variable, expressed as a percentage of the difference between the final and the initial steady-state values

Note 1 to entry: The CDD code of this entry for Electronic Data Exchange is ABD684.

3.1.1.15

repeatability

closeness of agreement between the results of successive measurements of the same measurand, carried out under the same conditions of measurement, i.e.:

- by the same measurement procedure,
- by the same observer,
- with the same measuring instruments, used under the same conditions,
- in the same laboratory,
- at relatively short intervals of time.

Note 1 to entry: The concept of "measurement procedure" is defined in VIM 2.5

[SOURCE: IEC 60050-311:2001, 311-06-06]

3.1.1.16

settling time

for a step response the duration of the time interval between the instant of the step change of an input variable and the instant, when the difference between the step response and their steady-state value remains smaller than the transient value tolerance

[SOURCE: IEC 60050-351:2013, 351-45-37, modified: figure and Note missing]

3.1.1.17

signal

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

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

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

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

3.1.1.18

span

algebraic difference between the values of the upper and lower limits of the measuring range

Note 1 to entry: Limit has not to be intend as physical limits regarding the capabilities of the device, rather the upper and lower values defined for the relevant application.

Note 2 to entry: The CDD code of this entry for Electronic Data Exchange is ABB785, modified ("other variables" removed).

[SOURCE: IEC 60050-311:2001, 311-03-13, modified: Notes added]

3.1.1.19

span error

difference between the actual span and the ideal span, expressed as percentage of ideal span

Note 1 to entry: the CDD code of this entry for Electronic Data Exchange is ABB655.

[SOURCE: IEC 61987-13:2016, modified: Note added]

3.1.1.20

stability

ability of a measuring instrument to keep its performance characteristics unchanged during a specified time interval, all other conditions being the same

[SOURCE: IEC 60050-311:2001, 311-06-12]

3.1.1.21

start-up drift

drift in output monitored over a period of 4 h after power is switched on

[SOURCE: IEC 61298-2:2008, 7.1]

3.1.1.22

step response time

duration between the instant when the measurand (or quantity supplied) is subjected to a specified abrupt change and the instant when the indication (or quantity supplied) reaches, and remains within specified limits of, its final steady-state value

Note 1 to entry: This definition is the one conventionally used for measuring instruments. Other definitions exist.

Note 2 to entry: The dead time of the transmitter response is included in the step response time (see Figure 5).

[SOURCE: IEC 60050-311:2001, 311-06-04, modified: Note 2 added]

3.1.1.23

variable quantity

variable

physical quantity the value of which is subject to change and can usually be measured

Note 1 to entry: The term "variable" alone is frequently used to circumvent the lengthy but correct designation "variable quantity".

[SOURCE: IEC 60050-351:2013, 351-41-01]

3.1.1.24

zero offset

deviation of the actual zero output from the specified zero output

Note 1 to entry: For example, the specified output of a 4-20 mA pressure transmitter is 4 mA.

3.1.1.25

zero output

output signal of a PMT at the lower range value

3.1.1.26

zero point error

absolute error of a device under reference conditions, when the input is at the lower range value

Note 1 to entry: The CDD code of this entry for Electronic Data Exchange is ABB656.

[SOURCE: IEC 61298:2008]

3.1.2 Terms related to the uncertainty

3.1.2.1

combined standard measurement uncertainty

standard measurement uncertainty that is obtained using the individual standard measurement uncertainties associated with the input quantities in a measurement model

[SOURCE: ISO/IEC Guide 99:2007, 2.31, modified: Note missing]

3.1.2.2

coverage factor

number larger than one by which a combined standard measurement uncertainty is multiplied to obtain an expanded measurement uncertainty

Note 1 to entry: A coverage factor is usually symbolized by k (see also ISO/IEC GUM Guide 98-3:2008, 2.3.6).

[SOURCE: ISO/IEC Guide 99:2007, 2.38]

3.1.2.3

expanded measurement uncertainty

product of a combined standard measurement uncertainty and a factor larger than the number one

Note 1 to entry: The factor depends upon the type of probability distribution of the output quantity in a measurement model and on the selected coverage probability.

Note 2 to entry: The term “factor” in this definition refers to a coverage factor.

[SOURCE: ISO/IEC Guide 99:2007, 2.35, modified: Note 3 missing]

3.1.2.4

measurand

particular quantity subject to measurement

Note 1 to entry: Measurand is often called “measured value”.

[SOURCE: IEC 60050-311:2001, 311-01-03, modified: Note added]

3.1.2.5

measurement

process of experimentally obtaining one or more quantity values that can reasonably be attributed to a quantity

[SOURCE: ISO/IEC Guide 99:2007, 2.1, modified: Notes 1, 2 and 3 missing]

3.1.2.6

measurement uncertainty

non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

[SOURCE: ISO/IEC Guide 99:2007, 2.26, modified: Notes 1, 2, 3 and 4 missing]

3.1.2.7

total error

total probable error TPE

number obtained by taking the square root of the total sum of the squares of the individual errors factors, adopted to consistently compare the performances of two (or more) PMTs

Note 1 to entry: It is assumed that the variables of the individual errors are independent of each other.

Note 2 to entry: When combining all the error factors, the units of measure must all be the same.

Note 3 to entry: This note applies to the French language only.

3.1.2.8

uncertainty budget

statement of a measurement uncertainty, of the components of that measurement uncertainty, and of their calculation and combination

[SOURCE: ISO/IEC Guide 99:2007. 2.33, modified: Note missing]

3.1.3 Terms regarding operation and practical installation

3.1.3.1

influence quantity

quantity which is not the subject of the measurement and whose change affects the relationship between the indication and the result of the measurement

Note 1 to entry: This term is used in the "uncertainty" approach.

Note 2 to entry: Influence quantities can originate from the measured system, the measuring equipment or the environment.

Note 3 to entry: As the calibration diagram depends on the influence quantities, in order to assign the result of a measurement it is necessary to know whether the relevant influence quantities lay within the specified range.

[SOURCE: IEC 60050-311:2001, 311-06-01]

3.1.3.2

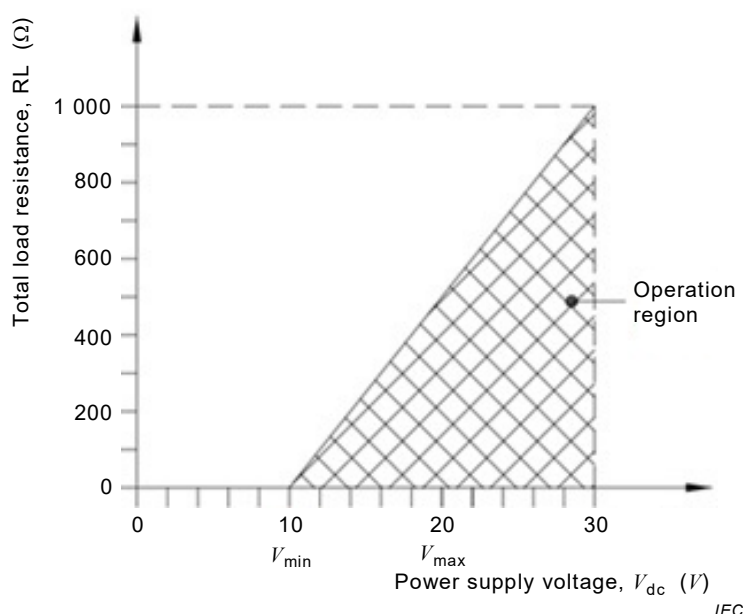
operation region

permissible range of supply voltage and output load within which a transmitter can operate within the specifications. For HART® devices, the communication resistance (e.g. 250 Ω) shall be taken into account when determining the maximum permitted load resistance.

EXAMPLE: Figure 1 referring to an output current at full scale of 20 mA.

Note 1 to entry: The supply voltage is often referred to as the input terminal voltage or auxiliary power.

Note 2 to entry: HART® is the trade name of a communication protocol specified by FieldComm Group. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.



Key

- V_{dc} Actual supply voltage in V
- V_{max} Maximum supply voltage, 30 V in this example
- V_{min} Minimum supply voltage, 10 V in this example
- RL Max. load resistance in Ω at the actual supply voltage
- $RL \leq (V_{dc} - 10) / 0,02$ (in the example reported in Figure 1)

Figure 1 – Example of limit operation region in terms of output load resistance versus supply voltage

3.1.3.3

turndown ratio TD

maximum turndown ratio

ratio of the maximum span to the minimum span to which an instrument can be adjusted within the specified accuracy rating

Note 1 to entry: $TD = |URV - LRV|_{max} / |URV - LRV|_{min}$, where Upper and Lower Range Value (URV and LRV), are both always related to the same datum point.

Note 2 to entry: TD is always ≥ 1 .

Note 3 to entry: This note applies to the French language only.

[SOURCE: IEC 61360-4, Domain Process Automation, ABA967, modified]

3.1.3.4

operating ambient temperature range

range of temperature for the PMT enclosure over which the device must function within the specified tolerances

Note 1 to entry: Whenever required, a temporary limiting operating condition could be specified as well.

3.1.3.5

operating process temperature range

range of temperature for the process medium in contact with the PMT sensing element over which the device must function within the specified tolerances

3.1.4 Terms related to test procedures

3.1.4.1

acceptance test

contractual test to prove to the customer that the device under test meets certain conditions of its specification

[SOURCE: IEC 60050-151:2001, 151-16-23]

3.1.4.2

routine test

conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.1.4.3

test procedure

statement of the tests to be carried out, and the conditions for each test, agreed between the manufacturer, the test laboratory, and the purchaser/user before the evaluation starts

[SOURCE: IEC 61298-1:2001, 3.13]

3.1.4.4

type test

conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.2 Abbreviated terms

DCS	Distributed Control System
DUT	Device Under Test
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
HART®	(for Highway Addressable Remote Transducer) Foundation trademark
LOP	List Of Properties
PMT	Process Measurement Transmitter (Industrial and Process Measurement Transmitter)
SAT	Site Acceptance Test
SCADA	Supervisory, Control And Data Acquisition
SIL	Safety Integrity Level
SIT	Site Integration Test
TPE	Total Probable Error

3.3 Reference to CDD

The IEC common data dictionary contains a classification of measuring devices with lists of properties for the device types most often met in practice. These properties can be used to describe the performance of a device, the effect of any quantities influencing its performance as well as the reference standards against which it was tested with test results.

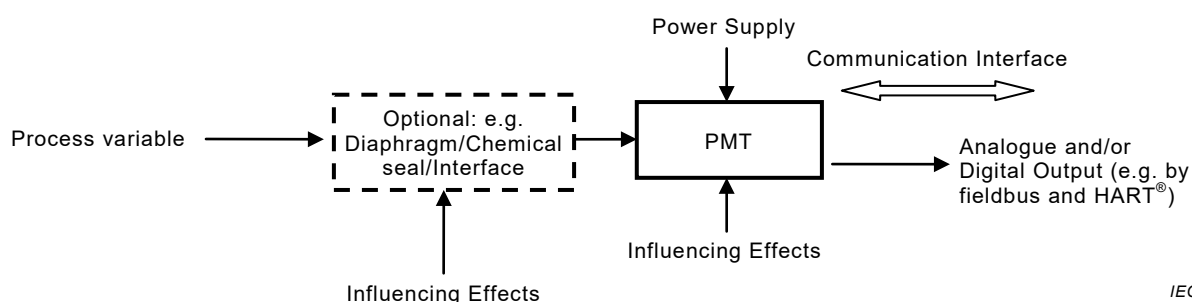
Each property has a unique identifier, e.g. ABB551, which is quoted in this document as appropriate. By entering the appropriate properties in the LOPs it is possible to exchange test results electronically between interested parties. The CDD is to be found at the following address: <http://std.iec.ch/cdd/iec61987/cdddev.nsf>.

The various measuring devices are to be found in the domain “Process automation (IEC 61987 series)”; ABA000 – Equipment for industrial-process automation; ABV000 – Characterization; ABA001 – Measuring Instruments. The device characterization is also to be found in IEC 61987-11.

4 General description of the PMT

The definition of a detailed test protocol requires a deep knowledge of the specific PMT under test and its components. This is obtained by a close collaboration between the assessor and the manufacturer during the evaluation.

For the scope of the present document, which only defines general test procedures, a short description of the functional blocks of the PMT is sufficient (see informative Annex A). However, a simplified block diagram of a PMT is described in Figure 2.



IEC

Figure 2 – Block diagram of a generic PMT

In general terms, a PMT can be defined as “fixed scale transmitter” when the measuring range is set by the manufacturer, and “variable scale transmitter” when the measuring range is adjustable (turn-down ratio).

5 Reference test conditions

5.1 General

This clause defines “standard reference test conditions” and “ambient and process reference test conditions” for quantities influencing operation for type and routine tests to be considered when evaluating the static and dynamic behaviour of the analogue and digital PMTs during tests performed according to the procedures described in Clause 6. “Reference design criteria” considers mechanical, electrical and functional properties of a device that are not in themselves influence quantities but for which design standards exist, against which the device can be assessed.

The standard reference test conditions are a reduced set of standardized conditions implemented to assess the performance values of the PMT. These conditions do not represent the actual operating conditions in which the PMT is intended to be installed.

The reference test conditions for ambient and process quantities influencing operation represent the real conditions that the PMT might encounter at the location in which it is intended to be installed. These test conditions are made in order to determine the impact of the influence quantities on the performance of the PMT and to verify the mechanical and the electrical conditions which a PMT can withstand and still work within its specifications.

These operating conditions are defined in terms of ranges (classes) of the parameters characterizing the various locations and are determined in laboratory tests that evaluate the performance of the PMT by means of a variation of the influencing parameters around the reference test values.

5.2 Standard reference test conditions

5.2.1 General

According to IEC 61298-1, the reference test conditions are essentially related to the environmental conditions, power supply conditions, load conditions and mounting arrangements.

5.2.2 Environmental test conditions

The PMT shall be evaluated under the conditions specified in Table 1.

Table 1 – Environmental test conditions

Environmental test conditions	Temperature °C	Relative humidity %	Atmospheric pressure kPa
Standard reference atmosphere	20	65	101,3
Limits for the atmosphere test conditions	15 ÷ 25	50 ÷ 70	86 ÷ 106
NOTE Different environmental conditions can be used if agreed between user and manufacturer			

The test temperature shall be stated in the test report, and the test results shall be corrected to the standard reference atmospheric conditions as reported in IEC 61298-1.

NOTE It is recognized that a factor to correct humidity is not always available.

The maximum rate of change of the ambient temperature permissible during any test shall be 1 °C in 10 min, but not more than 3 °C/h.

Special equipment could be required to maintain the basic test conditions within the specified limits.

5.2.3 Power supply conditions

The reference values for voltage and if applicable frequency shall be specified by the manufacturer.

Unless other tolerances are agreed between user and manufacturer, the following shall apply:

- rated voltage: $\pm 1 \%$;
- rated frequency: $\pm 1 \%$;
- harmonic distortion (a.c. supply): less than 5 %;
- ripple (d.c. supply): less than 0,1 %.

NOTE Tolerances on supply conditions are not applicable to PMTs with self-contained power supplies (e.g. battery-powered). The tolerances for battery powered equipment can be agreed.

5.2.4 Load conditions

The reference minimum and maximum load conditions during the evaluation tests shall be specified by the manufacturer.

5.2.5 Mounting positions

The instrument shall be installed in only one of its specified normal operating positions, with a $\pm 3^\circ$ tolerance or less, in accordance with the manufacturer's instructions. The position used shall be clearly stated in the test report.

Where appropriate, the mounting bracket supplied with the instrument shall be used.

All covers supplied with the instrument shall be in place.

5.3 Reference test conditions for ambient and process quantities influencing operation

5.3.1 General

This clause defines all the parameters that have to be considered as influence quantities for the operating conditions. Whenever possible, they are identified in terms of ranges (classes) for the various parameters affecting the test results.

5.3.2 Process conditions

For process conditions (rated process temperature, pressure, pulse, etc.) reference is generally made to the applicable international or national standards. These conditions shall be specified by the manufacturer or agreed with the user.

5.3.3 Environmental atmospheric conditions

5.3.3.1 General

The PMT shall be evaluated using the limiting operating conditions specified by the manufacturer or, if no specific values are given, according to the conditions specified in IEC 60654-1.

For the definition of environmental atmospheric conditions, the climatic conditions in various locations are usually expressed in terms of ranges (classes) of air temperature and humidity.

NOTE The barometric pressure is usually not relevant for the PMTs.

The standardized location classes typically used are the following:

Class A: weather-protected locations, air-conditioned locations;

Class B: weather-protected locations, heated and/or cooled enclosed locations;

Class C: weather-protected locations, sheltered and/or unheated enclosed locations;

Class D: non weather-protected locations, outdoor locations.

5.3.3.2 Ambient temperature

The PMT shall be evaluated using the conditions specified by the manufacturer, or if the manufacturer does not indicate any limits, under the conditions specified in IEC 60654-1 for the typical operating application.

Table 2 gives an example of common ambient temperatures ranges for various operating applications.

Table 2 – Common ambient temperatures ranges

Temperature °C		Temperature class (IEC 60654-1)	Typical operating application
min.	max.		
+20	+25	A1	Air conditioned locations
+15	+30	B1	Heated or/and cooled enclosed locations
+5	+40	B2	
-5	+45	C1	Sheltered locations
-25	+55	C2	
-33	+40	D1	Outdoor locations

5.3.3.3 Ambient relative humidity

The PMT shall be evaluated using the conditions specified by the manufacturer, or if the manufacturer does not give any limits, under the conditions specified in IEC 60654-1 for the typical operating application.

Table 3 gives an example of reference ambient relative humidity ranges for various operating applications.

Table 3 – Common ambient relative humidity ranges

Relative humidity %		Humidity class (IEC 60654-1)	Typical operating application
min.	max.		
20	75	A1	Air conditioned locations
10	75	B1	Heated or/and cooled enclosed locations
5	85	B2	
5	95	C1	Sheltered locations
10	100	C2	
15	100	D1	Outdoor locations

5.3.4 Mechanical vibration

The PMT shall be evaluated using the conditions specified by the manufacturer, or if the manufacturer does not specify any limits, the reference values specified in Table 4 for various typical operating applications shall be used. Reference test procedures are those specified in IEC 60068-2-6.

Table 4 – Vibration test levels

Typical application	Test frequency range Hz	Displacement peak amplitude mm	Acceleration peak amplitude m/s ²
Control room or field with low vibration level	10 to 150	0,35	1
Control room or field with medium vibration level	10 to 150	0,75	2
Field with general application or pipeline with low vibration	10 to 1 000	0,15	20
Field with high vibration level or pipe line with high vibration	10 to 1 000	0,35	50

5.3.5 Shock, drop and topple

The PMT shall be evaluated using the conditions specified by the manufacturer, or if the manufacturer does not specify any limits, the following values for shock, drop and topple in terms of height for free fall shall be used: 25 mm, 50 mm, 100 mm, 250 mm, 500 mm, 1 000 mm or > 1 000 mm for more severe conditions. Reference test procedures are those specified in IEC 60068-2-27.

5.3.6 Power supply

The PMT shall be evaluated using the conditions specified by the manufacturer, or if the manufacturer does not specify any limits under the conditions specified in Table 5 for voltage and frequency.

Table 5 – Power supply ranges for voltage and frequency

Power supply class for voltage	Tolerance of AC power supply voltage	Tolerance of DC power supply voltage
1	± 1 %	± 10 %
2	± 10 %	+ 10 % / – 15 %
3	+ 10 % / – 15 %	+ 15 % / – 20 %
4	+ 15 % / – 20 %	+ 30 % / – 25 %
Power supply class for frequency	Tolerance of AC power supply frequency	
1	± 0,2 %	
2	± 1 %	
3	± 5 %	

5.3.7 Electromagnetic compatibility (EMC)

The PMT shall be evaluated against electromagnetic immunity and emission using the limits specified by the manufacturer, or if the manufacturer does not specify any limits, then under the conditions specified in the IEC 61326 standard series, that shall be used as a reference also for test set-up and test procedures.

The choice of the relevant limits shall be determined after taking into account the emission and immunity requirements appropriate for the location of use.

5.4 Reference design criteria

5.4.1 General

Reference design criteria concern standards to which a device has been designed. In some cases, e.g. ingress and impact protection, the stated properties can be tested. In other cases, e.g. protection, evidence of conformance will normally be required in the form of documentation or test certification by an independent authority.

5.4.2 Enclosure protection against solid, liquid (IP) and impact (IK)

5.4.2.1 Overview

The protection classes for the instrument enclosure against solid and liquid ingress and against mechanical impacts are specified in IEC 60529 and IEC 62262 respectively. The PMT shall withstand the conditions defined by the code stated by the manufacturer.

5.4.2.2 Enclosure protection against solid and liquids (IP code)

IEC 60529 defines codes of protection against solid and liquid ingress (IP) with the associated test conditions.

5.4.2.3 Enclosure protection against mechanical impact (IK code)

See IEC 62262 for a complete classification of the codes of protection IK against mechanical impacts.

5.4.3 Enclosure protection against corrosive and erosive influences

IEC 60654-4 defines enclosure protection classes against corrosive and erosive influences (gas, vapours and aerosol) with the associated test conditions.

5.4.4 Electrical safety (insulation resistance, dielectric strength)

IEC 61010-1 defines the safety aspects of the design of equipment with regard to insulation resistance and dielectric strength with associated test conditions.

5.4.5 Hazardous environment (for application in explosive atmosphere)

Where a device has been designed for use in a explosion hazardous area according to the IEC 60079-10 series, the type of protection and zone of use shall be specified by the manufacturer. Proof of conformance shall be furnished in the form of test certification from a recognised independent test authority.

5.4.6 Functional safety

Where a device has been designed to conform with reference standard series IEC 61508 IEC 61511 for industrial process applications or IEC 62061 for machinery applications, the safety level attained and standard used shall be specified by the manufacturer. Proof of conformance shall be furnished in the form of test certification from a recognised independent test authority or full documentation in accordance with the test standard.

6 Test procedures

6.1 General

6.1.1 Overview

This clause specifies the test procedures required to verify the performance characteristics of the PMT for the standard and ambient and process conditions given in Clause 5.

These test procedures are generally applicable for both analogue and digital PMTs. Specific test procedures for digital PMTs are defined in the relevant clauses.

In case of a PMT with integrated sensing element, a process variable adequate to the test to be performed shall be generated in a suitable way. When the sensing element can be separated (e.g. RTD or thermocouple), the process variable can be electrically simulated.

6.1.2 Classification of the tests

The tests are classified into: type tests, acceptance tests and routine tests according to the definitions given in Clause 3. In addition, the term evaluation tests is used to indicate, a complete set of tests to establish the performance of a PMT under any likely operating conditions, to permit comparison with the manufacturer's published or stated performance specification for the PMT, or the user's requirement.

The type tests are normally performed by the manufacturer on one or more PMTs taken from the normal production or pre-production. They are intended to assess the performance strictly dependent on the design of the PMT. They are made on new products or on products on which significant design modifications have been made.

The routine tests are performed by the manufacturer at the production stage in order to check the proper manufacturing process and the final calibration of the PMT. These tests are often limited to the safety and metrological aspects. Usually these tests are much simpler than the type tests and usually do not provide evidence of behaviour in severe climatic and/or electromagnetic conditions.

The acceptance tests are also performed by the manufacturer, usually in the presence of the customer, in order to verify if the PMTs supplied by the manufacturer meet the requirements set out in the specification of the manufacturer and/or of the customer. Typically these tests are similar to the routine tests, if not otherwise specified and/or requested by the customer.

The tables of informative Annex B and informative Annex C give a list of the complete set of test procedures considered in this Clause, in relation to the standard and operating reference test conditions respectively. These tables summarize the procedures, highlighting the peculiarities of each test and indicating which tests are to be considered as type tests and/or acceptance tests and/or routine tests.

Generally, routine and acceptance tests contain a smaller number of test procedures than type tests and the procedures are simpler.

NOTE For example, the routine accuracy test is done taking only one measurement cycle for each 25 % of the device span, while a type test consists of at least 3 measurement cycles for each 20 % of the device span. In addition, only type tests are conducted at different zero and span adjustments, when applicable.

For analogue devices another classification is made in relation to the settings of span and lower range value adjustments (Table 7) and in relation to the number of measurement cycles and number and location of test points (Table 6), for the various tests, namely:

- FT1: for 1 full traverse cycle test (for example for routine tests)
- FT3: for 3 full traverse cycle test (for example for type tests)
- FT5: for 5 full traverse cycle tests (for example for extended tests, although rather unusual)
- Z/S: verifying the change in lower range-value (zero) and upper range-value (span) caused by the influencing factor (for example for over range, mounting position, etc.)
- 10 %: verifying the change only with a 10 % input signal (for example for output ripple)
- 50 %: verifying the change only with a 50 % input signal (for example for vibration, EMC tests, etc.)

- 90 %: verifying the change only with a 90 % input signal (for example for start-up and long-term drift).

Table 6 – Example of number of measurement cycles and number and position of test points

Kind of test		Number of measurement cycles	Number of test points	Position of test points (% of specified measuring range)
Complete tests	Evaluation test	3 or 5	6	0, 20, 40, 60, 80, 100
	Type tests		11	0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100
Simplified tests	Routine tests	1	5	0, 25, 50, 75, 100
	Acceptance tests			

Table 7 – Example of settings of span and lower range value adjustments for analogue devices

Kind of test		Adjustable span	Zero suppression and/or elevation
Complete tests	Evaluation test	Setting A ^a	Setting B ^b
	Type test		
Simplified tests	Routine tests	Setting C ^c	Setting D ^d
	Sample test		

^a Setting A : Span adjustment set at the maximum and minimum values specified by the manufacturer, and at one intermediate value.

^b Setting B : Normally, tests will be done at only one setting of lower range value, without suppression or elevation, but further tests at minimum and maximum settings may be required if the effects are significant.

^c Setting C : Unless otherwise specified in the test programme, the span is the one set by the manufacturer.

^d Setting D : Unless otherwise specified in the test programme, the lower range value is the one set by the manufacturer.

The choice of the tests to be performed depends on the type of transmitter, manufacturer's specifications and user requirements.

6.1.3 Preparation of the tests

Before defining an evaluation test program, the PMT under consideration shall be analysed, along the lines of the following model, to decide which functions of a single section shall be considered as a separate entity.

The following situations shall be considered:

- In many cases the data processing unit and the output subsystem are fully integrated and the intermediate signals are not available. In that case, the definition and consideration of the separate transfer functions are not relevant.
- Other PMTs could be supplied without the sensor assembly (e.g. without thermocouple or RTD for temperature transmitters). For these PMTs, the evaluation tests are performed using a suitable simulation, e.g. in accordance with the appropriate reference temperature tables.

- A sensor in contact with the process medium may be influenced by the medium characteristics and the installation conditions. As a remote unit, it may also be subject to more severe environmental conditions. The evaluation shall, therefore, consider combined environmental and process conditions. Sensor assemblies including sensors of different nature (such as auxiliary for compensation or diagnostic purposes) require suitable measurement arrangements.
- The choice of the test set-up and the way to provide a physical quantity in an accurate and traceable way to the input of the DUT is an important issue from the technical and economic point of view. Extensive equipment may be required, in which all factors influencing the quantity to be applied to the instrument are controlled. This equipment may be, for certain tests (for instance vibration, ambient temperature tests), extremely expensive. Therefore, a deep analysis has to be conducted to decide which kind of test facility is necessary for the various tests. Except for the accuracy measurements, the tests often require only stable and accurately adjustable signals, and it may be decided to perform these tests with facilities fulfilling only these requirements.
For example, when the measurement of a full calibration curve becomes economically unfeasible, it may be decided, when the I/O-characteristic of the DUT is linear, to perform measurements at "zero-input" and/or 100 % input or at another arbitrary input.
- If not otherwise agreed, the uncertainty of the test facilities and of the associated measuring equipment shall be better or equal 1/3 of the uncertainty of the instrument to be evaluated.

6.1.4 Preliminary assessment

Before the device is tested, a preliminary assessment shall be made of the device on the basis of the checklists to be found in Table 8 to Table 14. These contain a minimum number of checks for assessing functionality, configurability, hardware configuration, adjustment and tuning procedures, operability, dependability and manufacturer's support.

Should additional check items be required, they shall be agreed between the manufacturer and user.

Please note that some of the functions/capabilities to be considered for evaluation apply to digital PMTs only.

Table 8 – Checklist for assessing functionality

Function/capability	Aspects to be considered during evaluation (if applicable)
Main function(s)	Give a concise description of the measurement principle(s). Describe instrument status information and measurement information (separate and composite quantities) available at the human and communication interfaces and electrical output subsystem. Describe the firmware structure (function blocks and how they can be organised) and rules for application software.
Auxiliary function(s)	Give a concise description of auxiliary analogue and digital input and output functions.
Function blocks	List the available standardised function blocks (according to either IEC 61499 series or IEC 61804 series) or in case of proprietary function blocks, describe and categorise them in terms of: - time dependent function blocks (totalizers, controllers, timers, lead/lag); - time-independent function blocks, to be divided into: - calculation blocks (e.g. sensor linearization, square root, exponential); - logic blocks (and, or, etc.). For each function block give: - Name; - Adjustment range if user-adjustable; - Default values if applicable; - Check recognition and rejection of invalid values; - For details on checking function block features, see Annex D.
Signal cut-off	- Check the availability of signal cut-off. Signal cut-off is usually possible at the lower end of the characteristic to avoid invalid or noisy signals, but also signal cut-off at the upper end can be present. Indicate which option is available and whether cut-off values are user-configurable. - Check whether a dead band is present between activation and release and whether it is user adjustable.
Filters	If filters are provided: - Are they analogue (hardware) or digital (software)? - What type (1st, 2nd order) and is the time constant adjustable?
Backward compatibility	Check if a new transmitter is compatible with an old version it is intended to replace. NOTE New releases of a transmitter should be compatible with old versions both in hardware and software. The manufacturer should specify the compatibility in the documentation. In the case a new transmitter does not have full backward compatibility, a correlation table could help in identifying the old/new hardware/software peculiarities.

Table 9 – Checklist for assessing configurability

Function/capability	Aspects to be considered during evaluation (if applicable)
Fieldbus or wireless communication compatibility	Check whether the instrument under test is suited for either: • Connection to other devices or to a fieldbus in accordance with IEC 61158 series; • Or stand-alone application in combination with a temporary connection to a proprietary fieldbus or communication link; • Or stand-alone application; • Or connection to wireless communication. Provide a list of communication/fieldbus compatible instrument versions.
Configuration tools	Check if the instrument can be configured from: • Local controls (human interface) on instrument; • Remotely from a PC or a host computer; • Via a temporarily connected handheld communication unit. Notice obvious difficulties that appeared when configuring the instrument with these tools. Difficulties could be: – Some parameter entries may give an unnoticed change to other previously set parameters relevant to correct operation; – Inconsistencies in handling parameters such as no warning message when trying to change a protected parameter.
On-line (re)configuration	Check whether functions and parameters can be changed in control mode. If so, whether the output is unacceptably affected. Check whether there is a security mechanism that prohibits on-line access to all or some parameters and functions.
Off-line configuration	Check whether it is possible to set up and store configurations for a number of transmitters on a separate (off-line) PC. Measure the time required for off-line configuration.
Up/download to/from PC	Check if configuration upload is possible. Check if download of off-line prepared configurations is possible. Measure the time required to perform these actions (only one PMT participant): • When commissioning a fieldbus system; • In an operative (active) fieldbus system.
Configurable restart conditions	When a transmitter is provided with a process control function, it may also be equipped with “configurable restart conditions” to be implemented after a power down. An example of usual restart conditions provided are: • Return to last value; • Go to a user-defined value; • Return to manual mode. Check all conditions that apply.
Configurable fail-safe conditions	List the actions that can be configured in the transmitter in the event of detecting an internal failure or sensor failure.

Table 10 – Checklist for assessing hardware configuration

Function/capability		Aspects to be considered during evaluation (if applicable)
Mechanical construction	Hinges/covers	Comment, for these items, on the complexity and soundness of construction and protection against damage. Refer, if applicable, to mechanical problems that have appeared during preparation of the evaluation and during the performance of any test.
	Internal modules	
	Support	
	Protruding parts	Comment, for internal modules, on the location/position and addressing of the hardware by DIP switches or software.
	Local controls	
	Sensor connections	
	Electrical connections	
	Mechanical connections	
Ease of mounting		The mounting procedure may influence the calibration. Check whether it draws adequate attention to alignment, fixation to installation, thermal insulation, etc. Notice any obvious difficulties that may have appeared when dismounting and mounting the instrument. Also, determine the time needed for correct mounting.

Table 11 – Checklist for assessing adjustment and tuning procedures

Function/capability	Aspects to be considered during evaluation (if applicable)
Adjustment procedure	Aspects to be considered are: • How many adjustment procedures exist and what are the differences (which one is advised, etc., on-line and off-line adjustment and tuning or configuration)? • What external equipment is needed for calibration, adjustment and tuning? • How many times does the user have to interact and when? • Is any part of the procedure automatically performed? • Are adjustment, calibration and tuning data (name of operator, date, parameters, etc.) stored in non-volatile memory? • What are the range limits? • What is the resolution of zero/span adjustments both at upper and lower range limits? • Is linearization part of the procedure? • Measure the time required for adjustment, calibration and tuning. Record any obvious or potential difficulties that may have appeared when performing the procedure.
Tuning procedure	Certain instruments require adaptation and tuning to process conditions and properties, installation conditions and environmental conditions. Briefly describe the procedure. The following shall be considered: • In certain cases, tuning/adaptation may require the setting of fixed process related parameters particularly when configuring the instrument. Often, this method has limited validity, in particular where the actual process parameters may vary over a wide range; • It may also be an automatic procedure to be performed under live conditions. If so, how many times does the user need to interact? Are resulting parameters automatically activated or can the user ignore/change them and fill in different values? Record the instrument's output during the procedure. The record may show the limitations of the procedure; • Is adjustment and tuning be integrated inseparably into one procedure? • Measure the time required for tuning.

Table 12 – Checklist for assessing operability

Function/capability	Aspects to be considered during evaluation (if applicable)
Local controls (tools) for access	Give a concise description of: • The keys (pushbuttons) available; • Ergonomic layout and use of the keys; • Protection/suitability of keys for use in hazardous locations.
Local displays	Give a concise description of the data that can be shown on the local displays such as: • Number of lines and characters per line; • Control parameters given; • Error messages; • Readability of display without removing the electronics covers.
Human interface(s) at external system	Describe, for PC-based software, the organisation and hierarchy of the various user access groups and related displays and the possible availability of dedicated keyboards. Give, for a handheld communicator, a picture with layout of display and keyboard.
Provisions and tools for engineering and maintenance personnel	Give, for PC-based provisions, a concise description of the organisation and hierarchy of the engineering and maintenance related software and display templates. If available, list other hardware tools (such as switches, potentiometers, etc.) that can be used for configuration, installation, adjustments and calibration.
Process diagnostic aspects	Check whether the instrument – in addition to the main measuring function – has provisions for diagnosing defects and faults in the process and process installations. In the following example list, some aspects are specific to particular device types: • Cavitation; • Abrasion and corrosion (chemical/mechanical origin); • Product contamination (e.g., including condensation); • Product inconsistencies (e.g. gas entrapped in liquid); • Blockage of product flow; • Excess vibration of installation; • Temperature and pressure; • Loop integrity and performance using information coming from the instruments and function blocks used in the loop; • Fracture, wear, fatigue or corrosion of piping or vessels, etc. Describe relevant tests and alarms implemented such as: • Analysis in time or frequency domain of main sensor signal; • Fingerprinting; • Availability of additional sensors; • Additional software tools for the accumulation of operational time, time at certain load, number of cycles. Check whether these tools are embedded in the transmitter or in the host; • Are tests on-line automatic or operator-initiated? • Are test parameters user-adaptable? • Actions of transmitter on appearance of diagnostic alarms.

Table 13 – Checklist for assessing dependability

Function/capability	Aspects to be considered during evaluation (if applicable)
Transmitter diagnostics	Describe how the transmitter diagnoses internal failures and secures safe operation in case of failures. Mechanisms may be implemented for detecting: - Flash Read Only Memory failure; - no free time; - reference voltage failure; - drive current failure; - critical Non Volatile Memory failure; - auxiliary sensor failures (e.g. internal temp, pressure). Check whether fieldbus devices may provide specific messages such as: - I/O processor fault; - output not running; - static parameters lost; - calibration data read error. Check which diagnostics are performed: - On-line (in operation) automatically, continuously or intermittently; - On-line (in operation) user-initiated; - Offline (out of operation). Does the manufacturer provide a coverage factor with respect to detection of internal failures?
Detection of incorrect use	Does the instrument or the fieldbus system detect errors and failures due to incorrect and/or unintended operation and/or maintenance actions such as: - incorrect address settings via jumpers or dip switches (if provided); - reverse connection of power wiring, connectors, printed circuit boards (if possible); - putting connectors at incorrect positions (if length of wiring permits this); - leaving an open circuit by not connecting a connector; - performing an incomplete or incorrect start-up procedure; - leaving the instrument at an incorrect security level; - multiple use of same tag names and numbers for different transmitters in a multi-drop digital communication system; - causing a short circuit by touching adjacent parts when performing mechanical adjustments.
Alarms	Two groups of alarm types can be differentiated: - Process alarms (related to the above mentioned process diagnostic aspects). Alarm settings may be user-adjustable; - Self-test alarms (related to internal failures of the transmitter). These alarms are in general not user-changeable. List the alarms provided in both groups and indicate how they are communicated to: - Host via fieldbus; - Hard wired via relay outputs; - Local display. Check whether the alarms appear automatically on-line or only on user-request or in any other way.
Security against unauthorised access	Describe the implemented security methods: - Hardware (write protect switch); - Software (passwords, number of access levels and the degrees of access and configurability at these levels); - Access to local controls and adjustment/tuning facilities.

Table 14 – Checklist for assessing manufacturer's support

Function/capability	Aspects to be considered during evaluation (if applicable)
Manufacturer's maintenance support	- Does the manufacturer offer maintenance contracts? - What is their scope? - What is the guaranteed time for providing maintenance personnel on the spot?
Spares	- Mention the smallest replaceable unit; - Mention content/size of recommended stock of spare parts; - Spares availability after the end of transmitter production.
Warranty	Indicate warranty period and the extent.

The results of the preliminary assessment shall be documented in paper or electronic form. After a review of the results and where the extent of testing is subject to agreement between manufacturer and user, the device functions and properties to be tested shall be agreed.

The definition of these functions and properties, to be considered in the evaluation is based on the concept of data flow paths. The parties involved need to define the relevant data flow paths and measurement ranges of the PMT to be evaluated. Table 15 and Table 16 give examples of a format for listing and defining the functions to be evaluated. Table 15 is an example related to a single variable transmitter of differential pressure with temperature compensation, while Table 16 is an example related to a PMT with a multi-variable transmitter of differential pressure with temperature compensation plus an additional temperature sensor for process media.

Table 15 – Example of functions listing for a temperature compensated single variable PMT (differential pressure)

Reference number	Measured values (outputs) to be observed							Sensor characteristics		Related physical quantities to be provided at input(s)		
	Measured Variable	Measuring range	Type of measurement		Data flow path to:			Measurement principle	Measuring range	Quantity	Source	
			Main	Auxiliary ¹⁾	Local display	External system	Electrical output: (4 to 20) mA				Physical quantity	Simulator
1	Differential pressure	(0 to 100) kPa ²⁾	S ³⁾			X	X	Capacitive	(- 500 to + 500) kPa	Differential pressure	X	
2 ⁴⁾	Internal temperature ⁵⁾	- 40 to + 50 °C		A ⁶⁾	X ¹⁾			RTD	(- 40 to + 100) °C	Temperature	X	
¹⁾ This auxiliary parameter may not be available in output. ²⁾ At the range of (0 to 100) kPa a limited set of tests are to be performed, these tests shall be explicitly indicated in the matrices of 6.2 and 6.3. ³⁾ S: Single variable. ⁴⁾ Only for temperature compensation. ⁵⁾ The internal temperature shall be monitored at the local display for all tests. Any large deviations to the ambient temperature may indicate a defect. ⁶⁾ A: Auxiliary variable.												

Table 16 – Example of functions listing for a temperature compensated multi-variable PMT (differential pressure plus pressure and temperature)

Reference number	Measured values (outputs) to be observed							Sensor characteristics		Related physical quantities to be provided at input(s)		
	Measured Variable	Measuring range	Type of measurement		Data flow path to:			Measurement principle	Measuring range	Quantity	Source	
			Main	Auxiliary ¹⁾	Local display	External system	Electrical output. (4 to 20) mA				Physical quantity	Simulator
1	Differential pressure	(0 to 100) kPa ²⁾	S ³⁾			X	X	Capacitive	(- 500 to + 500) kPa	Differential pressure	X	
2 ⁴⁾	Internal temperature ⁵⁾	- 40 to + 50 °C		A ⁶⁾	X ¹⁾			RTD	(- 40 to + 100) °C	Temperature	X	
3	Static pressure	(0 to 10) MPa ²⁾	S ³⁾			X	X	Capacitive	(0 to + 20) MPa	Pressure	X	
4	Process media temperature	- 0 to + 400 °C	S ³⁾			X	X	TC	(- 0 to + 500) °C	Temperature	X	
¹⁾ This auxiliary parameter may not be available in output. ²⁾ At the range of (0 to 100) kPa a limited set of tests are to be performed, these tests shall be explicitly indicated in the matrices of 6.2 and 6.3. ³⁾ S: Single variable. ⁴⁾ Only for temperature compensation. ⁵⁾ The internal temperature shall be monitored at the local display for all tests. Any large deviations to the ambient temperature may indicate a defect. ⁶⁾ A: Auxiliary variable.												

6.2 Type tests at standard reference test conditions

6.2.1 General

These tests refer to accuracy, static behaviour and dynamic behaviour of the DUT.

Before starting the tests, the correct functioning of the DUT shall be verified. If the DUT has a display to indicate the measured value (and other indications), any display malfunctions display (missing digit sections, brightness, contrast, and angle of view before loss of brightness/contrast) shall be visually checked during and after the tests.

6.2.2 Accuracy and related factors

6.2.2.1 General

The accuracy test aims at detecting the actual output signal and at comparing it with the stated value.

6.2.2.2 Test procedures applicable both for analogue and digital PMTs

Where there are selectable ranges and settings, the tests shall be repeated to cover all ranges or settings strictly necessary to verify the complete PMT performances.

When the DUT is supplied calibrated for use, the first set of tests shall be carried out without adjustment.

Generally, instruments should be evaluated, in respect to the accuracy, under each of the conditions which they are likely to meet in operation. Unfortunately, it is not practical or economical to evaluate performance under all possible combinations of operating conditions. A standard test procedure is therefore specified which is practical under laboratory conditions and which provides sufficient data on which a prediction of field performance can be made. The use of a small number of standard conditions covering the range simplifies testing and enables tests on different devices to be more readily compared.

The testing of a PMT which has provision for substantial adjustment of both span and lower range value may require an impractically large number of tests. In such a case, preliminary tests shall be conducted to determine the effect of changing span and lower range value adjustments on the characteristic being measured. This should allow the cancelling of some tests from the test program, in those cases where the characteristics can be reliably inferred from fewer tests. For example, hysteresis may not be significantly affected by selection of the lower and upper range value if the span is held constant and often may be inferred for different spans from measurements at a single span setting.

However, the report shall indicate clearly relevant values of the measured parameters for each setting, so that the values of inaccuracy, hysteresis, etc., can all be referenced to the same adjustment of the PMT.

Generally, unless otherwise specified in the test program, the test for accuracy related factors shall be carried out with the settings A, B, C, and D listed in Table 7, whenever the span and/or the lower range value are adjustable further than the adjustments for the manufacturing tolerances.

Prior to start the tests, the DUT shall be preconditioned by putting it in the test ambient for a sufficient time to reach stable temperature conditions (usually at least 1 h).

With power applied to the DUT, a further sufficient time shall be allowed to ensure stabilization of the operating temperature of the DUT. In the absence of any recommendations in the test program, this time shall not be shorter than 30 min; the testing equipment – for the measurements of the input and output signal – shall also be allowed to stabilize.

Before proceeding to the accuracy test, the DUT shall be subjected to three full range traverses in each direction.

The performance of the DUT shall be verified over the full range for increasing and decreasing values using the same number of steps in each direction.

For example, if a step of 20 % is selected, the values 20 %, 40 %, 60 %, 80 % and 100 % will be tested going upscale, and the values 80 %, 60 %, 40 %, 20 % and 0 % will be tested returning downscale.

The number of measurement cycles and the number of the test points depend on the kind of test under consideration. Unless otherwise specified for a particular type of PMT, the values that should be adopted are given in Table 6.

Initially, an input signal equal to the lower range value is generated, and then the input signal is slowly increased to reach, without overshoot, the first test point; after an adequate stabilization period, the value of the corresponding input and output signal is recorded.

Then the input signal is slowly increased to reach, without overshoot, the value of the next test point and, after a stabilization period, the corresponding value of the output signal is recorded.

The operation is repeated for all the predetermined values up to 100 % of the input span. After measurement at this point, the input signal is slowly decreased to the test value directly below 100 % of input span, and then to all the other values in turn down to 0 % of input span, thus closing the measurement cycle.

NOTE For PMTs without hysteresis, e.g. temperature transmitters, a single measuring cycle can be conducted only with increased (preferable) or decreased input.

6.2.2.3 Processing of the measured values

The difference between the output signal values obtained at the various test points for each upscale and downscale traverse and the corresponding stated values are recorded as the output errors.

The errors shall be generally expressed as a percentage of the stated output span.

For each measuring point, the readings obtained in successive cycles for upscale and downscale error, respectively, shall be averaged to give the average upscale and downscale values, and these once again averaged to obtain the average value at that point.

For convenience, all the error values obtained shall be shown in a table (see example of Table 17), and the average values presented graphically (see Figure 3) to obtain the accuracy or the measurement uncertainty, according to the definitions given in Clause 3.

6.2.2.4 Determination of the accuracy

6.2.2.4.1 General

Because of the limited number of measurements (e.g. see Table 6) the following accuracy related factors shall be determined by treating the errors in a simple way (difference between measured values and ideal value or comparison value), as for example reported in Table 17. This simple method applies to all the subclauses from 6.2.2.4.2 to 6.2.2.4.8.

6.2.2.4.2 Inaccuracy

Inaccuracy is determined (see example of Table 17) by selecting the greatest positive and negative deviations of any measured value from the stated value, for increasing and decreasing inputs, for any test cycle separately, and reporting these deviations in percent of stated output span.

Table 17 – Example table of PMT errors

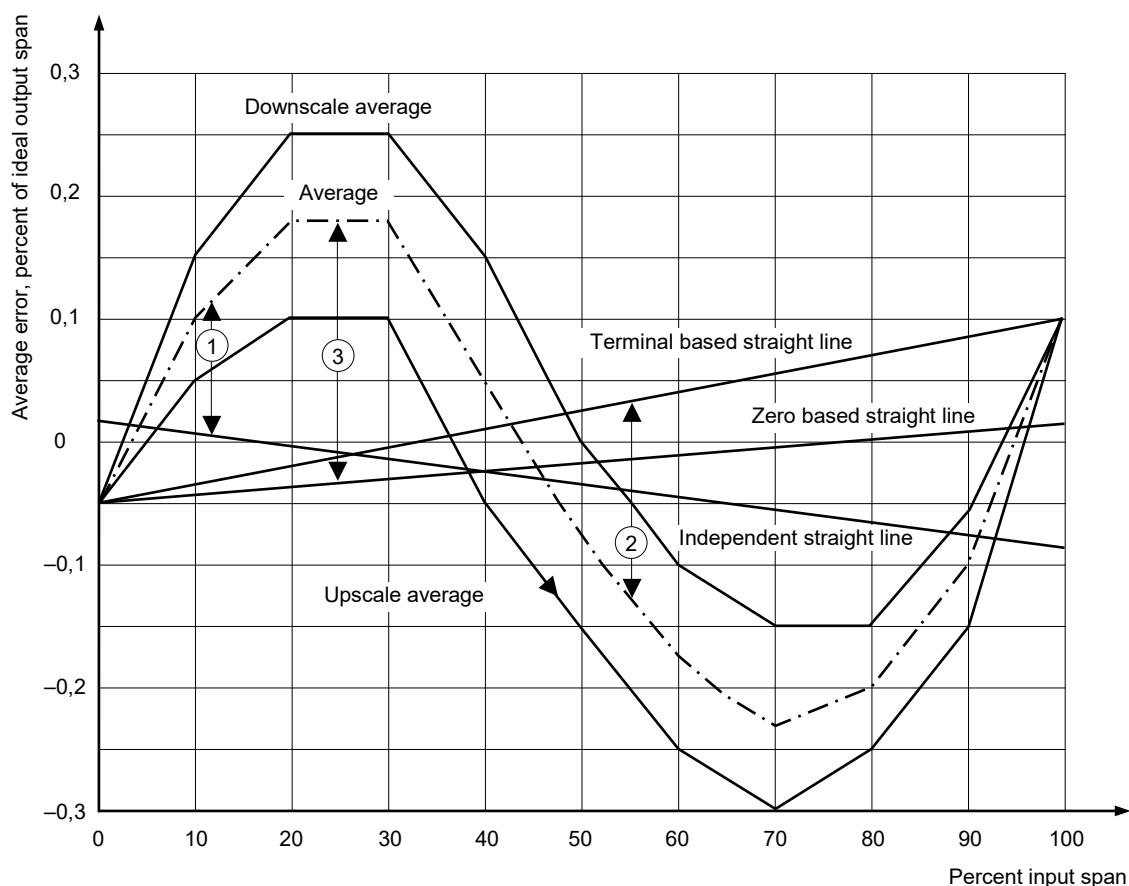
	1 st cycle		2 nd cycle		3 rd cycle		Average of the cycles		Total average
	Error (in % of ideal span)								
Input in % span	Up actual	Down actual	Up actual	Down actual	Up actual	Down actual	Up actual	Down average	Average error
	%	%	%	%	%	%	%	%	%
0		−0,04		−0,05		+0,06		−0,05	−0,050
10	+0,06	+0,14	+0,04	+0,15	+0,05	+0,16	+0,05	+0,15	+0,100
20	+0,13	+0,23	+0,08	+0,26	+0,09	+0,26	+0,10	+0,25	+0,175
30	+0,11	+0,24	+0,09	+0,25	+0,10	+0,26	+0,10	+0,25	+0,175
40	−0,04	+0,13	−0,07	+0,15	−0,04	+0,17	−0,05	+0,15	+0,050
50	−0,18	−0,02	−0,16	+0,01	−0,13	+0,01	−0,15	0,00	−0,075
60	−0,27	−0,12	−0,25	−0,10	−0,23	−0,08	−0,025	−0,10	−0,175
70	−0,32	−0,17	−0,30	−0,16	−0,28	−0,12	−0,30	−0,15	−0,225
80	−0,27	−0,17	−0,26	−0,15	−0,22	−0,13	−0,25	−0,15	−0,200
90	−0,16	−0,06	−0,15	−0,05	−0,14	−0,04	−0,15	−0,05	−0,100
100	+0,09		+0,11		+0,10		+0,10		+0,100

Non-repeatability = +0,05 %

Hysteresis = +0,22 %
= hysteresis error + dead band

Maximum measured error = −0,30 %

Inaccuracy = −0,32 % +0,26 %



- ① Independent non-linearity = $\pm 0,2 \%$
- ② Terminal based non-linearity = $-0,28 \%$ and at $\pm 0,28 \%$
- ③ Zero based non-linearity = $\pm 0,22 \%$

IEC

Figure 3 – Error curves corresponding to the example of Table 17

6.2.2.4.3 Maximum measured error

The maximum measured error is determined (see example of Table 17) by selecting the greatest positive or negative value from the average upscale errors and the average downscale errors.

6.2.2.4.4 Non-linearity

For PMTs that have a linear input/output relationship, the non-linearity is determined from the curve plotted using the overall average of corresponding upscale and downscale average errors (see example of Table 17 and corresponding Figure 3).

The maximum positive or negative deviation between the average curve and the selected straight line, expressed in percent of stated output span, is the non-linearity, that is independent from hysteresis.

The following different non-linearity expressions are in common use.

a) Terminal based non-linearity

Terminal based non-linearity is determined by drawing a straight line so that it coincides with the average calibration curve at the upper range value and at the lower range value.

NOTE Where calibrations in workshops and adjustments in the field are made, only terminal based non-linearity is of practical interest.

b) Independent non-linearity

Independent non-linearity is determined by drawing a straight line through the average curve in such a way as to minimize the maximum deviation. It is not necessary that the straight line is horizontal, or passes through the end points of the average calibration curve.

c) Zero based non-linearity

Zero based non-linearity is determined by drawing a straight line so that it coincides with the average calibration curve at the lower range value (zero), and minimizes the maximum deviation.

In any statement regarding linearity and accuracy calculation, the terminal based non-linearity shall always be used.

6.2.2.4.5 Non-conformity

Non-conformity (terminal based non-conformity, independent non-conformity, and zero based non-conformity) is used for PMTs which have a non-linear input-output relationship (e.g., logarithmic, square root, etc.).

The non-conformity is determined and presented using the same procedures as for non-linearity.

In any statement regarding conformity and accuracy calculation, the terminal based non-conformity shall always be used.

6.2.2.4.6 Hysteresis

Hysteresis is determined directly from the deviation values (see example of Table 17), as the difference between consecutive upscale and downscale outputs for any single test cycle at the same test point.

The maximum value observed from all the test cycles is reported as "hysteresis", and shall be expressed as percent of the ideal output span. If required, hysteresis error may be determined by subtracting the value of dead band from the corresponding value of hysteresis for a given measured point; its maximum value may be reported as "hysteresis error" in percent of the stated output span.

NOTE Dead band can be determined at 50 % of the input signal, increasing and decreasing the input signal until the output signal varies, but in today's PMTs this gap is very little and so this test can be eliminated.

6.2.2.4.7 Non-repeatability

Non-repeatability is the algebraic difference between the extreme values obtained by a number of consecutive measurements of the output over a short period of time, for the same value of the input, under the same operating conditions, approaching from the same direction, for full range traverses.

Non-repeatability is usually expressed in percentage of ideal output span, and does not include hysteresis.

Non-repeatability is determined (see example of Table 17) from the maximum difference in percent of the stated output span, between all values of output for any single input value, considering upscale and downscale curves separately. The maximum value from either upscale or downscale value is reported as non-repeatability.

6.2.2.4.8 Presentation of the results

The results of measurements made to assess the values of inaccuracy, measured error, non-linearity, non-conformity, hysteresis and non-repeatability, shall be determined in accordance

with the previous clauses 6.2.2.4.2 to 6.2.2.4.7, and shall be presented in the test report by including tables and figures, like the example in Table 17 and Figure 3.

For acceptance tests, the corresponding values of the same accuracy related factors specified by the manufacturer shall be tabulated alongside the values determined from the tests. The accuracy of device can be said to be in conformance with its specification when the measured values are equal to or better than the declared values.

NOTE The accuracy related terms could be stated by the manufacturer in different ways, e.g. as inaccuracy (which includes hysteresis and non-repeatability) and hysteresis; or measured error (which includes hysteresis) and the hysteresis; or even non-linearity/non-conformity (which does not include hysteresis), the hysteresis and the dead band.

In the example reported in Table 17, the measured inaccuracy varies from – 0,32 % to + 0,26 % as a function of the input; therefore, if the rated accuracy specified by the manufacturer is, for example, $\pm 0,35$ %, this specified value is upheld.

6.2.2.5 Determination of the measurement uncertainty

The results obtained from the measurements, as those reported in Table 17, can be processed to determine the measurement uncertainty according to the following documents:

- *Vocabulary international of metrology* (VIM: ISO/IEC Guide 99:2007);
- *Guide to the expression of uncertainty in measurement* (GUM: ISO/IEC Guide 98-3:2008).

A short description of the approach is in Annex E.

6.2.3 Static behaviour

6.2.3.1 General

For the purposes of this document, to evaluate the static behaviour of PMTs with analogue or digital output there is no need to test all possible configurations. The configuration tested shall be representative of typical use of the PMT under evaluation. The manufacturer shall specify the configuration to be adopted.

6.2.3.2 Insulation resistance

The DUT shall be set up for normal operation. The insulation resistance of each input and output circuit shall be measured with reference to ground. The test shall be carried out on the unpowered DUT by applying the d.c. test voltage between the short-circuited input, output, or power supply terminals in turn, and the enclosure connected to ground.

To avoid current surges, the applied test voltage shall be raised to its full value gradually, and, upon completion of the test period, shall then be reduced gradually. Unless otherwise agreed, the nominal d.c. test voltage shall be 500 V according to IEC 61010-1.

After application of the full test voltage for at least 30 s, the value of insulation resistance shall be measured with appropriate equipment. The measured value shall be in accordance with the data declared by the manufacturer.

6.2.3.3 Dielectric strength

The r.m.s. value of test voltage shall be determined by reference to the value of the rated voltage (or insulation voltage) reported in IEC 61010-1 and/or national standard. With the DUT unpowered, and the case (if any) fitted, the test voltage shall be applied between the input, output, and power supply terminals in turn and ground. During every test, the case and terminals not directly involved shall be connected together and grounded.

The test voltage shall be raised gradually to its specified value, and by using such steps that no appreciable transients occur, and shall then be maintained at the specified level for 1 min.

During the test, no breakdown or flashover shall occur.

6.2.3.4 Power consumption

The purpose of this test is to determine the power consumption of the DUT at the normal supply operating condition.

This test shall be conducted at the input and load conditions which produce the maximum power consumption of the DUT.

For a.c. powered PMTs, the power absorbed shall be measured, taking into account measurements of effective (r.m.s.) values. The measurement shall be made at the nominal voltage and frequency, and at the maximum voltage and minimum frequency specified by the manufacturer for the given supply.

For d.c. powered PMTs, the current absorbed shall be measured at nominal supply voltage.

The measured value shall be in accordance with the data declared by the manufacturer.

6.2.3.5 Operation region

For two-wires analogue PMTs (loop powered current output), the operation region shall be verified varying the input signal from 0 to 100 % and checking the corresponding output signal at:

- minimum supply voltage and minimum resistance load, and
- maximum supply voltage and maximum resistance load.

For any combination voltage/load in the operation region, the output signal shall not vary.

6.2.3.6 Influence of power supply variations

For all the PMTs with the exception on loop-powered analogue transmitters covered by 6.2.3.5, the test shall be carried out varying the input signal from 0 to 100 % and checking the corresponding output signal at the following supply voltage and frequency variations (if applicable) as follows:

- voltage: nominal value, maximum value, minimum value
- frequency: nominal value, maximum value, minimum value

where the maximum and minimum values are defined in relation to the PMT supply classes defined in Table 5.

Each value of voltage shall be combined with each value of frequency so that the result will be nine sets of measurements for a.c. supplies or three sets of measurements for d.c. supplies.

The voltage and frequency changes shall be made smoothly and gradually; the measurements at 0 % and 100 % of output shall be made in steady-state conditions of voltage and frequency.

The changes at 0 % and 100 % of output shall be reported in per cent of span.

For acceptance tests the output variations with respect to nominal conditions shall remain within the values specified for the DUT under every combination of voltage/frequency.

6.2.3.7 Output load effects

The purpose of this test is to determine any effects on the output signal of analogue PMTs when the output load is varied.

To determine any effect on an electrical output signal, the load resistance shall be varied from the minimum to the maximum value specified by the manufacturer. Any changes in lower range-value and span caused by these variations shall be expressed as a percentage of the output span. The output voltage drop at the DUT at the upper range value shall also be recorded when the DUT is a two-wire PMT. Consideration should be given to the effect of connecting capacitive or inductive loads.

For acceptance tests, the output variations with respect to its nominal value shall remain within the values specified for the DUT for any value of load applied.

6.2.3.8 Output ripple

The maximum peak-to-peak values and the fundamental frequency component of any ripple content of the output of analogue PMTs shall be measured and recorded with 10 % and 90 % input signals at both minimum and maximum load specified for the DUT.

For acceptance tests, the output ripple shall remain within the values specified for the DUT for any test condition.

6.2.3.9 Overrange

This test shall be carried out by measuring any changes in lower range-value and span which result from over-ranging the input by 50 % at the minimum and maximum span settings, if not otherwise specified by the manufacturer to avoid damage.

The input shall be increased gradually from the lower range-value to the over-range selected for the test.

After the over-range has been applied for 1 min, the input shall be reduced to the nominal lower range-value.

NOTE If the out of range condition produces significant thermal effects, the duration of application is increased to reach a thermal steady-state condition.

After a further 5 min have elapsed, the lower range-value and the span shall be determined in per cent of output span.

If the DUT is to be tested for over-range effect in both directions, as with differential measuring PMTs and PMTs whose input may be both below the lower range-value and above the upper range-value, it shall be tested as described above, first over-ranging above the upper range-value, and then over-ranging below the lower range-value.

Any changes of lower range-value and span determined after over-ranging in each direction shall be recorded. For acceptance tests, these changes shall remain within the values specified for the DUT.

6.2.3.10 Mounting position

Where the DUT might be position sensitive, the change in lower range-value and span caused by 10° inclinations from the position(s) specified by the manufacturer shall be measured and recorded in percent of output span.

Four measurements shall be made with tilt applied in two planes at right angles to each other.

Where a 10° inclination is excessive due to the design of the DUT, the maximum inclination specified by the manufacturer shall be used.

Any changes of lower range-value and span determined in each test positions shall be recorded. For acceptance tests, these changes shall remain within the values specified for the DUT.

6.2.4 Dynamic behaviour

6.2.4.1 General

The objective of this subclause is to define test procedures for the evaluation of the dynamic behaviour of PMT with analogue or digital output.

The configuration tested shall be representative of typical use of the PMT under evaluation. The manufacturer shall specify the configuration to be adopted and the performance values to be met for each characteristics.

Step and sine wave input signals can be used to obtain the dynamic response of the PMT.

Sine wave test data are most generally useful for mathematical analysis, for graphical solution of control problems, and for characterization of dynamic performance of linear systems.

Step tests permit the measurement of the dead time and the time constant.

In order to define a practical number of tests, only one value of output load and a minimum number of input signal configurations need to be adopted.

It is recognized that the data from the specified step and sine wave tests are not sufficient to describe completely the dynamic behavior of a PMT. However, following the requirements of this document, comparable data, useful to identify the dynamic behavior of simple PMTs and to give qualitative indications for the more complex ones, can be collected. In special cases, more detailed testing may be specified in the test program.

NOTE The specified output loads and the levels of input signals are sufficient to give valid data for the most usual test requirements, and qualitative indications on the effect of unusual large, changing signals.

Depending on their construction principle, not all the PMTs can be tested for all the parameters specified in the following subclauses.

6.2.4.2 Step response

A series of step changes shall be applied to the input of the DUT. The rise time of the step input shall be small compared with response time of the DUT.

Input step and output response shall be recorded together.

The following preferable input steps are applied:

- a step corresponding to 80 % of output span, giving an output change from 10 % to 90 %, then another from 90 % to 10 %;
- steps, corresponding to 10 % output span, giving output changes up and down as follows: 5 % to 15 %; 45 % to 55 %; and 85 % to 95 %.

The time for the output to reach and remain within 1 % of output span of its final steady value (settling time) shall be measured for each test condition. The amount of dead time and transient overshoot, if any, shall be stated (see Figure 4 and Figure 5).

NOTE Measurement of step response time to 90 %, or time constant to 63 %, can also be useful.

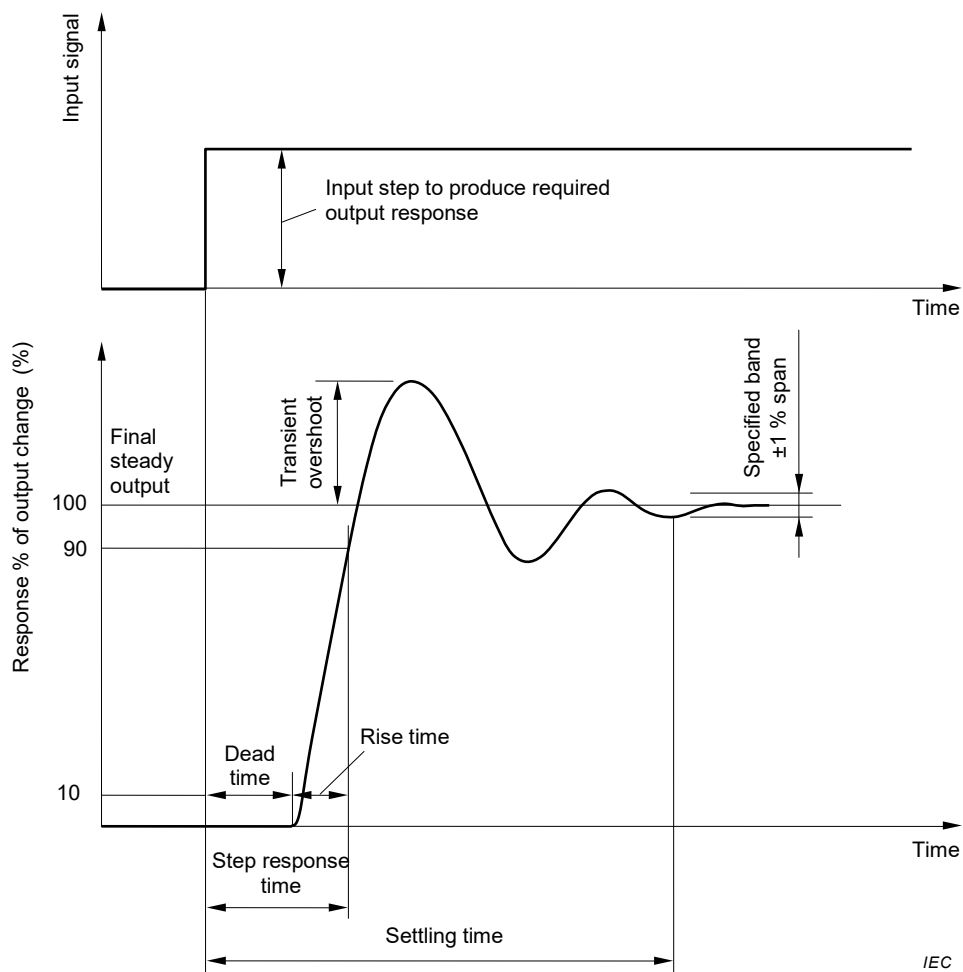


Figure 4 – Example of responses to a step input with overshoot

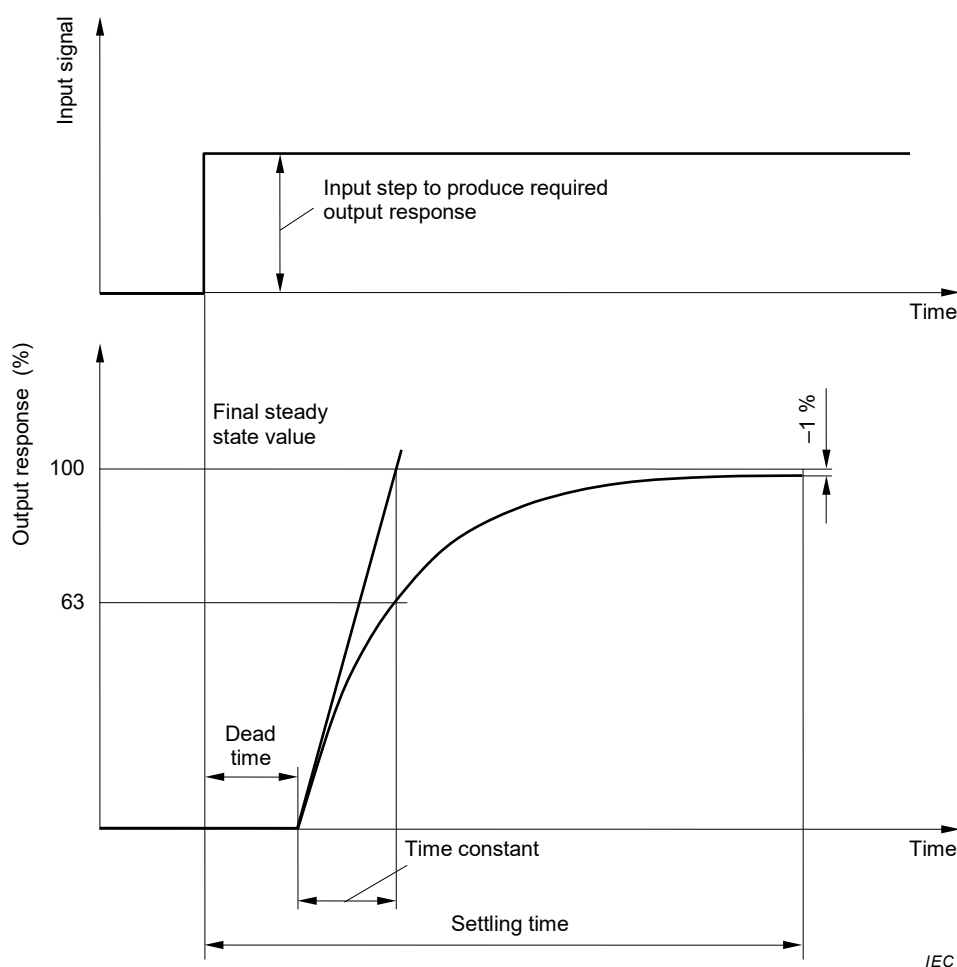


Figure 5 – Example of responses to a step input without overshoot

6.2.4.3 Frequency response

A sinusoidal signal shall be applied by a function generator to the input of the DUT.

The peak-to-peak amplitude of the sinusoidal signal should not exceed 20 % of span, but shall be sufficient to allow a valid measurement without causing distortion or saturation of the output.

The frequency of the input signal shall be increased in increments, from an initial value low enough to determine the static gain, to a higher frequency at which the output is attenuated to less than 10 % of its initial amplitude, or at which the phase lag will be 300° .

At least one complete cycle of the input and output shall be recorded simultaneously at each frequency step.

The results of these tests shall be presented graphically in the following form (see Figure 6 and Figure 7): the gain and the phase lag shall be plotted against frequency on a logarithmic scale.

From the graphs, the following values shall be obtained:

- the frequency at which the relative gain is 0,7;
- the frequency at which the phase lag is 45° ;
- the frequency at which the phase lag is 90° ;

d) the maximum relative gain, and the corresponding frequency and phase angle.

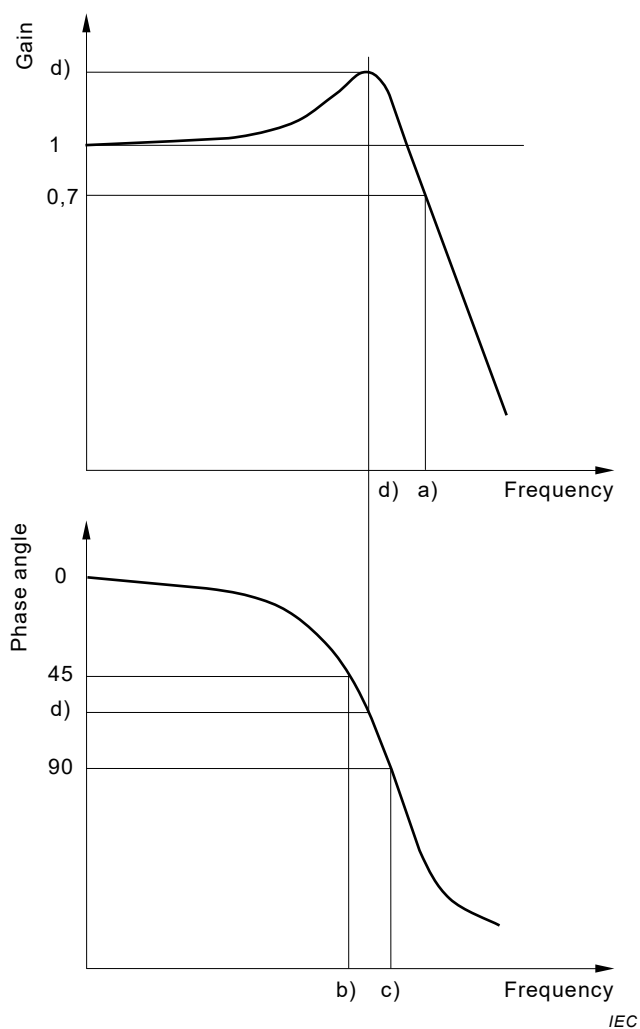


Figure 6 – Example 1 of frequency response

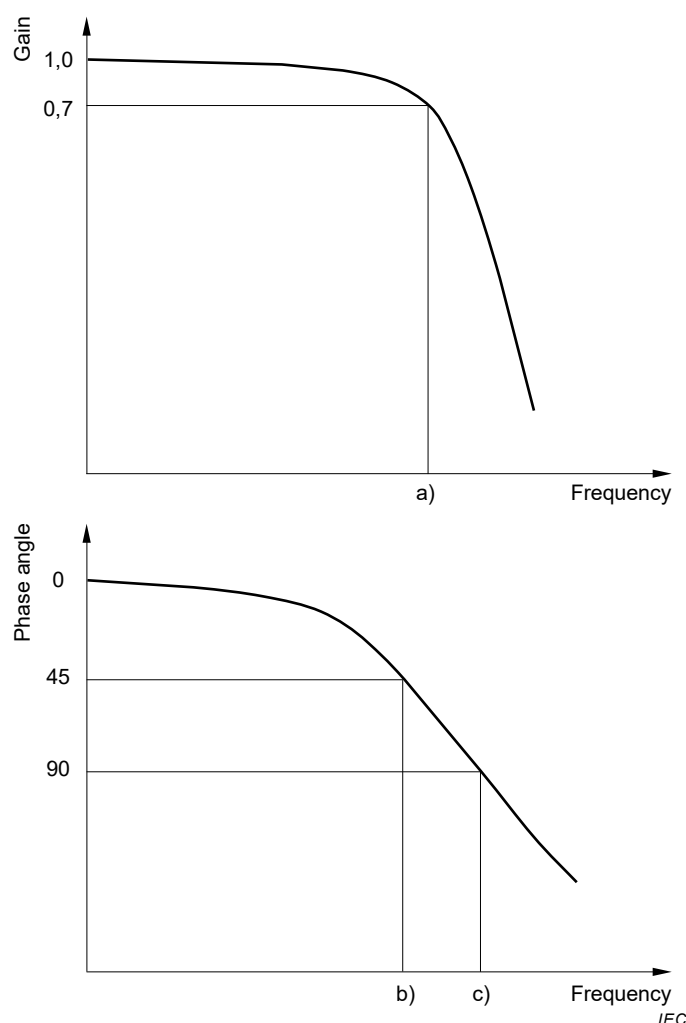


Figure 7 – Example 2 of frequency response

6.2.4.4 Drift characteristics

6.2.4.4.1 Start-up drift

This test shall be carried out by measuring the changes which occur in the output after energizing the DUT.

Prior to the test, the PMT is subjected to ambient environmental conditions, or as advised by the manufacturer, for a period of at least 12 h, but not energized. The span should be adjusted to the approximate mean of the maximum and minimum span, and with the lower range value set approximately at the mid-point of its permissible range of adjustment.

With a 90 % input signal applied to the PMT, it should be switched on, and the output monitored until the output stabilizes (for a maximum period of 4 h). The measurements obtained shall be recorded, and the start-up drift reported as the time for the output to reach and remain within the manufacturer's specified limits.

6.2.4.4.2 Long-term drift

The PMT shall be operated for 30 days and, where practical, a steady input signal corresponding to 90 % of the span shall be maintained.