# INTERNATIONAL STANDARD

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## Transmitters for use in industrial-process control systems –

## Part 3: Methods for performance evaluation of intelligent transmitters



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# TRANSMITTERS FOR USE IN INDUSTRIAL-PROCESS CONTROL SYSTEMS –

## Part 3: Methods for performance evaluation of intelligent transmitters

## FOREWORD

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The International Standard IEC 60770-3 has been prepared by subcommittee 65B, Devices, of IEC technical committee 65: Industrial-process measurement and control.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 65B/580/FDIS | 65B/587/RVD |

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

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

IEC 60770 consists of the following parts, under the general title *Transmitters for use in industrial-process control systems*:

Part 1: Methods for performance evaluation

Part 2: Methods for inspection and routine testing

Part 3: Methods for performance evaluation of intelligent transmitters

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

A bilingual version of this standard may be issued at a later date.

# INTRODUCTION

New transmitters for use in industrial process control systems are now equipped with micro-processors which utilise digital data processing and communication methods, auxiliary sensors and artificial intelligence. This makes them more complex than conventional analogue transmitters and gives them considerable added value.

An intelligent transmitter is an instrument that uses digital data processing and communication methods for performing its functions and for safeguarding and communicating data and information on its operation. It may be equipped with additional sensors and functionality which support the main function of the intelligent transmitter. The variety of added functionality can for instance enhance accuracy and rangeability, self-test capabilities, and alarm and condition monitoring. Therefore accuracy-related performance testing, although still a major tool for evaluation, is no longer sufficient to show the flexibility, capability and other features with respect to engineering, installation, maintainability, reliability and operability.

Because of the complexity of intelligent transmitters, a close collaboration should be maintained between the evaluating body and the manufacturer during the evaluation. Note should be taken of the manufacturer's specifications for the instrument, when the test programme is being decided, and the manufacturer should be invited to comment on both the test programme and the results. His comments on the results should be included in any report produced by the testing organisation.

This part of IEC 60770 addresses, in its main body, structured and mandatory methods for a design review and performance testing of intelligent transmitters. Intelligent transmitters will, in many cases, also have the capacity to be integrated into digital communication (bus) systems, where they have to co-operate with a variety of devices. In this case, dependability, (inter)operability and real-time behaviour are important issues. The testing of these aspects depends largely on the internal structure and organisation of the intelligent transmitter and the architecture and size of the bus system. The Annexes A, B and C give a non-mandatory methodology and framework for designing specific evaluation procedures for dependability and throughput testing and function block testing in a specific case.



When a full evaluation, in accordance with this part of IEC 60770, is not required or possible, those tests which are required, should be performed and the results reported in accordance with the relevant parts of this standard. In such cases, the test report should state that it does not cover the full number of tests specified herein. Furthermore, the items omitted should be mentioned, in order to give the reader of the report a clear overview.

The structure of this part of IEC 60770 largely follows the framework of IEC 62098. For performance testing, the IEC 61298 series should also be consulted. A number of tests described there are still valid for intelligent transmitters. Further reading of the IEC 61069 series is recommended, as some notions in this part of IEC 60770 are based on concepts brought forward therein.

# TRANSMITTERS FOR USE IN INDUSTRIAL-PROCESS CONTROL SYSTEMS –

## Part 3: Methods for performance evaluation of intelligent transmitters

## 1 Scope and object

This part of IEC 60770 specifies the following methods.

- Methods for
  - reviewing the functionality and the degree of intelligence in intelligent transmitters;
  - testing the operational behaviour, as well as the static and dynamic performance of an intelligent transmitter.
- Methodologies for
  - determining the reliability and diagnostic features used to detect malfunctions;
  - determining the communication capabilities of the intelligent transmitters in a communication network.

The methods and methodologies are applicable to intelligent transmitters, which convert one or more physical, chemical or electrical quantities into digital signals for use in a communication network or into analogue electrical signals (as specified in the IEC 60381 series).

The methods and methodologies listed in this part of IEC 60770 are intended for use by:

– manufacturers to determine the performance of their products and

– users or independent testing laboratories to verify equipment performance specifications.

Manufacturers of intelligent transmitters are urged to apply this part of IEC 60770 at an early stage of development.

This standard is intended to provide guidance for designing evaluations of intelligent transmitters by providing:

– a checklist for reviewing the hardware and software design in a structured way;

– test methods for measuring and qualifying the performance, dependability and operability under various environmental and operational conditions;

– methods for reporting the data obtained.

## 2 Normative references

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

IEC 60050-300, *International Electrotechnical Vocabulary (IEV) – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

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

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

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

IEC 60068-2-31, *Environmental testing. Part 2: Tests. Test Ec: Drop and topple, primarily for equipment-type specimens*

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

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*

IEC 60381(all parts), *Analogue signals for process control systems*

IEC 60529:1989, *Degree of protection provided by enclosures (IP Code)*
Amendment 1 (1999)

IEC 60654 (all parts), *Operating conditions for industrial-process measurement and control equipment*

IEC 60721-3 (all parts), *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities*

IEC 60770-1:1999, *Transmitters for use in industrial-process control systems – Part 1: Methods for performance evaluation*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61158 (all parts), *Digital data communications for measurement and control – Fieldbus for use in industrial control systems*

IEC 61298 (all parts), *Process measurement and control devices – General methods and procedures for evaluating performance*

IEC 61326:2002, *Electrical equipment for measurement, control and laboratory use – EMC requirements*

IEC 61499 (all parts), *Function blocks*

IEC 61804 (all parts), *Function blocks (FB) for process control*

CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

## 3 Terms and definitions

For the purposes of this part of IEC 60770, the definitions given in IEC 60770-1 and IEC 60050-300 as well as the following, apply.

**3.1**
**intelligent transmitter**
transmitter provided with means for bi-directional communication with external systems and human operators for sending measurement and status information and receiving and processing external commands

**3.2**
**intelligent single variable transmitter**
transmitter that measures one single physical quantity

**3.3**
**intelligent multi variable transmitter**
transmitter that measures two or more identical or different physical quantities

**3.4**
**adjustment**
set of operations carried out on a measuring instrument in order that it provides given indications corresponding to given values of the measurand

NOTE 1 When the instrument is made to give a null indication corresponding to a null value of the measurand, the set of operation is called zero adjustment.

NOTE 2 Many manufacturers use the term calibration for adjustment of zero, span and linearity or conformity.

**3.5**
**user adjustment**
adjustment, employing only the means at the disposal of the user, specified by the manufacturer

**3.6**
**calibration**
set of operations which establishes by reference to standards the relationship which exists, under specified conditions, between an indication and a result of a measurement

NOTE The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

**3.7**
**tuning**
process of adjusting the various instrument parameters, required for obtaining a stable and optimal measurement. This can range from "trial and error" to an automatic proprietary procedure provided by the manufacturer

**3.8**
**base load**
minimum amount of software necessary to execute the essential function(s)

**3.9**
**signal generator**
installation or device that provides the physical quantity to be measured by a transmitter. The output of the signal generator shall be accurate and traceable to international standards both under reference conditions and controlled operational conditions in the required range

**3.10**
**configuring**
process of implementing the functionality required for a certain application

**3.11**
**configurability**
extent to which an intelligent transmitter can be provided with functions to control various applications

**3.12**
**set-up**
process of configuring, calibrating and tuning a transmitter for optimal measurement

**3.13**
**dead band**
finite range of values within which reversal of the input variable does not produce any noticeable change in the output variable

NOTE The dead band may be entirely defined by the resolution of the digital processing in the data processing subsystem and the electrical output system.

**3.14**
**operating mode**
selected method of operation of a transmitter

**3.15**
**accuracy**
closeness of agreement between the result of a measurement and the (conventional) true value of the quantity being measured

**3.16**
**error**
algebraic difference between the measured value and the true value of a measured quantity

**3.17**
**conformity error**
absolute value of maximum deviation between the calibration curve and the specified characteristic curve

**3.18**
**linearity error**
absolute value of maximum deviation between the calibration curve and the specified straight line



## 4 Design review



### 4.1 General

The design review is meant to identify and make explicit, in a structured way, the functionality and capabilities of the intelligent transmitter under consideration. As stated in the introduction, intelligent transmitters appear in a great variety of designs. A design review is the necessary tool for showing the details of:

– The physical structure.
– The functional structure.

Subclause 4.2 guides the evaluator through the process of describing the physical structure of intelligent transmitters by identifying the hardware modules and the inputs and outputs to the operational and environmental domains. Thereafter, the functional structure can be described, using the checklist of 4.3. The checklist gives a framework of the relevant issues, which need to be addressed by the evaluator, mainly through adequate qualitative and quantitative experiments.

### 4.2 Transmitter analysis

#### 4.2.1 General

Two different types of transmitters can be identified:

- **Single-variable transmitter.** The measured value (output) represents one single physical quantity measured by one type of sensor.

- **Multi-variable transmitter.** This type of transmitters appears in two versions:
  - An instrument providing a variety of measured values (outputs), each of which is related to a measurement of one distinct input quantity with a specific sensor.
  - An instrument providing composite measured variables resulting from the measurement of more than one quantity through more than one type of sensor and processed through a distinct algorithm (e.g. flow computer, mechanical power meter). In many cases, the individual measured variables are also available to the user.

Each type of intelligent transmitter may be equipped with independent auxiliary sensors and auxiliary (mainly digital) outputs, which are not involved in the primary measurement process.

The generic transmitter model of Figure 1 gives a maximum configuration and is a tool for setting up a blockscheme and concise description of the transmitter to be evaluated. It is also important for defining the functions to be considered in the performance tests (see Clause 5).

Functionally, a transmitter is an information transformer. Data enters and then exits the instrument through the various (external) domains given in Figure 1, following distinct data flow paths. The following paths can be defined, but are not always resident in a specific transmitter under consideration:

- Sensors (process domain) to external systems (remote data processing systems).
- Sensors (process domain) to operator displays (human domain).
- Sensors (process domain) to external systems (electrical outputs).
- Operator commands through local keyboard (human domain) to data processing subsystem, consequently affecting the above-mentioned data flows to external systems (remote data processing systems and electrical outputs).
- Remote commands (from external remote data processing systems) to the instrument's data processing subsystem, consequently affecting the above-mentioned data flows to external systems (electrical outputs) and local operator displays (human domain).

A blockscheme and description shall be included in the evaluation report and may be enhanced with photographs or drawings of important details.



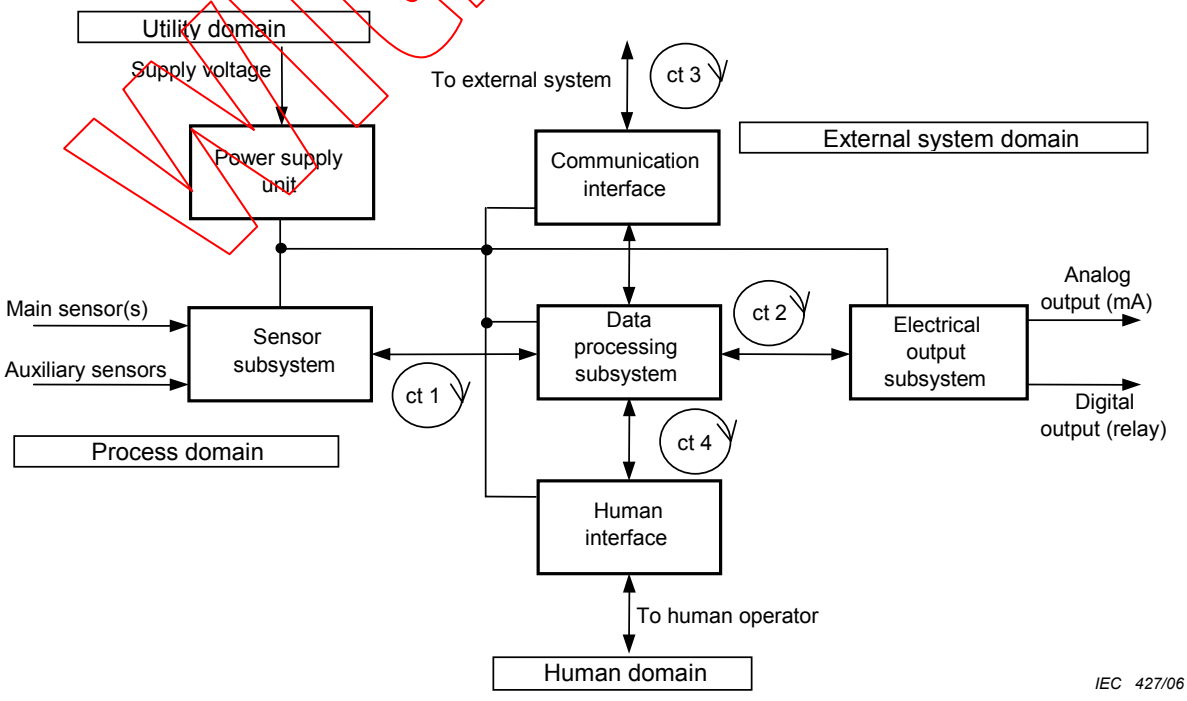


**Figure 1 – Intelligent transmitter model**

For an intelligent transmitter, the main physical modules and provisions for connection to external systems and human operators are defined in 4.2.2 to 4.2.9.

### 4.2.2 Data processing subsystem

The data processing subsystem is the heart of an intelligent transmitter. Its main function is to provide and process the measured quantity(ies) for further real-time use by the human and communication interfaces and/or at the electrical output subsystem. Many transmitters measure one quantity by means of one (main) sensor, but composite measured variables such as heat- or mass-flow and mechanical power require more sensors.

Besides the main measurement function, a transmitter may be equipped with a number of additional functions that can vary considerably from make to make. Amongst the additional functions that may be resident in a transmitter are:

– configuration;
– adjustment, and tuning;
– self-testing, diagnostics, condition monitoring;
– external process control function;
– trending and data storage.

Part of the functionality may be located in external devices that are temporarily or continuously connected to the communication interface (e.g. configuring, trending).

### 4.2.3 Sensor subsystem

The sensor subsystem converts the physical or chemical quantity(ies) to be measured into electrical signals that are conditioned and digitised for use by the data processing unit. The subsystem may also be equipped with electrical circuits for sensing binary signals (e.g. change measurement range on an external command), or auxiliary sensors of a different type (e.g. auxiliary for compensation or internal diagnostics and condition monitoring purposes).

The sensor and sensor subsystem may be integrated with the other modules in one enclosure. The sensor can also be located remotely (e.g. densitometer, thermocouple transmitter). Certain transmitters (e.g. thermocouple and Resistance Thermometer Detector (RTD)) utilise standardised (third party) sensors that provide an electric signal. In such a case, it may be agreed to perform the evaluation with an acceptable simulator instead of the application of the actual quantity.

Depending on the measurement principle used, the sensor may not require auxiliary (external) power (e.g. thermocouples) or it may require auxiliary power (e.g. strain gauges) or a specifically characterised power source (e.g. electromagnetic and Coriolis flowmeters).

Sensors are, in general, incorporated in the process installations and in many cases, they may also be in direct contact with the process medium. As such, medium properties, medium conditions and installation conditions may adversely influence them. As a remote unit, the sensor may also be subjected to more severe environmental conditions than the other subsystems. Moreover, it shall also be considered whether it is necessary to apply combined environmental and process conditions during an evaluation.

As part of the design review, a list of the types of sensors that are provided and their measuring ranges shall be compiled.