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Evaluation methods for microprocessor-based instruments

Méthodes d'évaluation des instruments à microprocesseur

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EVALUATION METHODS FOR MICROPROCESSOR-BASED INSTRUMENTS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

IEC 62098, which is a technical specification, has been prepared by subcommittee 65B: Devices, of IEC technical committee 65: Industrial-process measurement and control.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
65B/388/CDV	65B/401/RVC

Full information on the voting for the approval of this technical specification 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 3.

Annex A forms an integral part of this technical specification.

Annexes B, C, D and E are given for information only.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

- transformed into an International Standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

Rationale

An evaluation of an instrument or a process controller is a supportive tool for assessing the cost of ownership for a measurement or a control function in a plant over the lifetime of that plant. The cost of ownership then comprises all costs for investments (including replacements over plant lifetime), engineering, installation, maintenance, energy and material consumption.

New instruments for process control and measurement are often equipped with microprocessors, thereby utilising digital data processing methods and artificial intelligence. This makes them more complex, and the existing standardised evaluation methods are not always sufficient to show the instrument capabilities.

An evaluation can consist in its most extended form of the following activities:

- design review (hardware and software);
- performance (functional) testing;
- study of testing for reliability, maintainability;
- safety study and testing for safety;
- field testing.

The evaluation methods described herein mainly treat aspects related to performance and reliability testing. This Technical Specification can be seen as an expansion on IEC 61298. Methods mentioned therein that are still valid for microprocessor-based instruments are mentioned here for completeness but are not repeated in full. When relevant, that publication shall be consulted.

Some considerations on the evaluation of microprocessor-based instruments in this technical specification are based on ideas brought forward in IEC 61069.

In the future, microprocessor-based instruments will increasingly be integrated in digital communication systems. Therefore the communication aspect and its possible influence on real-time operation and further performance of the instruments will also be considered.

EVALUATION METHODS FOR MICROPROCESSOR-BASED INSTRUMENTS

1 General

1.1 Scope

This Technical Specification aims at providing background information for developing evaluation methods for microprocessor-based instruments.

An evaluation starts with analysis of the instrument in terms of the external and internal information flows from and to the process, the human operator and external systems. Main function blocks in the instrument are then identified. By using the checklists given in 4.2 and 4.3, the functions and properties that may be embedded in the function blocks of the instrument to be evaluated can be identified.

Subclause 4.4 gives a checklist for identification of the relevant influencing conditions for the instrument to be evaluated.

Depending on the application of an instrument, the user of this technical specification may have to define further functions and properties or influencing conditions.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Technical Specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this Technical Specification are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to, applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050-351, *International Electrotechnical Vocabulary (IEV) – Part 351: Automatic control*

IEC 60546 (all parts), *Controllers with analogue signals for use in industrial-process control systems*

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

IEC 61069 (all parts), *Industrial-process measurement and control – Evaluation of system properties for the purpose of system assessment*

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

1.3 Definitions

For the purposes of this technical specification the definitions given in IEC 60050-351, IEC 60546, IEC 60770-1, IEC 61069 and IEC 61298 apply.

2 Developments in instrumentation

Instrument functions can be realised in various ways.

In analogue instruments, functions are realised by the layout and size of hardware components and by the use of analogue data processing.

The first instruments equipped with microprocessors and using digital data processing techniques appeared in the late 1970s and early 1980s. Since then, the use of software-based digital data processing techniques for measuring instruments and controllers has grown disproportionally. Also there has been an increase in functionality and data processing capacity.

Microprocessor-based instruments are sampled data systems. That means that the outputs and other relevant data are refreshed or updated with new data at certain time intervals or cycle times. Besides the measurement task, the instrument has in the same operating interval to perform other tasks such as communication and self-testing. In particular, for time-dependent functions (control, integration, etc.) microprocessor-based instruments can become time-critical. This means that errors can appear when time-housekeeping is either inaccurate or disturbed. Time-housekeeping can for instance be upset when the design allows simultaneous operation of various tasks without a careful prioritisation in the multi-tasking.

The extensive data processing, memory and storage capabilities of microprocessors permit the integration of control algorithms (e.g. PID) and process trend information in measuring instruments.

The data processing capabilities also permit the use of more complex sensing techniques. They have provided opportunities to develop more “exotic” types of sensors where the measuring principle needs for instance the use of statistical methods to determine the physical quantity.

Increased knowledge of sensors has led to better mapping of the sensor characteristics. These maps can be embedded in the software, and by the use for instance of internal auxiliary sensors they can be used to provide a much greater rangeability such as in pressure and differential pressure sensors.

Moreover, the processing capacity provides the possibility of processing sensor data to derive other information that can be of interest for maintenance purposes. Maintenance may also be supported by auxiliary sensors that provide information on wear-out or overloading etc. of the instrument or the equipment to which it is connected. Stored historic, diagnostic and statistical data may also be used for improving maintenance.

The communication interface may be designed for communication with a high-level operator interface over a digital communication link. It may also allow direct instrument-to-instrument communication over the same link.

Some of the above-mentioned considerations are summarised in table 1.

Table 1 – Analog and microprocessor-based instrument functions

Functionality	Analogue instruments	Microprocessor-based instruments
Data processing	– continuously: pneumatic or electric – single function	– sampled data (can be time-critical) – multifunction often provided with a library of standardised function blocks – large processing capacity, suitable for complex calculations, (smart) alarming – suitable for new sensing techniques
Process I/O functions	– single sensor – single output analogue – limited rangeability	– multisensor – multi-output analogue and/or digital – extended rangeability by better mapping of sensor characteristics and use of auxiliary internal sensors for temperature, pressure compensation, etc. – equipped with binary inputs for sensing contact closure
Human I/O functions	– dial gauges, potentiometers	– local digital displays and pushbuttons for parameter adjustment – remote control via CRT and keyboard
Communication functions	– analogue (4-20 mA)	– digital with local hand terminals – digital over long cables – integration in DCS (digital communication system)
Construction	– one integrated unit	– modular construction
Self-testing	– limited (live zero, TC-break)	– extensive – check for internal failures – check for line break/power failure – check on related external devices – check for preventive maintenance

3 Evaluation considerations

3.1 System approach

The system approach gives the best explanation of the development of the evaluation technology addressed in this technical specification. The term “system” is defined as follows:

"A system is a set of interdependent elements constituted to achieve a given objective by performing a definite function.”

An informative note accompanying the definition gives an alternative approach, which is of equal importance as it indicates the boundaries of a system with its environment; it reads:

"A system is considered to be separated from the environment and other external systems by an imaginary surface which cuts the links between them and the considered system. Through these links the system is affected by the environment and is acted upon by the external systems, or acts itself on the environment or the external systems."

Using this definition, every instrument can be treated as a system.

An ideal system (the concept) should be able to indefinitely perform its function without error, fault, failure and unwanted delay. However, the real system developed from the functional concepts is not ideal due to the imperfect (time- and space-bound) nature of the materials used. It is therefore sensitive to disturbing external factors.

Because of this non-ideal behaviour of the real system, there is a practical need for characterising the points of concern with respect to their application in more or less measurable properties, such as accuracy, stability, reliability, maintainability, etc.

The specifications of the properties indicate the deviations between the functional concepts and the realisation of the functions of a system and are a measure of its quality.

The main constituents of a system described above and the interaction with the environment are clearly shown in figure 1. The environment is for practical reasons further split into a number of domains. The boundary is expanded to a boundary area consisting of a number of interfaces. The various environmental domains are the sources of disturbance (influencing conditions) for an instrument.

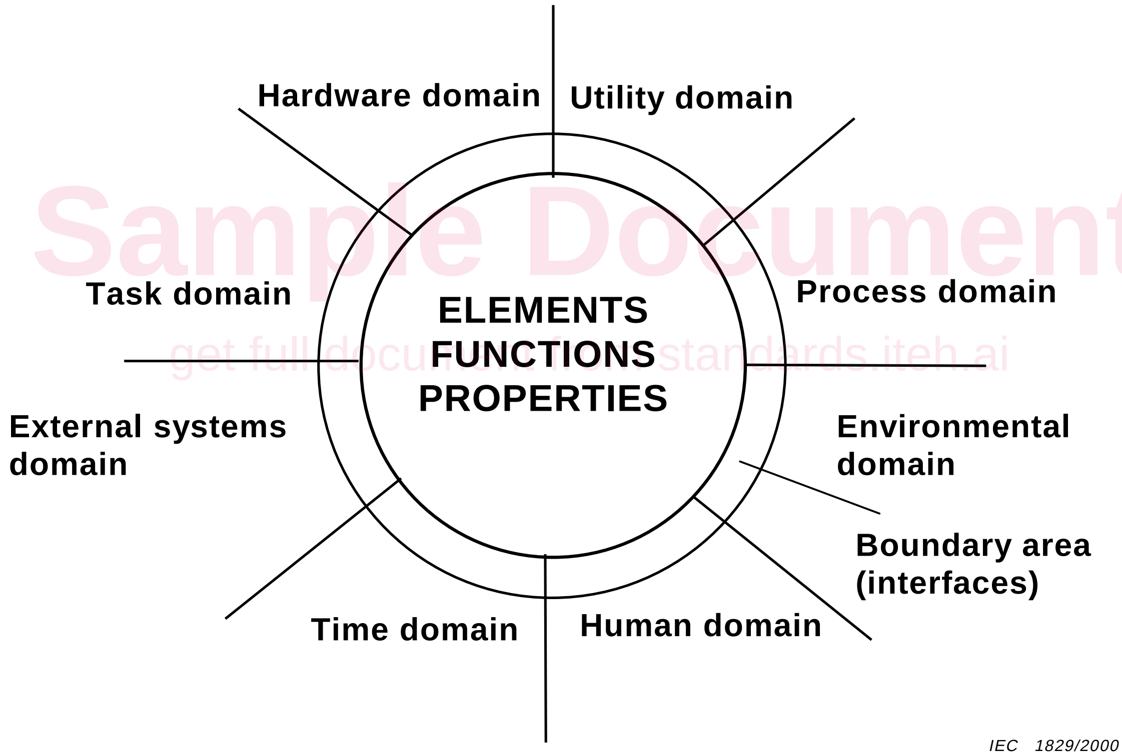

Figure 1 – Generic system model

3.2 Evaluation matrix

The main points to be defined in detail for an evaluation are:

a) instrument elements;

b) instrument functions;

c) instrument properties;

d) influencing conditions.

The choice made may not cover the totality of requirements and specifications for an instrument under consideration and is a compromise between the parties involved.