

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Telecontrol equipment and systems –  
Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion  
standards**

**Matériels et systèmes de téléconduite –  
Partie 5-6: Lignes directrices pour les essais de conformité des normes  
d'accompagnement IEC 60870-5**



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## CONTENTS

|  |    |
|--|----|
| FOREWORD.....  | 3  |
| INTRODUCTION.....  | 5  |
| 1 Scope.....   | 6  |
| 2 Normative references .....                               | 6  |
| 3 Terms and definitions .....                              | 7  |
| 4 Abbreviations .....                                      | 11 |
| 5 Conformance testing .....                                | 12 |
| 5.1 General.....   | 12 |
| 5.2 Conformance test procedures.....                       | 12 |
| 5.3 Quality assurance and testing .....                    | 13 |
| 5.4 Quality plan .....                                     | 13 |
| 5.5 Testing.....   | 14 |
| 5.6 Testing process.....                                   | 18 |
| 5.7 Documentation .....                                    | 20 |
| Bibliography.....  | 22 |
| Figure 1 – Conceptual conformance assessment process ..... | 16 |
| Figure 2 – Testing process.....                            | 18 |
| Figure 3 – Quality program .....                           | 19 |

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## TELECONTROL EQUIPMENT AND SYSTEMS –

Part 5-6: Guidelines for conformance testing for  
the IEC 60870-5 companion standards

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International Standard IEC 60870-5-6 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This bilingual version (2017-06) corresponds to the English version, published in 2006-03.

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

| FDIS        | Report on voting |
|-------------|------------------|
| 57/792/FDIS | 57/807/RVD       |

Full information on the voting for the approval of this part of IEC 60870-5 can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

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

IEC 60870-5 consists of the following parts, under the general title *Telecontrol equipment and systems – Part 5: Transmission protocols*:

- Part 5-1: Transmission frame formats
- Part 5-2: Link transmission procedures
- Part 5-3: General structure of application data
- Part 5-4: Definition and coding of application information elements
- Part 5-5: Basic application functions
- Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion standards
- Part 5-101: Companion standard for basic telecontrol tasks
- Part 5-102: Companion standard for the transmission of integrated totals in electric power systems
- Part 5-103: Companion standard for the informative interface of protection equipment
- Part 5-104: Network access for IEC 60870-5-101 using standard transport profiles
- Part 5-601: Conformance test cases for the IEC 60870-5-101 companion standard

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## INTRODUCTION

This part of IEC 60870-5 specifies methods and procedures for conformance testing of Telecontrol equipment or systems using IEC 60870-5 standard(s).

This part of IEC 60870-5 contains general subjects and guidelines for the test environment. Detailed test cases, mandatory and optional mandatory test cases for the companion standards will become available as technical specifications (IEC 60870-5-60x).

Tests according to EMC requirements or related to environmental and organisational conditions are beyond the scope of this part of IEC 60870-5. This part of IEC 60870-5 only focuses on the protocol implementation and the related system functionality necessary to validate the protocol implementation.

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## TELECONTROL EQUIPMENT AND SYSTEMS –

### Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion standards

#### 1 Scope

This part of the IEC 60870-5 series specifies methods for conformance testing of telecontrol equipment, amongst Substation Automation Systems (SAS) and telecontrol systems, including front-end functions of SCADA.

The use of this part of IEC 60870-5 facilitates interoperability by providing a standard method of testing protocol implementations, but it does not guarantee interoperability of devices. It is expected that using this part of IEC 60870-5 during testing will minimize the risk of non-interoperability.

The goal of this part of IEC 60870-5 is to enable unambiguous and standardised evaluation of IEC 60870-5 companion standard protocol implementations. The guidelines and conditions for the testing environment are described in this part of IEC 60870-5. The detailed test cases per companion standard, containing among others mandatory and optional mandatory test cases per Basic Application Function, ASDU and transmission procedure, will become available as technical specifications (IEC 60870-5-60x). Other functionalities may need test cases, but this is beyond the scope of this part of IEC 60870-5.

This part of IEC 60870-5 deals mainly with communication conformance testing; therefore other requirements, such as safety or EMC are not covered. These requirements are covered by other standards (if applicable) and the proof of compliance for these topics should be done according to those standards.

#### 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 60870-5-1, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section One: Transmission frame formats*

IEC 60870-5-2, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 2: Link transmission procedures*

IEC 60870-5-3, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 3: General structure of application data*

IEC 60870-5-4, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 4: Definition and coding of application information elements*

IEC 60870-5-5, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions*

ISO/IEC 9646 (all parts), *Information technology – Open Systems Interconnection – Conformance testing methodology and framework*



### 3 Terms and definitions

For the purposes of this part of IEC 60870-5, the following terms and definitions apply.

#### 3.1

##### **configuration (of a system or device)**

step in system design: selecting functional units, assigning their locations and defining their interconnections

#### 3.2

##### **configuration list**

supplies an overview of all compatible hardware and software versions of components of controlled/controlling stations including the software versions of relevant supporting tools

#### 3.3

##### **address config**

address config is the configuration file containing the ASDU-addressing including the information object addresses necessary to test all the functionality defined as in the PID

#### 3.4

##### **conformance test**

verification process of the protocol implementation in a device by executing tests according to the applicable test plan, which contain mandatory and possibly mandatory optional test cases, so as to be able to answer the following question:

*“Does the protocol implementation in device xxx of supplier yyy conform to the IEC 60870-5-10x standard and the applicable Protocol Implementation Document (PID)?”*

NOTE A supplier-independent party that is allowed to issue a Conformance Statement can carry out a conformance test.

#### 3.5

##### **device**

mechanism or piece of equipment designed to serve a purpose or perform a function

[IEEE STD 100-1996, IEEE Dictionary of Electrical and Electronic Terms]

#### 3.6

##### **direction**

communication direction in which the device exchanges the data

NOTE IEC 60870-5 companion standards describe functions and ASDU's in the monitor direction (from the controlled to the controlling station) and control direction (from controlling to controlled station) as Normal direction (N). For some purposes, the functions or ASDU's can be used also in the Reverse direction (R) or in Both directions (B). The way they are used should be indicated in the PICS. If reversed direction is enabled, by using R or B, the functionality is used in the reverse direction, the applicable test cases in the normal direction are applicable for the reversed functionality.

#### 3.7

##### **error**

behaviour, which does not conform to the standard and/or the applicable test cases as described in this part of IEC 60870-5

#### 3.8

##### **Factory Acceptance Test**

##### **FAT**

customer agreed functional tests of the specifically manufactured telecontrol equipment or its parts using the parameter set for the planned application

NOTE The FAT should be carried out in the factory of the manufacturer by the use of process simulating test equipment.

### 3.9 function

tasks performed by the telecontrol equipment

NOTE Generally, functions will exchange data with each other.

### 3.10 hold point H

point, defined in the appropriate document beyond which an activity should not proceed without the approval of the initiator of the conformance test. If necessary, the test facility could provide a written notice to the initiator at an agreed time prior to the hold point. The initiator or his representative is obliged to verify the hold point and approve the proceeding of the activity

### 3.11 quality program

quality program for the IEC 60870-5 series as described in Figure 3

### 3.12 initiator of conformance test

party initiating a conformance test that may be executed by a test facility

### 3.13 interface

shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

### 3.14 interoperability

ability of two or more telecontrol devices from the same vendor, or different vendors, to exchange information and use that information for correct co-operation

### 3.15 interoperability test

verification of the information exchange of two or more devices from the same vendor or different vendors.

In case of an open protocol, the test shall give an answer to the following question:

*“Are the devices under test (DUT) able to communicate correctly according to the IEC 60870-5-10x standard and the Protocol Implementation Document (PID)?”*

The interoperability test can be carried by a supplier-independent party that may result in an interoperability statement. A basic condition for this interoperability test is a passed conformance test of both devices

NOTE Interoperability does not necessarily mean that both systems are communicating according a specific protocol, but that both those devices are able to communicate and this might be an open protocol. Interoperability is not interchangeability.

### 3.16 interchangability

ability to replace a device from the same vendor, or from different vendors, using the same communication interface and as a minimum, with the same functionality, and with no impact on the rest of the system

**3.17****mandatory optional test case**

test case initially marked as optional in the column “required”, indicated by “PICS, ....” or “PIXIT” which becomes a mandatory test case if this functionality is enabled and/or described in the PICS or the PIXIT. This optional test case then becomes a mandatory test case

**3.18****negative test**

test to verify the correct response of a device or a system on:

- IEC 60870-5 series conformant information and services, which are not implemented;
- non conformant communication traffic

**3.19****open protocol**

communication protocol of which the protocol specification is freely accessible for all market parties, for example an IEC protocol communication standard

**3.20****Physical Connection****PC**

communication link between physical devices

**3.21****Physical Device****PD**

independent physical entity capable of performing one or more specified device functions in a particular context and delimited by its interfaces. A physical device is equivalent to or is part of a controlling or controlled station

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**3.22****plausibility test**

a plausibility test is passed if the corresponding time, value, status or other items have been shown to have the correct value (no tolerance) for time-stamp, values, status and for the other items regarding the requirements in 5.6.3

NOTE Applicable tolerances may be part of the PIXIT.

**3.23****Protocol Implementation eXtra Information for Testing****PIXIT**

the PIXIT document contains system specific information regarding the capabilities of the system to be tested and specifies which items are optional, in the applicable Companion Standard or outside the scope of the 60870-5 series. The PIXIT is not subject to standardisation, but 5.5.1.4 describes guidelines and recommendations for setting up a PIXIT

NOTE It is recommended to integrate the PIXIT and the PICS into one document, which is the PID.

**3.24****positive test**

test to ensure the correct implementation of the system capabilities as defined by the supplier. A positive test has a described and defined response

**3.25****Protocol Implementation Conformance Statement****PICS**

summary of the capabilities of the system to be tested. Every companion standard contains a PICS. The use of the interoperability sheets of the particular standard for the definition of the PICS is mandatory

NOTE It is recommended to integrate PIXIT and PICS into one document, which is the PID.

**3.26  
Protocol Implementation Document  
PID**

describes the way a specific area (country, company, functionality) uses and implements the protocol. The PID consists of the PICS and the PIXIT. The PID shall not be subject to standardisation and is system specific. The PID always contains the PICS and is mandatory for conformance testing

NOTE It is recommended to integrate the PIXIT and the PICS into one document, which is the PID.

**3.27  
Remote Terminal Unit  
RTU**

acts as an interface between the communication network and the substation equipment

NOTE An RTU is typically an outstation.

**3.28  
review  
R**

optional systematic examination, defined in the appropriate document, of the quality document(s) for an activity

NOTE The test facility can provide the documentation to be reviewed to the initiator of the conformance test at an agreed time prior to the associated hold or witness point. It is subject to agreement how the review will be conducted.



**3.29  
system**

set of interrelated elements considered in a defined context as a whole and separated from its environment

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**3.30  
logical system**

union of all communicating functions performing some overall tasks such as “management of a substation”

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**3.31  
physical system**

composition of all devices and the interconnecting physical communication network

NOTE The boundary of a system is given by its logical or physical interfaces. Within the scope of IEC 60870-5, system always refers to Telecontrol equipment and systems, if not mentioned otherwise.

**3.32  
system test**

check of correct behaviour of the controlled/controlling station under various application conditions

NOTE The system test marks the final stage of the development of a Telecontrol equipment or system.

**3.33  
test equipment**

all tools and instruments, which simulate and verify the communication traffic, input or outputs of the system under test

**3.34  
test facility**

supplier-independent organisations, which are able to provide appropriate test equipment and trained staff for conformance testing

NOTE The management of conformance tests and the resulting information should follow a quality system according to ISO 9001/ISO 9002 as far as applicable.

Test facilities should comply with the requirements as described in this part of IEC 60870-5.

**3.35****test item**

one single test step out of the sequence of tests defined to verify conformance

**3.36****type test**

verification of correct behaviour of the DUT by use of the system tested software under the environmental test conditions corresponding with the technical data

NOTE The type test marks the final stage of the hardware development and is the precondition for the start of the production. This test should be carried out with IED's, which have been manufactured through the normal production cycle.

**3.37****witness point****W**

point, defined in the appropriate document, at which an inspection should take place on an activity. The activity may proceed without the approval of the initiator of the conformance test. The test facility can provide a written notice to the initiator at an agreed time prior to the witness point. The initiator or his representative has the right, but is not obliged, to verify the witness point

**3.38****receiving system**

system that receives the message, either on physical, link or application layer level, and can be a controlling (Master) station or a controlled (Slave) station

**4 Abbreviations**

|       |   |
|-------|---|
| ASDU  | Application Service Data Unit                         |
| BAF   | Basic Application Function                            |
| CASDU | Common Address of ASDU                                |
| COT   | Cause Of Transmission                                 |
| DUT   | Device Under Test                                     |
| FAT   | Factory Acceptance Test                               |
| HMI   | Human Machine Interface                               |
| IED   | Intelligent Electronic Device                         |
| IOA   | Information Object Address                            |
| IP    | Inter-Networking Protocol                             |
| MTTF  | Mean Time To Failure                                  |
| PICS  | Protocol Implementation Conformance Statement         |
| PID   | Protocol Implementation Document (=PICS + PIXIT)      |
| PIXIT | Protocol Implementation eXtra Information for Testing |
| RTU   | Remote Terminal Unit                                  |
| SAT   | Site Acceptance Test                                  |
| SCADA | Supervisory Control And Data Acquisition              |
| SUT   | System Under Test                                     |
| TCP   | Transport Control Protocol                            |
| TE    | Telecommunication Environment                         |

## 5 Conformance testing

### 5.1 General

There are many steps involved from the development and production of a device to the proper running of a complete system designed according to the specific needs of a customer. Suitable test steps are incorporated in this process.

The quality system of the producer/supplier forms the basis of reliable testing in development and production activities.

Many internal tests during the development of a device (or a system kit) result in a type test (unit level test) performed at least by the provider and – if required by applicable standards – by an independent test authority. In the context of this document, the term type test is restricted to the functional behaviour of the device.

Continuing routine tests in the production chain are necessary to ensure a constant quality of delivered devices in accordance with the quality procedures of the producer.

A conformance test is the type test for communication and – since communication establishes a system – the system related test of the incorporated IED's. As a global communications standard, the IEC 60870-5 series includes standardised conformance tests to ensure that all suppliers comply with applicable requirements.

Type tests and conformance test do not completely guarantee that all functional and performance requirements are met. However, when properly performed, such tests significantly reduce the risk of costly problems occurring during system integration in the factory and on-site.

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Conformance testing does not replace project-specific system related tests such as the FAT and SAT. The FAT and SAT are based on specific customer requirements for a dedicated substation automation system and are done by the system integrator and normally witnessed by the customer. These tests increase the confidence level that all potential problems in the system have been identified and solved. These tests establish that the delivered substation automation system is performing as specified.

### 5.2 Conformance test procedures

In general, conformance testing of the communication behaviour of devices shall address the functional requirements and performance requirements of typical applications supported by these devices in a system.

Conformance testing demonstrates the capability of the DUT to operate with other devices in a specified way according to the PID. The conformance test shall prove that the communication of the DUT works according to the PID.

The role of institutions and test bodies for conformance testing and certifying the results is described in this Subclause.

For conformance testing, the following points shall be considered:

- The problem of any testing is the completeness of the tests. The number of all possible situations could be very large. This part of IEC 60870-5 and the technical specifications (IEC 60870-5-60x) takes into consideration the normal operating cases, but not the failure cases. Only some failure cases are defined and it is recommended to add failure test cases in case of a critical function.

- A communication standard does not standardise the functions of the communicating equipment, including failure modes of the functions. But both the existence of distributed functions and the impact of function response in devices on the data flow create some interdependence.
- Depending on the definition range of the standard, some properties of the device may be proven not by the conformance test itself, but by information and documents to be provided with the DUT for the conformance testing.

For every companion standard, the PICS form the basis for the tests. As input, PICS defines the supported functions of a device. The output is the test plan for the applicable companion standard that contains the PICS and the marked check boxes (with N, R or B) that indicates that the applicable mandatory test cases are validated and approved by a test facility. Optional or additional test cases can be part of the test plan but will be marked separately, including their reference to the PIXIT. If test cases are applicable as indicated in the PICS and/or PIXIT, these test cases are mandatory optional test cases.

The test plan for each companion standard is the same for the controlling and/or controlled station. The check box at the beginning of the PICS indicates whether a controlling or controlled station is tested and approved.

### 5.3 Quality assurance and testing

In order to assure the quality during conformance testing, a quality assurance system shall be in place. This shall be clearly demonstrated by the test facility. This applies also to the quality systems of all sub-suppliers.

In general, quality surveillance is used to monitor and verify the status of components during all phases of the conformance tests. For this purpose, inspections can be carried out, based on hold and witness points that are indicated by the purchaser or its representative in the test and inspection book that is supplied by the test facility. These inspections are process related and will provide information on, and confidence in, the quality of the tests. It will reduce the risks of failure during the Factory Acceptance Test (FAT) and Site Acceptance Test (SAT).

### 5.4 Quality plan

#### 5.4.1 Conformance test quality plan

The test facility can supply, for evaluation, a quality plan for the conformance test.

This plan describes all measures for the scope of work and/or deliveries in the areas of budget, organisation, time, information and quality. There is only one plan for the test facility and its sub-suppliers.

The conformance test quality plan shall also contain the following:

- The complete and detailed description of the work methods which guarantees that all verifiable activities will fulfil all applicable requirements and conditions as stated in the scope of work during the total lead time.
- A detailed description of all tasks to be performed, including references to the schedule, an overview of the involved staff, materials and work methods as well as relevant methods and procedures.
- A detailed description of the organisation, including the assignments, tasks and responsibilities of mentioned staff for all tests, inspections, research and audits during the various stages of the tests and the dates at which they will take place. These programs will be part of the test and inspection book.
- A method for handling deviations, changes and modifications during all stages of the test.
- A sign off procedure and a description of the documentation to be supplied.