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TECHNICAL SPECIFICATION

colour inside

Telecontrol equipment and systems –
Part 5-604: Conformance test cases for the IEC 60870-5-104 companion standard

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FOREWORD

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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.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60870-5-604, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

a) Resolution of ambiguities between IEC 60870-5-104:2006 and IEC TS 60870-5-604:2016 (together with IEC 60870-5-104/AMD1);
b) Refinement of some test cases to enhance operability between tested devices;
c) Additional test cases (mainly negative test cases) added.

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

Enquiry draft	Report on voting
57/1614/DTS	57/1683/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 2.

A list of all parts of IEC 60870 series, published under the general title *Telecontrol equipment and systems,* can be found on the IEC website.

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

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- withdrawn,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

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 60870, which is a technical specification, describes test cases for conformance testing of telecontrol equipment or systems using the IEC 60870-5-104 companion standard and IEC 60870-5-6, *Guidelines for conformance testing for the IEC 60870-5 companion standards*.

TELECONTROL EQUIPMENT AND SYSTEMS –

Part 5-604: Conformance test cases for the IEC 60870-5-104 companion standard

1 Scope

This part of IEC 60870, which is a technical specification, describes test cases for conformance testing of telecontrol equipment, Substation Automation Systems (SAS) and telecontrol systems, including front-end functions of SCADA, using the IEC 60870-5-104 companion standard and IEC 60870-5-6, *Guidelines for conformance testing for the IEC 60870-5 companion standards*.

The use of this part of IEC 60870 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 specification during testing will minimize the risk of non-interoperability.

The goal of this part of IEC 60870 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 IEC 60870-5-6. 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 a technical specification. Other functionality may need additional test cases but this is outside the scope of this part of IEC 60870. For proper testing, it is recommended to define these additional test cases. This document is such a Technical Specification for the mentioned companion standard.

This part of IEC 60870 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 is done according to these standards.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.[1]

IEC 60870-5-4:1993, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 4: Definition and coding of application information elements*

IEC 60870-5-5:1995, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions*

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[1] The base standard always takes precedence. In case of ambiguity between this technical specification and the base standards (IEC 60870-5-1 to IEC 60870-5-5, IEC 60870-5-104), this part of IEC 60870 needs to be clarified or amended.

When testing, negative behaviour is not described in the base standard, the behaviour described in this document prevails and should be observed.

The conformance statement produced after testing indicates any lack of conformance to either the test plan or the base standard.

IEC 60870-5-6:2006, *Telecontrol equipment and systems – Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion standards*

IEC 60870-5-101:2003, *Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*

IEC 60870-5-104:2006, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

IETF RFC2200, *Internet Official Protocol Standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60870-5-6 apply.

4 Abbreviated terms

For the purposes of this document, the abbreviations given in IEC 60870-5-6 apply.

5 Conformance testing for IEC 60870-5-104

5.1 Overview and legend

An overview of tests is given in Tables 1 to 26. Procedural and functional testing shall always start with the Station Initialisation function and proceeds with the next Basic Application Functions. The procedure in each test case shall be followed, which means that the DUT is able to function as described in the specific test case.

The test procedures in Tables 1 through 11 shall be carried out with no errors detected during testing of all the Basic Application Functions in Tables 12 through 26. These tests are preferably automatically performed by the used test platform.

In addition to the performance criteria listed in the test procedures, 5.3 lists the protocol specifications that shall be verified automatically by the testing software or verified manually by review of the test history log after execution of the test procedures. The verification shall result in no errors detected during the complete test procedure.

This test plan has a direct reference to the PICS and possibly a PIXIT. Without a reference to a PICS or PIXIT this test plan is obsolete.

Test case numbering syntax is subclause number + table number + test case number.

Test cases are mandatory depending on the description in the column ‘Required’. The following situations are possible:

M = Mandatory test case regardless if enabled in the PICS/PIXIT, not only in one situation but during execution of all the tests as in the PICS and/or PIXIT

PICS, x.x = Mandatory test case if the functionality is enabled in the PICS (by marking the applicable check box), with a reference to the section number of the PICS (x.x);

NOTE PICS 9.x always refers to 60870-5-104:2006, Clause 9.

PIXIT = Mandatory test case if the functionality is enabled/described in the PIXIT. Verification of these test cases by the user/owner of the PIXIT is required before the test is started.

For each test case the test results shall be marked in the appropriate column of the test result chart in 5.5 and 5.6. Each test case can either pass the test (Passed), fail the test (Failed), not applicable, when the configuration value is not supported by the device (N.A.), or the test case was not performed (Empty). Ideally, there should be no empty boxes when testing is complete.

For testing reverse direction, the same test procedures apply in the opposite direction (replace "Controlling" with "Controlled" and vice versa), except for COT44-47 which are only defined in Monitor direction (only a controlled station is allowed to send these COT).

The test tables are divided into 5 subclauses:

- Subclause 5.2 Configuration parameters IEC 60870-5-104
- Subclause 5.3 Verification of IEC 60870-5-104 communication
- Subclause 5.4 Conformance test procedures
- Subclause 5.5 Test result chart
- Subclause 5.6 Test results of command transmission

The procedure to perform all the mandatory test cases, according to the PID, is shown in Figure 1.

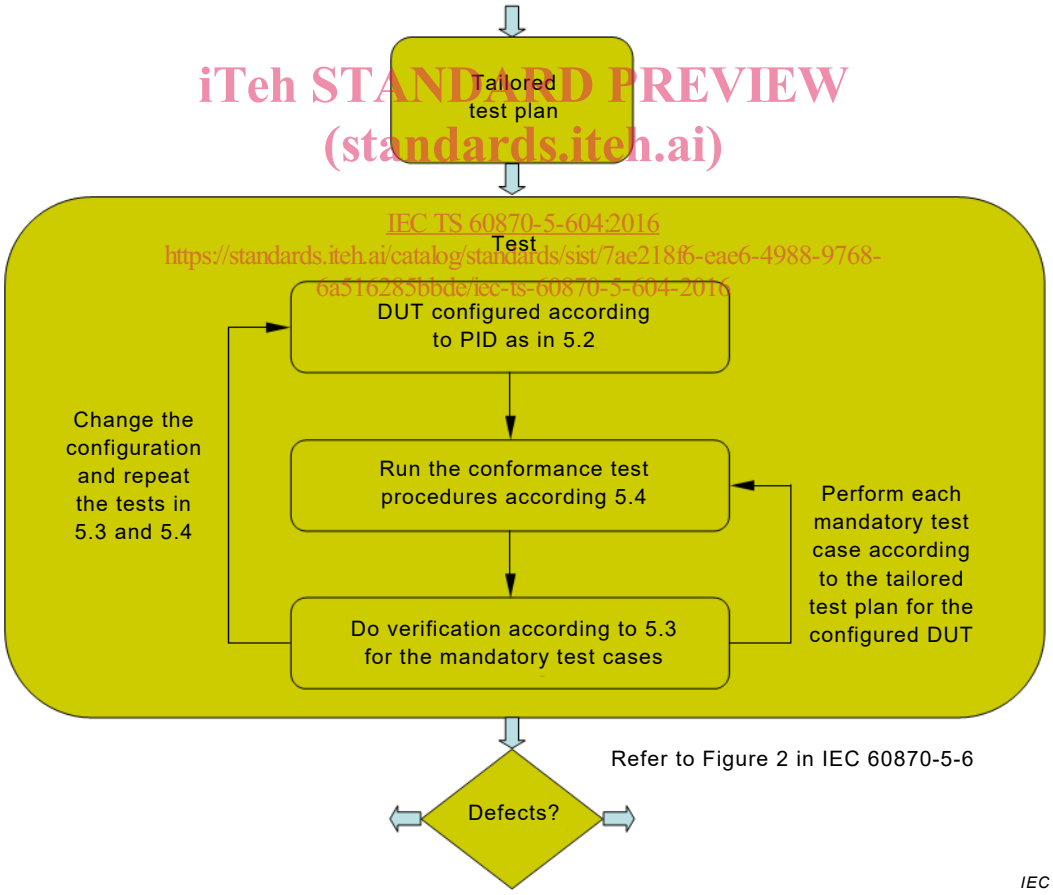

Figure 1 – Test procedure

5.2 Configuration parameters IEC 60870-5-104

Since IEC 60870-5-104 contains a number of configuration parameters affecting protocol behaviour, the conformance test procedures in 5.4 and verification in 5.3 shall be performed at least once for each supported value of the parameters listed in Table 1. Basically the DUT shall be tested if the functionality in 5.3 and 5.4 behaviour is correct for the configuration(s) in Table 1.

Table 1 – Run the Conformance Test Procedures for each of the following supported configuration parameter values

No.	Test	Description	Reference	Required
5.2.1.1	System definition	Controlling station test (Master)		PICS, 9.1
5.2.1.2		Controlled station test (Slave)		PICS, 9.1
5.2.1.50	Frame length	Maximum length L (control direction)	IEC 60870-5-101:2003, 6.2	PICS, 9.4
5.2.1.51		Maximum length L (monitor direction)	IEC 60870-5-101:2003, 6.2	PICS, 9.4
5.2.1.70	COMMON ADDRESS of ASDU	Two (2) octets for Common Address of ASDU (CASDU)	IEC 60870-5-101:2003, 7.2.4	PICS, 9.5
5.2.1.80	INFORMATION OBJECT ADDRESS	Three (3) octets for Information Object Address (structured or unstructured)	IEC 60870-5-101:2003, 7.2.5	PICS, 9.5
5.2.1.90	CAUSE OF TRANSMISSION	Two (2) octets for COT field (2^{nd} octet is Originator address)	IEC 60870-5-101:2003, 7.2.3	PICS, 9.5

5.3 Verification of IEC 60870-5-104 communication

This subclause lists the protocol specifications that shall be verified automatically by the testing software or verified manually by review of the test history log after execution of the test procedures. Every test case describes functionality that has passed the test if the functionality as in the the description column was shown to be correct. Correct means: the functionality shall be checked either automatically or manually, and also be checked by the test engineer in a human readable format log-file. For example to test the IV qualifier of some information elements, the ASDU containing this element shall be sent with the IV=1. Every test case marked “Passed”, has to be verifiable during testing and archived in log-files for post assessment.

To identify if a test case is mandatory, it is necessary to read 5.1 carefully.

Table 2 – Tests on transport provider level *(1 of 5)*

No.	Test	Description	Reference	Required
5.3.2.1	IP FRAME	IP Header, IP Fragment Re-assembling	IETF RFC2200	M
5.3.2.2		Source Address, Destination address	IETF RFC2200	M
5.3.2.3	TCP FRAME	TCP Header, TCP Control field (specifically ACK, RST, SYN, FIN), TCP Sequencing	IETF RFC2200	M
5.3.2.4		[The server (controlled station) uses the] port number 2404 [(confirmed by IANA) in all cases, both for the listening port and established connections. The client (controlling station) is free to use ephemeral port number, e.g. as allocated by the client's TCP/IP implementation]	IEC 60870-5-104:2006, 5.4	M
5.3.2.5		Actively *opening* a new TCP connection starts with a TCP frame containing (SYN) from the node that takes the initiative to establish the TCP connection. This is answered by the other node with (SYN, ACK), which in turn is answered by the initiating node with (ACK). Thereinafter the TCP connection is established	IETF RFC2200 IEC 60870-5-104:2006, 7.1	M
5.3.2.6		Actively *closing* an established TCP connection starts with a TCP frame containing (FIN) from the node that takes the initiative to close the TCP connection. This is answered by the other node (ACK) followed by a TCP frame from this same other node containing also (FIN). This in turn is answered by the initiating node with (ACK). Thereinafter the TCP connection is closed. It can be accepted if a node combines an (ACK) and a (FIN) in a single TCP frame in reply to a TCP frame with a (FIN).	IETF RFC2200 IEC 60870-5-104:2006, 7.1, Figure 19	M
5.3.2.7		During the test no problems should be detected on TCP/IP level	IETF RFC2200	M
5.3.2.10	CS104 APDU FRAME LAYOUT	Start character of APDU: 68_H	IEC 60870-5-104:2006, Clause 5	M
5.3.2.11		Configured number of octets L as the maximum number of Data octets (ASDU + Control field) in APDU: The maximum length of APDU for both directions is 253. It is a fixed system parameter.	IEC 60870-5-104:2006, Clause 5	M
5.3.2.12		4-octet Control field	IEC 60870-5-104:2006, Clause 5	M

Table 2 *(2 of 5)*

No.	Test	Description	Reference	Required
5.3.2.20	CS104 I-FORMAT APDU Information transfer frame	Control field octet 1 bit 1 (LSB) = 0	IEC 60870-5-104:2006, Clause 5	M
5.3.2.21		Control field octets 1-2, bit 2..16 contain send sequence number N(S) range 0..Maximum value 32767	IEC 60870-5-104:2006, Clause 5	M
5.3.2.22		Control field octet 3 bit 1 (bit 17) = 0	IEC 60870-5-104:2006, Clause 5	M
5.3.2.23		Control field octets 3-4, bit 18..32 contain Receive sequence number N(R) range 0..maximum value 32767	IEC 60870-5-104:2006, Clause 5	M
5.3.2.24		I-format frame contains exactly one ASDU	IEC 60870-5-104:2006, Clause 5	M
5.3.2.25	CS104 S-FORMAT APDU Numbered Supervisory function frame	Control field octet 1, bit 1-2 have value 01_B	IEC 60870-5-104:2006, Clause 5	M
5.3.2.26		Control field octets 1-2, bit 3..16 all contain value 0	IEC 60870-5-104:2006, Clause 5	M
5.3.2.27		Control field octet 3 bit 1 (bit 17) = 0	IEC 60870-5-104:2006, Clause 5	M
5.3.2.28		Control field octets 3-4, bit 18..32 contain Receive sequence number N(R) range 0..maximum value 32767	IEC 60870-5-104:2006, Clause 5	M
5.3.2.29		S-frame APDU only contains a single APCI field	IEC 60870-5-104:2006, Clause 5	M
5.3.2.30	CS104 U-FORMAT APDU Unnumbered Control function frame	Control field octet 1, bit 1-2 have value 11_B	IEC 60870-5-104:2006, Clause 5	M
5.3.2.31		Control field octet 1, bit 3 used for control function STARTDT Activation	IEC 60870-5-104:2006, Clause 5	M
5.3.2.32		Control field octet 1, bit 4 used for control function STARTDT Confirmation	IEC 60870-5-104:2006, Clause 5	M
5.3.2.33		Control field octet 1, bit 5 used for control function STOPDT Activation	IEC 60870-5-104:2006, Clause 5	M
5.3.2.34		Control field octet 1, bit 6 used for control function STOPDT Confirmation	IEC 60870-5-104:2006, Clause 5	M
5.3.2.35		Control field octet 1, bit 7 used for control function TESTFR Activation	IEC 60870-5-104:2006, Clause 5	M
5.3.2.36		Control field octet 1, bit 8 used for control function TESTFR Confirmation	IEC 60870-5-104:2006, Clause 5	M
5.3.2.37		Control field bit 3..8 contains exactly one active (bit with value 1) Control function (TESTFR, STARTDT, STOPDT, either Activation or Confirmation) per U-frame	IEC 60870-5-104:2006, Clause 5	M
5.3.2.38		Control field octets 2-4, bit 9..32 all contain value 0	IEC 60870-5-104:2006, Clause 5	M
5.3.2.39		U-frame APDU only contains a single APCI field	IEC 60870-5-104:2006, Clause 5	M

Table 2 *(3 of 5)*

No.	Test	Description	Reference	Required
5.3.2.50	TRANSMISSION PROCEDURE	Balanced transmission (after TCP connection has been established)	IEC 60870-5-104:2006, Introduction	M
		The initial values of the Send sequence number N(S) and the Receive sequence number N(R) are set to 0 (zero) after a new TCP connection is successfully established which is then a Stopped connection	IEC 60870-5-104:2006, 5.1	M
		An I-frame contains the current values of the Send sequence number N(S) and the Receive sequence number N(R)	IEC 60870-5-104:2006, 5.1	M
		After *sending* an I-frame, the Send sequence number N(S) in the Primary station is incremented with 1	IEC 60870-5-104:2006, 5.1	M
		After *receiving* a valid I-frame, the Receive sequence number N(R) in the Secondary station is incremented with 1	IEC 60870-5-104:2006, 5.1	M
		Yet unacknowledged I-frames from the Primary station are acknowledged by either an I-frame or an S-frame from the Secondary station	IEC 60870-5-104:2006, 5.1	M
		The Receive sequence number N(R) acknowledges all yet unacknowledged I-frames with N(S) < N(R)	IEC 60870-5-104:2006, 5.1	M
		A Primary station **sends at most the configured amount of K unacknowledged I-frames** before it stops and waits for an acknowledgement	IEC 60870-5-104:2006, 5.5	M
		A Secondary station sends an acknowledgement after **receiving at most the configured amount of W I-frames**	IEC 60870-5-104:2006, 5.5	M
		An APDU with a Send sequence number N(S) that is *higher or lower (called "out of sequence")* than the current Receive sequence number N(R), results in [sending an S-frame to confirm the I-frames that it has received (if applicable) after which] a TCP Active close (TCP Control field FIN) is given by the Secondary Station (because one or more previous APDUs may have been lost along the way to their destination due to connection failures)	IEC 60870-5-104:2006, 5.1	M
		U-Frame Control function STARTDT_ACT answered with STARTDT_CON	IEC 60870-5-104:2006, 5.3	M
		U-Frame Control function STOPDT_ACT answered with STOPDT_CON	IEC 60870-5-104:2006, 5.3	M
		U-Frame Control function TESTFR_ACT answered with TESTFR_CON	IEC 60870-5-104:2006, 5.2	M