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Electric railway equipment – Train bus –

Part 2: Train communication network conformance testing

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC RAILWAY EQUIPMENT – TRAIN BUS –

Part 2: Train communication network conformance testing

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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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International Standard IEC 61375-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is to be read in conjunction with IEC 61375-1, second edition.

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

FDIS	Report on voting
9/1014/FDIS	9/1034/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.

A list of all parts of IEC 61375 series, published under the general title *Electric railway equipment – Train bus* can be found on the IEC website.

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.

Following the decision of the committee, some parts of the text and some figures of this publication are copied from the IEC 61375-1 for keeping the maximum of clarity.

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

INTRODUCTION

TCN is an International Standard with the aim of defining interfaces so as to achieve plug-in compatibility:

a) between equipment located in different vehicles, and

b) between equipment and devices located within the same vehicle.

One of the key success factors for deployment of any technology is the standardisation and the ensuring interoperability among various implementations. To facilitate interoperability a conformance test should be implemented.

In this part of IEC 61375, the TCN hierarchical structure deals with two levels of busses:

a) the train bus called the Wire Train Bus (WTB);

b) the vehicle bus called the Multifunction Vehicle Bus (MVB).

No other busses are taken into consideration even though they are foreseen by IEC 61375-1, see the note below.

WTB and MVB share the same real-time protocols, which offer two communication services:

a) process variables, a distributed, real-time database, periodically refreshed through broadcasting;

b) messages, transmitted on demand either as:

   0. unicast messages (point-to-point) or/and

   1. multicast messages.

WTB and MVB share a common network management, which allows debugging, commissioning and maintenance over the network.

NOTE TCN states that several vehicle busses may apply, provided that such busses are able to provide the services of Real_Time Protocols. However, this part of IEC 61375 is focused on MVB as vehicle bus, even if the conformance test may apply to other busses, the exact conformance test should be derived upon.

This standard is structured into 7 clauses and 2 annexes.

The clauses and annexes are listed and briefly described in the Table 1.

Table 1 – Document structure

Clause/sections	Description
1. General	This clause describes the scope of this standard and introduces basic terms and abbreviations not reported in IEC 61375-1.
2. Conformance test: approach, requirements and boundaries	This clause is an overview of the methods of TCN implementation verification that are available to the developer and regulatory personnel. Supplies information concerning the ICS and IXITpPro-forma(s).
3. Conformance test of an MVB device	This clause covers all tests on MVB devices that are grouped by classes, from Class 0 up to Class 4. The main contents are: the MVB PICS and PIXIT; the MVB test suites; the MVB test procedures.
4. Conformance test of a WTB device	Contents: All tests on WTB are classified by nodes related to WTB itself and MVB only. The main contents are: the WTB PICS and PIXIT; the WTB test suites; the WTB test procedures.
5 Conformance test of RTP	This clause lists the tests covered in Clauses 3 and 4 fulfilling the real time protocol.
6. Conformance test of a WTB-equipped vehicle	This clause covers the Physical Layer while the Services given by the WTB node are covered by the previous clauses. Application profiles are covered by other bodies, like UIC for profile UIC 556.
7 Conformance test of NM	Partially covered by Clauses 3 and 4. Remaining parts are not covered.
Annex A – Test laboratory role and client role	This annex is normative.
Annex B – Test instrumentation and dedicated test bed	This annex is informative.

ELECTRIC RAILWAY EQUIPMENT – TRAIN BUS –

Part 2: Train communication network conformance testing

1 General

1.1 Scope

This part of IEC 61375 applies to all equipment and devices implemented according to IEC 61375-1, i.e. it covers the procedures to be applied to such equipment and devices when the conformance should be proven.

The applicability of this standard to a TCN implementation allows for individual conformance checking of the implementation itself and is a pre-requisite for further interoperability checking between different TCN implementations.

NOTE 1 For a definition of TCN implementation see 1.3.

1.2 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 60571:*Electronic equipment used on rail vehicles*

IEC 60807, *Rectangular connectors for frequencies below 3 MHz*

IEC 61375-1: 2007, *Electric railway equipment – Train bus – Part 1: Train communication network*

ISO/IEC 9646-1:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 1: General concepts* (Also available as ITU-T Recommendation X.290 (1995))

ISO/IEC 9646-7:1994, *Information technology – Open Systems Interconnection –Conformance testing methodology and framework – Part 7: Implementation Conformance Statements* (Also available as ITU-T Recommendation X.296 (1995))

UIC 556, *Information transmission in trains (train bus)*

1.3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 9646-1 and IEC 61375-1 apply.

2 Conformance test: approach, requirements and boundaries

2.1 The approach

This standard specifies a general methodology for testing the conformance to the TCN protocol standard of products in which the standard is claimed to be implemented.

This standard is organised into clauses structured into different phases of the conformance testing process, these phases being characterised by the following roles:

a) the specification of abstract test suites for particular TCN protocols according to ISO/IEC 9646-1;

b) the derivation of executable test suites and associated testing tools according to ISO/IEC 9646-7;

Annex A specifies the rules on clients and laboratory specifying:

c) the role of a client of a test laboratory, having an implementation of TCN protocols to be tested;

d) the operation of conformance testing, culminating in the production of a conformance test report which gives the results in terms of the test suite(s) used and the relevant documentation produced.

In all clauses of this standard, the scope is limited in order to meet the following objectives:

e) to achieve an adequate level of confidence in the tests as a guide to conformance;

f) to achieve comparability between the results of the corresponding tests applied in different places at different times;

g) to facilitate communication between the parties responsible for the roles described above.

Each objective involves the framework for development of TCN test suites, as listed hereinafter:

h) how they should relate to the various types of conformance requirement;

i) the types of test to be standardised and the types not needing standardisation;

j) the criteria for selecting tests for inclusion in a conformance test suite;

k) the notation to be used for defining tests;

l) the structure of a test suite.

Certification, an administrative procedure which may follow conformance testing, is outside the scope of this standard.

Requirements for procurement and contracts are outside the scope of this standard.

2.1.1 Requirements

2.1.1.1 General

In the context of TCN, a real system is said to exhibit conformance if it complies with the requirements of applicable TCN standard clauses in its communication with a reference system, i.e. the tester.

A TCN standard is a set of interrelated clauses which, together, define behaviour of TCN systems in their communication. Conformance of an IUT will, therefore, be expressed at two levels, conformance to each individual clause, and conformance to the set of clauses.

The following clauses define the conformance requirements and classify them according to attributes and into feasible groups. Attributes and grouping are defined from the general point of view with reference to a TCN specification itself and from the IUT point of view. In the second case, the requirement shall be declared in the appropriate PICS and PIXIT.

2.1.1.2 Conformance requirements

The conformance requirements can be:

a) mandatory requirements: these are to be observed in all cases;

b) conditional requirements: these are to be observed if the conditions, set out in the clause, apply;

c) options: these can be selected to suit the implementation, provided that any requirements applicable to the option are observed.

TCN essential functionality are mandatory requirements; additional functionality can be either conditional or optional requirements.

Furthermore, conformance requirements in a Part can be stated:

d) positively: they state what shall be done;

e) negatively (prohibitions): they state what shall not be done.

Finally, conformance requirements fall into two groups:

f) static conformance requirements;

g) dynamic conformance requirements;

these are discussed in 2.1.1.3 and 2.1.1.4, respectively.

2.1.1.3 Static conformance requirements

To facilitate interoperability static conformance requirements define the allowed minimum capabilities of an implementation. These requirements may be at a broad level, such as the grouping of functional units and options into protocol classes, or at a detailed level, such as a range of values that have to be supported for specific parameters of timers.

Static conformance requirements and options in TCN parts can be of two varieties:

a) those which determine the capabilities to be included in the implementation of the particular protocol;

b) those which determine multi-layer dependencies, for example those which place constraints on the capabilities of the underlying layers of the system in which the protocol implementation resides. These are likely to be found in upper layer parts (e.g. network management vs real time protocols).

All capabilities not explicitly stated as static conformance requirements are to be regarded as optional.

2.1.1.4 Dynamic conformance requirements

Dynamic conformance requirements are all those requirements (and options) which determine what observable behaviour is permitted by the relevant TCN part in instances of communication. They form the bulk of each TCN protocol document. They define the set of allowable behaviours of an implementation or real system. This set defines the maximum capability that a conforming implementation or real system can have within the terms of the TCN protocol document.

A system exhibits dynamic conformance in an instance of communication if its behaviour is a member of the set of all behaviours permitted by the relevant TCN protocol part in a way which is consistent with the PICS.

2.1.1.4.1 A conforming system

A conforming system or implementation is one which is shown to satisfy both static and dynamic conformance requirements, consistent with the capabilities stated in the PICS, for each protocol declared in the system conformance statement.

2.1.1.4.2 Interoperability and conformance

The primary purpose of conformance testing is to increase the probability that different implementations are able to inter-operate.

Successful interoperability of two or more real open systems is more likely to be achieved if they all conform to the same subset of a TCN part, or to the same selection of TCN parts, than if they do not.

To prepare two or more systems to successfully inter-operate, it is recommended that a comparison is made of the system conformance statements and PICSs of these systems.

If there is more than one version of a relevant TCN part indicated in the PICSs, the differences between the versions need to be identified and their implications for consideration, including their use in combination with other parts.

While conformance is a necessary condition, it is not on its own a sufficient condition to guarantee interoperability capability. Even if two implementations conform to the same TCN protocol part, they may fail to interoperate because of factors outside the scope of this standard.

Trial interoperability is recommended to detect these factors. Further information to assist interoperability between two systems can be obtained by extending the PICS comparison to other relevant information, including test reports and PIXIT. The comparison can focus on:

a) additional mechanisms claimed to work around known ambiguities or deficiencies not yet corrected in the TCN standard or in peer real systems, for example solution of multi-layer problems;
b) selection of free options which are not taken into account in the static conformance requirements of the TCN parts;
c) the existence of timers not specified in the TCN parts and their associated values.

NOTE The comparison can be made between two individual systems, between two or more types of product, or, for the PICS comparison only, between two or more specifications for procurement, permissions to connect, etc.

2.1.2 Requirements declaration statements for an IUT

2.1.2.1 Protocol implementation conformance statement (PICS)

To evaluate the conformance of a particular implementation, it is necessary to have a statement of the capabilities and options which have been implemented, and any features which have been omitted, so that the implementation can be tested for conformance against relevant requirements, and against those requirements only. Such a statement is called a Protocol Implementation Conformance Statement (PICS).

In a PICS there should be a distinction between the following categories of information which it may contain:

a) information related to the mandatory, optional and conditional static conformance requirements of the protocol itself;
b) information related to the mandatory, optional and conditional static conformance requirements for multi-layer dependencies.

If a set of interrelated TCN protocol has been implemented in a system, a PICS is needed for each protocol. A system conformance statement will also be necessary, summarising all protocols in the system for each of which a distinct PICS is provided.

2.1.2.2 Protocol implementation extra information for testing (PIXIT)

In order to test a protocol implementation, the test laboratory will require information relating to the IUT and its testing environment in addition to that provided by the PICS. This *"Protocol*

Implementation eXtra Information for Testing" (PIXIT) will be provided by the client submitting the implementation for testing, as a result of consultation with the test laboratory.

The PIXIT may contain the following information:

a) information needed by the test laboratory in order to be able to run the appropriate test suite on the specific system (e.g. information related to the test method to be used to run the test cases, addressing information);
b) information already mentioned in the PICS and which needs to be made precise (e.g. a timer value range which is declared as a parameter in the PICS should be specified in the PIXIT);
c) information to help determine which capabilities stated in the PICS as being supported are testable and which are untestable;
d) other administrative matters (e.g. the IUT identifier, reference to the related PICS).

The PIXIT should not conflict with the appropriate PICS.

The abstract test suite specifier, test implementor and test laboratory will all contribute to the development of the PIXIT pro-forma.

2.2 Boundaries

2.2.1 General

Conformance testing as discussed in this standard is focused on testing for conformance to TCN clauses as they are specified in IEC 61375-1 (second edition).

In principle, the objective of conformance testing is to establish whether the implementation being tested conforms to the specification in the relevant clause. Practical limitations make it impossible to be exhaustive, and economic considerations may restrict testing still further.

Therefore, this standard distinguishes four types of testing, according to the extent to which they provide an indication of conformance:

a) basic interconnection tests, which provide *prima facie* evidence that an IUT conforms;
b) capability tests, which check that the observable capabilities of the IUT are in accordance with the static conformance requirements and the capabilities claimed in the PICS;
c) behaviour tests, which endeavour to provide testing which is as comprehensive as possible over the full range of dynamic conformance requirements within the capabilities of the IUT;
d) conformance resolution tests, which probe in depth the conformance of an IUT to particular requirements, to provide a definite yes/no answer and diagnostic information in relation to specific conformance issues; such tests are not covered by this standard.

Tests a), b), c) and d) are foreseen in A.6.3 of IEC 61375-1, and are described in detail by the following subclauses.

Relations to interoperability and performance are hereinafter considered and defined to clarify their boundaries.

2.2.2 Basic interconnection tests

Basic interconnection tests provide limited testing of an IUT to establish that there is sufficient conformance for interconnection to be possible, without trying to perform thorough testing.

2.2.2.1 Applicability of basic interconnection tests

Basic interconnection tests are appropriate:

a) for detecting severe cases of non-conformance;

b) as a preliminary filter before undertaking more costly tests;

c) to give a *prima facie* indication that an implementation which has passed full conformance tests in one environment still conforms in a new environment (e.g. before testing an (N)-implementation, to check that a tested (N – 1)-implementation has not undergone any severe change due to being linked to the (N)-implementation);

d) for use by users of implementations, to determine whether the implementations appear to be usable for communication with other conforming implementations, for example as a preliminary to data interchange.

Basic interconnection tests are inappropriate:

e) as a basis for claims of conformance by the supplier of an implementation;

f) as a means of arbitration to determine causes for communications failure.

Basic interconnection tests are standardised a subset of a conformance test suite (including capability and behaviour tests). They can be used on their own or together with a conformance test suite. The existence and execution of basic interconnection tests are optional.

2.2.3 Capability tests

Capability tests provide limited testing of each of the static conformance requirements in a Part, to ascertain what capabilities of the IUT can be observed and to check that those observable capabilities are valid with respect to the static conformance requirements and the PICS.

2.2.3.1 Applicability of capability tests

Capability tests are appropriate:

a) to check as far as possible the consistency of the PICS with the IUT;

b) as a preliminary filter before undertaking more in-depth and costly testing;

c) to check that the capabilities of the IUT are consistent with the static conformance requirements;

d) to enable efficient selection of behaviour tests to be made for a particular IUT;

e) when taken together with behaviour tests, as a basis for claims of conformance.

Capability tests are inappropriate:

f) on their own, as a basis for claims of conformance by the supplier of an implementation;

g) for testing in detail the behaviour associated with each capability which has been implemented or not implemented;

h) for resolution of problems experienced during live usage or where other tests indicate possible non-conformance even though the capability tests have been satisfied.

Capability tests are standardised within a conformance test suite. They can either be separated into their own test group(s) or merged with the behaviour tests.

2.2.4 Behaviour tests

Behaviour tests test an implementation as thoroughly as is practical, over the full range of dynamic conformance requirements specified in a Part. Since the number of possible combinations of events and timing of events is infinite, such testing cannot be exhaustive. There is a further limitation, namely that these tests are designed to be run collectively in a single test environment, so that any faults which are difficult or impossible to detect in that environment are likely to be missed. Therefore, it is possible that a non-conforming implementation passes the conformance test suite; one aim of the test suite design is to minimise the number of times that this occurs.

Behaviour tests with capability tests are the basis for the conformance assessment process.

Behaviour tests are inappropriate:

a) for resolution of problems experienced during live usage or where other tests indicate possible non-conformance even though the behaviour tests have been satisfied.

Behaviour tests are standardised as the bulk of a conformance test suite.

NOTE Behaviour tests include tests for valid behaviour by the IUT in response to valid, inopportune and syntactically invalid protocol behaviour by the real tester. This includes testing the rejection by the IUT of attempts to use features (capabilities) which are stated in the PICS as being not implemented. Thus, capability tests do not need to include tests for capabilities omitted from the PICS.

2.2.5 Conformance resolution tests

Conformance resolution tests provide diagnostic answers, as near to definitive as possible, to the resolution of whether an implementation satisfies particular requirements. Because of the problems of exhaustiveness, the definite answers are gained at the expense of confining tests to a narrow field.

The test architecture and test method will normally be chosen specifically for the requirements to be tested, and need not be ones that are generally useful for other requirements. They may even be ones that are regarded as being unacceptable for (standardised) abstract conformance test suites, for example involving implementation-specific methods using, say, the diagnostic and debugging facilities of the specific operating system.

The distinction between behaviour tests and conformance resolution tests may be illustrated by the case of an event such as a reset. The behaviour tests may include only a representative selection of conditions under which a reset might occur, and may fail to detect incorrect behaviour in other circumstances. The conformance resolution tests would be confined to conditions under which incorrect behaviour was already suspected to occur, and would confirm whether or not the suspicions were correct.

Conformance resolution tests are appropriate:

a) for providing a yes/no answer in a strictly confined and previously identified situation (e.g. during implementation development, to check whether a particular feature has been correctly implemented, or during operational use, to investigate the cause of problems);

b) as a means for identifying and offering resolutions for deficiencies in a current conformance test suite.

Conformance resolution tests are inappropriate

c) as a basis for judging whether or not an implementation conforms overall.

Conformance resolution tests are not standardised. As a by-product of conformance testing, errors and deficiencies in protocol parts may be identified.

2.2.6 Interpretation of clauses/subclauses and statements

The TCN described in IEC 61375-1 is subject to a sort of interpretation to translate some clauses/subclauses and requirements into realisable test suites. The complexity of most TCN protocols makes exhaustive testing impractical on both technical and economic grounds. To cope with a real implementation and extract from IEC 61375-1 all the relevant tests and some criteria were used. The criteria were grouped according to their characteristics:

a) imperatives;

b) illustrative;

c) directives;

d) options;

e) weak phrases.

The following subclauses describe the criteria.

2.2.6.1 Imperatives

Imperatives are those words and phrases commanding that something shall be provided and are classified as mandatory. They are:

a) **shall –** dictates the provision of a functional capability;

b) **must** or must not – establishes performance requirements or constraints;

c) **is required to** – is a specification statement written in the passive voice;

d) **are applicable** – includes, by reference, standards or other documentation as an addition to the requirements being specified;

e) **responsible for** – is a requirement written for architectures already defined. As an example, " In extended reply delay applications, the master is responsible for spacing the master frames so that the minimum time to transmit to a slave frame and the following master frame is greater than T_safe..";

f) **will** – is generally used to cite things that the operational or development environment are to provide to the capability being specified. For example, " If it was a strong master, it will signal its demoting to all nodes and it will remain in control of the bus as a weak master until a strong node is appointed";

g) **should** – when it is used, the specification statement is considered to be very weak. For example, " Devices supporting the message data capability should have a device address smaller than 256.".

Continuance

Phrases that follow an imperative and introduce the specification of requirements at a lower level, for a supplemental requirement count.

a) as follows,

b) below,

c) following,

d) in particular,

e) listed,

f) support.

Phrases that introduces temporal indication, that may lead to definite or indefinite actions, or enumerative that may lead to infinite test cases.

Table 2 – Continuance indication

	Statement	Example
1	for each	A PV_Set identifies a set of variables belonging to the same dataset, including for each variable the Memory_Address where it should be copied to (or from), and including for the whole dataset the Freshness_Time.)
2	while	While sending BD packets, the producer filters incoming BR packets and starts retransmission after insertion of a transmission pause (PAUSE_TMO in addition to the normal SEND_TMO)

The requirement containing temporal or enumerative is tested with a finite time or finite sample.