IEC 60966-1

Edition 3.0 2019-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Radio frequency and coaxial cable assemblies –
Part 1: Generic specification – General requirements and test methods

IEC 60966-1:2019-02 RLV(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC 60966-1

Edition 3.0 2019-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Radio frequency and coaxial cable assemblies –
Part 1: Generic specification – General requirements and test methods

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.120.10

ISBN 978-2-8322-6560-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD 7
1 Scope 9
2 Normative references 9
3 Terms and definitions 9
4 Design and manufacturing requirements 13
4.1 Cable design and construction 13
4.2 Connector design and construction 13
4.3 Outline and interface dimensions 13
5 Workmanship, marking and packaging 13
5.1 Workmanship 13
5.2 Marking 14
5.3 End caps 14
5.4 Packaging and labelling 14
6 Quality ~~assessment~~ management 14
7 Test methods – General 14
7.1 Standard atmospheric conditions for testing 14
7.2 Visual inspection 15
7.3 Dimensions inspection 15
7.3.1 Interface dimensions 15
7.3.2 Outline dimensions 15
8 Electrical tests 15
8.1 Reflection properties 15
8.1.1 Object 15
8.1.2 Test equipment 15
8.1.3 Procedure 16
8.1.4 Requirements 16
8.1.5 Information to be given in the detail specification 16
8.2 Uniformity of impedance 17
8.2.1 Object 17
8.2.2 Procedure 17
8.2.3 Requirements 17
8.2.4 Information to be given in the detail specification 17
8.3 Insertion loss 17
8.3.1 Procedure 17
8.3.2 Requirements 17
8.3.3 Information to be given in the detail specification 17
8.4 Insertion loss stability 17
8.4.1 Object 17
8.4.2 Procedure 17
8.4.3 Requirements 17
8.4.4 Information to be given in the detail specification 17
8.5 Propagation time 18
8.5.1 Procedure 18
8.5.2 Requirements 18
8.5.3 Information to be given in the detail specification 18

8.6 Stability of electrical length 18
8.6.1 Object 18
8.6.2 Procedures 18
8.6.3 Requirements 21
8.6.4 Information to be given in the detail specification 22
8.7 Phase difference 22
8.7.1 Object 22
8.7.2 Procedure 22
8.7.3 Requirements 22
8.7.4 Information to be given in the detail specification 22
8.8 Phase variation with temperature 22
8.8.1 Object 22
8.8.2 Procedure 22
8.8.3 Requirements 22
8.8.4 Information to be given in the detail specification 22
8.9 Screening effectiveness 23
8.9.1 Transfer impedance 23
8.9.2 Screening attenuation 23
8.10 Voltage proof 23
8.10.1 Procedure 23
8.10.2 Requirements 23
8.10.3 Information to be given in the detail specification 23
8.11 Insulation resistance 24
8.11.1 Procedure 24
8.11.2 Requirements 24
8.11.3 Information to be given in the detail specification 24
8.12 Inner and outer conductor continuity 24
8.12.1 Object 24
8.12.2 Procedure 24
8.12.3 Requirements 24
8.12.4 Information to be given in the detail specification 24
8.13 Power rating 24
8.13.1 Object 24
8.13.2 Procedure 25
8.13.3 Requirements 25
8.13.4 Information to be given in the detail specification 25
8.14 Intermodulation level measurement 25
8.14.1 Procedure 25
8.14.2 Requirements 25
8.14.3 Information to be given in the detail specification 25
9 Mechanical robustness tests 25
9.1 Tensile 25
9.1.1 Object 25
9.1.2 Procedure 26
9.1.3 Requirements 26
9.1.4 Information to be given in the detail specification 26
9.2 Flexure 26
9.2.1 Object 26
9.2.2 Procedure 26

9.2.3 Requirements 27
9.2.4 Information to be given in the detail specification 27
9.3 Flexing endurance 27
9.3.1 Object 27
9.3.2 Procedure 27
9.3.3 Requirements 28
9.3.4 Information to be given in the detail specification 28
9.4 Cable assembly crushing 28
9.4.1 Object 28
9.4.2 Procedure 28
9.4.3 Requirements 29
9.4.4 Information to be given in the detail specification 29
9.5 Torque 30
9.5.1 Procedure 30
9.5.2 Requirements 30
9.5.3 Information to be given in the detail specification 30
9.6 Multiple bending 30
9.6.1 Object 30
9.6.2 Procedure 30
9.6.3 Requirements 31
9.6.4 Information to be given in the detail specification 31
9.7 Abrasion test of cable assembly 31
9.7.1 Object 31
9.7.2 Procedure 31
9.8 Vibrations, shocks 31
9.9 Impact test 31
9.10 Mechanical endurance 31
10 Environmental tests 32
10.1 Recommended severities 32
10.2 Vibration, bumps and shock 32
10.3 Climatic sequence 32
10.3.1 Procedure 32
10.3.2 Requirements 32
10.3.3 Information to be given in the detail specification 32
10.4 Damp heat, steady state 32
10.4.1 Procedure 32
10.4.2 Requirements 32
10.4.3 Information to be given in the detail specification 33
10.5 Rapid change of temperature 33
10.5.1 Procedure 33
10.5.2 Requirements 33
10.5.3 Information to be given in the detail specification 33
10.6 Resistance to solvents and contaminating fluids 33
10.6.1 Procedure 33
10.6.2 Requirements 33
10.6.3 Information to be given in the detail specification 34
10.7 Water immersion 34
10.7.1 Procedure 34
10.7.2 Requirements 34

10.7.3 Information to be given in the detail specification 34
10.8 Salt mist and sulphur dioxide tests 34
10.8.1 Procedure 34
10.8.2 Requirements 34
10.8.3 Information to be given in the detail specification 34
10.9 Dust tests 34
10.9.1 Object 34
10.9.2 Procedure 35
10.9.3 Requirements 35
10.9.4 Information to be given in the detail specification 35
10.10 Flammability 36
10.10.1 Procedure 36
10.10.2 Requirements 36
10.10.3 Information to be given in the detail specification 37
11 Specialized test methods 37
12 Test schedules 37
Annex A (normative) Test methods for insertion loss determination 38
A.1 Purpose 38
A.2 Test methods 38
A.2.1 General 38
A.2.2 Test method 1 38
A.2.3 Test method 2 39
A.2.4 Test method 3 41
A.3 Correction for characteristic impedance differences 42
Annex B (informative) Measuring methods for propagation time 44
B.1 ~~Introduction~~ General 44
B.2 Resonance method for propagation time measurement 44
B.3 Time domain method for propagation time measurement 45
~~Annex C (informative) Measurement method for screening effectiveness .....~~
~~C.1 Introduction .....~~
~~C.2 Test method .....~~
Annex C (informative) Recommended severities for environmental tests 46
C.1 Introduction to the relationship between environmental conditions and severities of testing 49
C.1.1 General 49
C.1.2 Environmental conditions 49
C.1.3 Environmental testing 49
C.2 Recommended severities for environmental tests 50
C.2.1 Vibration 50
C.2.2 Bump 51
C.2.3 Shock 51
C.2.4 Climatic sequence 51
C.2.5 Damp heat, steady state 52
C.2.6 Rapid change of temperature 52
C.2.7 Salt mist 52
C.2.8 Sulphur dioxide test 52
C.2.9 Dust test 52
Annex D (normative) Quality ~~assessment~~ management 53

D.1 ~~Introduction~~ General 53
D.2 Object 53
D.3 ~~General~~ Basic aspects 53
D.3.1 Related documents 53
D.3.2 Standards and preferred values 53
D.3.3 Marking of the cable assembly and packaging (see 5.2) 53
D.3.4 Terminology 54
D.4 Quality ~~assessment~~ management procedures 54
D.4.1 Procedures for qualification approval 54
D.4.2 Procedures for capability approval 55
D.4.3 Quality conformance inspection 56
D.5 Capability manual and approval 57
D.5.1 Responsibilities 57
D.5.2 Contents of the capability manual 57
D.5.3 Criteria for capability limits 58
Bibliography 61

~~Figure – Dust measuring device ..... ~~
Figure 1 – Bending test: U shape assembly 19
Figure 2 – Bending test: straight assembly 20
Figure 3 – Twisting test: U shape assembly 21
Figure 4 – Fixture for cable assembly flexure test 27
Figure 5 – Apparatus for cable assembly flexing endurance test 28
Figure 6 – Fixture for cable crushing test 29
Figure 7 – Example of test fixture for torque 30
Figure 8 – Multiple bending test 31
Figure A.1 – Circuit for the determination of insertion loss 38
Figure A.2 – Circuit for the determination of insertion loss – principle 40
Figure A.3 – Alternative circuit for the determination of insertion loss 40
Figure A.4 – Double-pass circuit for the determination of insertion loss 41
Figure B.1 – Arrangement of test equipment 44
Figure C.1 – Description of action needed for the preparation of the environmental test specification 50

Table 1 – Standard range of atmospheric conditions 14
Table C.1 – Relationship between displacement and acceleration 51
Table C.2 – Relationship between peak acceleration and velocity change 51
Table D.1 – Example of capability limits for cable assemblies 59
Table D.2 – Example of capability limits for flexible cables 59
Table D.3 – Example of capability limits for connectors 59
Table D.4 – Example of flow chart (see D.5.2.5) 60

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RADIO FREQUENCY AND COAXIAL CABLE ASSEMBLIES –

Part 1: Generic specification – General requirements and test methods

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60966-1 has been prepared by technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

This third edition cancels and replaces the second edition published in 1999. This edition constitutes a technical revision.

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

a) Annex C (informative) Measurement method for screening effectiveness was cancelled;

b) Subclause 8.9 gives references to relevant test procedures.

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

FDIS	Report on voting
46/700A/FDIS	46/704/RVD

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

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

A list of all parts in the IEC 60966 series, published under the general title *Radio frequency and coaxial cable assemblies*, can be found on the IEC website.

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

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

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.

RADIO FREQUENCY AND COAXIAL CABLE ASSEMBLIES –

Part 1: Generic specification – General requirements and test methods

1 Scope

This part of IEC 60966 specifies requirements for radio frequency coaxial cable assemblies operating in the transverse electromagnetic mode (TEM) and establishes general requirements for testing the electrical, mechanical and environmental properties of radio frequency coaxial cable assemblies composed of cables and connectors. Additional requirements relating to specific families of cable assemblies are given in the relevant sectional specifications.

~~NOTE~~ The design of the cables and connectors used ~~should~~ will preferably conform to the applicable parts of IEC 61196 and IEC 61169 respectively.

NOTE 1 This document does not include tests which are normally performed on the cables and connectors separately. These tests are described in IEC 61196-1 (all parts) and IEC 61169-1 respectively.

NOTE 2 Wherever possible, cables and connectors used in cable assemblies, even if they are not described in the IEC 61196 or IEC 61169 series, are tested separately according to the tests given in the relevant generic specification.

NOTE 3 Where additional protection is applied to a cable assembly, the mechanical and environmental tests described in this document are applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068 (all parts), *Environmental testing*

~~IEC 60068-2-3:1969, *Environnmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*~~

IEC 60068-2-6~~:1995~~, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-11~~:1981~~, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

IEC 60068-2-14~~:1984~~, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27~~:1987~~, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

~~IEC 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*~~

IEC 60068-2-42~~:1982~~, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60068-2-68~~:1994~~, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*

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

~~IEC 60096-1:1986, *Radio frequency cables – Part 1: General requirements and measuring methods*~~

~~IEC 60332-1:1993, *Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable*~~

IEC 60332-1-2:2004, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed* flame

~~IEC 60339 (all parts), *General purpose rigid coaxial transmission lines and their associated flange connectors*~~

~~IEC 60512-5:1992, *Electromechanical components for electronic equipment, basic testing procedures and measuring methods – Part 5: Impact tests (free components), static load tests (fixed components), endurance tests and overload tests*~~

IEC 60512-6-2, *Connectors for electronic equipment –Tests and measurements – Part 6-2: Dynamic stress tests – Test 6b: Bump*

IEC 60512-7-2, *Connectors for electronic equipment – Tests and measurements – Part 7-2: Impact tests (free components) – Test 7b: Mechanical strength impact*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60966-2 (all parts), *Radio frequency and coaxial cable assemblies*

IEC 60966-3 (all parts), *Radio frequency and coaxial cable assemblies*

IEC 60966-4 (all parts), *Radio frequency and coaxial cable assemblies*

IEC 61169 (all parts), *Radio-frequency connectors*

IEC 61169-1:~~1992~~ 2013, *Radio-frequency connectors – Part 1: Generic specification – General requirements and measuring methods*

IEC 61196 (all parts), *Coaxial communication cables*

~~IEC 61196-1:1995, *Radio-frequency cables – Part 1: Generic specification – General definitions, requirements and test methods*~~

IEC 61196-1-119, *Coaxial communication cables – Part 1-119: Electrical test methods – RF power rating*

~~IEC 61726:1995, *Cable assemblies, cables, connectors and passive microwave components – Screening attenuation measurement by the reverberation chamber method*~~

IEC 62037-2, *Passive RF and microwave devices, intermodulation level measurement – Part 2: Measurement of passive intermodulation in coaxial cable assemblies*

IEC 62153-4-6, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method*

IEC 62153-4-7:2015, *Metallic communication cable test methods – Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring of transfer impedance Z_T and screening attenuation a_s or coupling attenuation a_C of connectors and assemblies up to and above 3 GHz – Triaxial tube in tube method*

~~IEC QC 001002:1986, *Rules of procedure of the IEC quality assessment system for electronic components (IECQ)*~~

~~ISO 9000, *Quality management and quality assurance standards*~~

~~ISO 9001:1994, *Quality systems – Model for quality assurance in design, development, production, installation and servicing*~~

~~ISO 9002:1994, *Quality systems – Model for quality assurance in production, installation and servicing*~~

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
cable assembly
combination of cable(s) and connector(s) with or without any additional protection and with specified performance, used as a single unit

3.2
flexible cable assembly
cable assembly where the cable is capable of repeated flexure

Note 1 to entry: The cable usually has a braid outer conductor.

3.3
semi-flexible cable assembly
cable assembly not intended for applications requiring repeated flexure of the cable in service, but bending or forming is permissible to facilitate installation

3.4
semi-rigid cable assembly
cable assembly not intended to be bent or flexed after manufacture

Note 1 to entry: Any bending or flexing during installation or use may degrade the performance of the cable assembly.

3.5
insertion loss
loss introduced by inserting a cable assembly into a system

Note 1 to entry: In this standard, it is the ratio, expressed in decibels, of the power (P_1) delivered to a load connected directly to a source and the power (P_2) delivered to a load when the cable assembly is inserted between the source and the load.

$$Insertion\ loss = 10 \times \log\left(\frac{P_1}{P_2}\right)$$

3.6
reflection factor
ratio of the complex wave amplitude of the reflected wave to the complex wave amplitude of the incident wave at a port or transverse cross-section of a transmission line

3.7
electrical length
equivalent free-space length of the cable assembly

3.8
electrical length difference
difference in electrical length between cable assemblies

3.9
phase difference
difference in phase between a transverse electromagnetic mode (TEM) wave which has traversed the cable assembly and an identical wave which has traversed another cable assembly

3.10
propagation time
time taken for the propagation of a TEM wave between the reference planes of the two connectors

3.11
minimum static bending radius
radius used in climatic tests

Note 1 to entry: It is the minimum permissible radius for fixed installation of the cable.

3.12
dynamic bending radius
~~the bending~~ radius ~~is~~ used for the insertion loss stability, stability of electrical length and flexing endurance tests

Note 1 to entry: It is the minimum bending radius for applications where the cable assembly is flexed. Larger bending radii will allow the increase of the maximum number of flexures.

~~**3.10 screening effectiveness**~~

3.13
transfer impedance
quotient of the induced voltage on the inside of the cable assembly and the inducing current outside the assembly

Note 1 to entry: In practice, this is between defined points on connectors mated to the connectors of the cable assembly

3.14
screening attenuation
ratio of the signal power inside the cable assembly to the total power that radiates outside the cable assembly

3.15
power rating
input power which may be handled continuously by the cable assembly when terminated by its characteristic impedance

Note 1 to entry: For practical application, the maximum power that may be handled is dependent upon the return loss.

Note 2 to entry: Power rating is dependent on mounting details, ambient temperature, air pressure and circulation. It is normally specified at an ambient temperature of 40 °C.

3.16
artificial ageing
process used to improve the stability of phase attenuation and expansion with temperature

Note 1 to entry: This process normally consists of submitting the complete cable assembly to a number of temperature cycles. Unless otherwise specified in the relevant detail specification, submitting the complete cable assembly to artificial ageing is optional, at the discretion of the supplier.

4 Design and manufacturing requirements

4.1 Cable design and construction

Cables in accordance with, or conforming to, IEC 61196 sectional or detail specifications ~~shall~~ should be specified wherever possible. Where cable designs deviating from IEC 61196 sectional or detail specifications are required, these cables shall comply with the requirements of the relevant sectional or detail specification of the manufacturer.

According to local regulation, raw material of the cable as well as those of additional protection shall be chosen to comply with regional or national Directives and Regulations such as RoHS and REACH in Europe.

4.2 Connector design and construction

Connector types conforming to the relevant part of IEC 61169 shall be specified wherever possible, but where a special connector design is required, the interface shall conform to the relevant part of IEC 61169, where available, and the connector construction shall comply with the requirements of the relevant detail specification.

According to local regulation, raw material of the connector as well as those of additional protection shall be chosen to comply with RoHS and other environmental regulation such as REACH in Europe.

4.3 Outline and interface dimensions

Outline dimensions shall be in accordance with the relevant detail specification of the cable assembly.

Interface dimensions shall be in accordance with the relevant detail specification.

5 Workmanship, marking and packaging

5.1 Workmanship

There shall be no observable defects in the cable assembly. It shall be clean and in good condition.

5.2 Marking

Marking shall be legible and in accordance with the relevant detail specification. It shall identify the manufacturer of the cable assembly.

5.3 End caps

Unless otherwise specified in the relevant detail specification, disposable end caps of suitable material for transport and storage shall be fitted to the connectors to protect at least each interface from damage and dirt.

5.4 Packaging and labelling

Packaging and labelling shall be in accordance with the relevant detail specification, unless otherwise specified.

6 Quality ~~assessment~~ management

A guide for quality ~~assurance~~ management including capability approval as well as qualification approval is given in Annex D.

7 Test methods – General

7.1 Standard atmospheric conditions for testing

~~Unless otherwise specified, all tests shall be carried out under the conditions specified in IEC 60068.~~

~~Before the measurements are made, the cable assemblies shall be stored at the measuring temperature for a time sufficient to allow the entire cable assembly to reach this temperature. When measurements are made at a temperature other than the standard temperature, the result shall, where necessary, be corrected to the standard temperature.~~

Standard atmospheric conditions need to be controlled within some range to ensure proper correlation of data obtained from measurements and test conducted in various facilities. Conduct measurement and test conditions under the following atmospheric conditions, unless otherwise specified. In some cases, special ambient conditions may be needed and be specified in the detail specification.

Table 1 gives the standard range of atmospheric conditions for carrying out measurements and tests.

Table 1 – Standard range of atmospheric conditions

Conditions	Standard
Temperature	23 °C ± 5 °C
Relative humidity	(45 ± 25) %
Atmospheric pressure (Limits are inclusive)	Site ambient

Keep variations in ambient temperature and humidity to a minimum during a series of measurements.

~~NOTE~~ Where it is impracticable to carry out tests under the standard atmospheric conditions for testing, a note to this effect, stating the actual conditions of tests, ~~should~~ shall be added to the test report.

7.2 Visual inspection

The specimen shall be visually examined to ensure that:

a) the condition, workmanship and finish are satisfactory;

b) the marking is in accordance with 5.2 of this document;

c) there is no mechanical damage, undesired movement or displacement of parts;

d) no pitting or flaking of materials or finishes is apparent.

Examination may generally be carried out using an instrument with up to three times magnification.

7.3 Dimensions inspection

7.3.1 Interface dimensions

The interface dimensions shall be tested for compliance with the relevant detail specification with the appropriate test equipment.

Where connectors conforming to IEC 61169 sectional and detail specifications are used, inspection of interface dimensions may be limited to those features likely to vary as a result of incorrect assembly, for example the axial dimensions from reference plane to dielectric, and to inner contact features.

Where other connectors are used or where special requirements exist, details shall be given in the relevant detail specification.

7.3.2 Outline dimensions

Outline dimensions shall be measured according to the sketches of IEC 60966-2 (all parts), IEC 60966-3 (all parts) or IEC 60966-4 (all parts) as relevant.

Any special requirements for the measurement of cable assembly outline dimensions shall be given in the relevant detail specification.

8 Electrical tests

8.1 Reflection properties

8.1.1 Object

To determine the amount of signal that is reflected back to the signal source by the cable assembly under test in a matched system. The reflection behaviour is preferably expressed in terms of 'dB return loss'.

8.1.2 Test equipment

A vector network analyzer (VNA) capable of performing s-parameter measurements using calibration standards (open, short, load) that enables the RF performance of radio frequency (RF) and microwave devices to be characterized in terms of network scattering parameters or S parameters.

The return loss of the cords under test shall be measured with the VNA over the specified range of interest.

A detailed description of the error correction (calibration) procedure is given in the manual of the VNA.

Precision test adaptors (or test leads) with small inherent reflections shall be fitted on both ends of the cord under test to allow direct connection to the VNA and terminating load.

8.1.3 Procedure

~~The return loss of a cable assembly should be measured with a suitable network analyser.~~

For the measurement of the reflection characteristics of cable assemblies, special care ~~must~~ shall be given to the following:

- ensure that the sweep speed is slow enough for the reflected signal to remain in the centre of the IF-filter of the receiver system. The longer the cable, the slower the sweep speed that ~~must~~ shall be chosen;
- cable assemblies might have narrow return loss spikes. For continuous network analyser-systems, the sweep rate shall be low enough and for digital network analyser-systems, the number of measurement points shall be high enough for resolving eventual return loss spikes.

For example, for digital systems, the number of points should be:

$$n \geq 3(f_2 - f_1)\ L\ /\ (120)$$

where

n is the number of sampling points in the frequency range f_1 to f_2 forming the response curve;

f_1 is the lowest frequency in the range, in MHz;

f_2 is the highest frequency in the range, in MHz;

L is the physical length of the test specimen, in m.

Failing to apply these criteria may result in too wide a distance between the frequency sampling points, thus leading to considerable measuring failures.

The return loss of cable assemblies is not necessarily symmetrical for both sides, and measurements from both sides might be required. Unless otherwise stated in the relevant detail specification, the worst case has to be within the specification.

The system has to be calibrated with the appropriate connector types. If these are not available, then adapters have to be used. The adapters will give a deterioration in the measured return loss, but, the result shall not be corrected for the adapters. The combined return loss, including the adapters, shall be within the specification.

Other techniques for measuring the reflection characteristics of a cable assembly may be used if agreed by the customer.

8.1.4 Requirements

The measured return loss values shall be within the specified limits.

8.1.5 Information to be given in the detail specification

a) minimum return loss, as a function of frequency, if appropriate;

b) frequency range;

c) required frequency resolution.

Measurements to be made from one or both ends.

8.2 Uniformity of impedance

8.2.1 Object

To determine the variation of local characteristic impedance of the cable assembly.

8.2.2 Procedure

Measurement is made using a time domain reflectometer (TDR) with input step applied to the cable assembly through an air line acting as an impedance reference (see IEC 61196-1-112 and 61169-1:2013, 9.2.1.2.2). Impedance variation along the assembly shall be observed.

Alternatively, a system using frequency domain to time domain conversion may be used.

8.2.3 Requirements

To be as specified in the relevant detail specification.

8.2.4 Information to be given in the detail specification

a) rise time of the TDR system;

b) limits of impedance variation.

8.3 Insertion loss

8.3.1 Procedure

The insertion loss shall be inspected in accordance with Annex A.

8.3.2 Requirements

The insertion loss shall not exceed the specified limits at any frequency within the frequency band indicated in the relevant detail specification.

8.3.3 Information to be given in the detail specification

a) maximum insertion loss, if appropriate, as a function of frequency;

b) frequency range.

8.4 Insertion loss stability

8.4.1 Object

To determine the change of attenuation at a given frequency when the cable assembly is subjected to dynamic bending.

8.4.2 Procedure

During insertion loss measurement according to 8.3, the cable is wound on a mandrel of radius equal to the dynamic bending radius and using the number of turns indicated in the relevant detail specification.

8.4.3 Requirements

During and after the test, the specified change of insertion loss given in the relevant detail specification shall not be exceeded.

8.4.4 Information to be given in the detail specification

a) dynamic bending radius of the cable (radius of the mandrel);

b) number of turns and portion of the cable assembly on the mandrel;

c) test frequencies.

d) maximum change of insertion loss.

8.5 Propagation time

8.5.1 Procedure

The propagation time is inspected in accordance with Annex B.

8.5.2 Requirements

The propagation time shall not exceed the limits indicated in the relevant detail specification.

8.5.3 Information to be given in the detail specification

a) frequency band in which the measurement is carried out (see Clause B.1) or rise time of the system (see Clause B.2);

b) propagation time and tolerance.

8.6 Stability of electrical length

8.6.1 Object

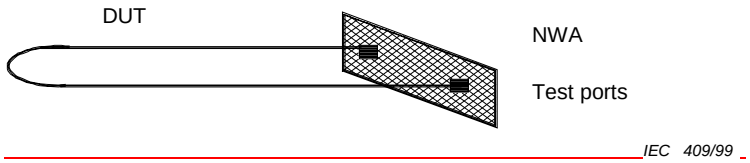
To determine the change of phase caused by the change in electrical length when the cable assembly is subjected either to bending or twisting.

8.6.2 Procedures

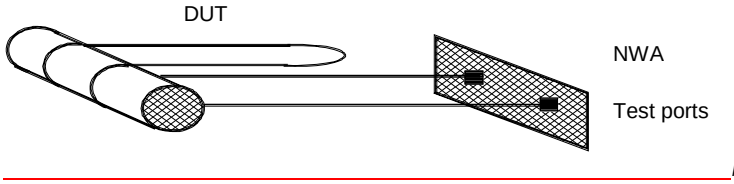
8.6.2.1 Bending

Method 1

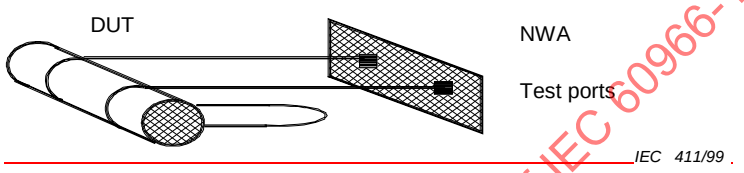
A cable assembly which is of a U shape ~~has to~~ shall be connected to a suitable network analyser ~~(NWA),~~ according to 8.1.2 (see Figure 1). During recording of the phase of the transmitting signal, the cable is wound around the mandrel for 180° (see Figure 1), unwound to the starting position, wound counter-clockwise for 180° around the mandrel (see Figure 1) and again unwound to its starting position. The initial position of the mandrel shall be chosen so that only the straight parts of the U will be bent during the test.



~~Figure 1a – Start position~~



~~Figure 1b – First bend~~



~~Figure 1c – Second bend~~

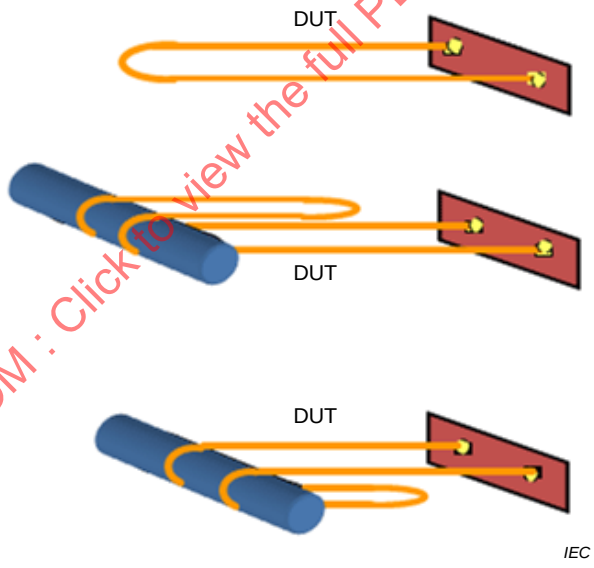
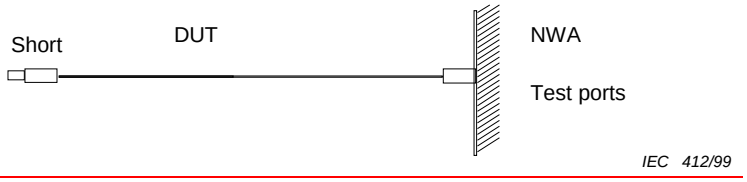


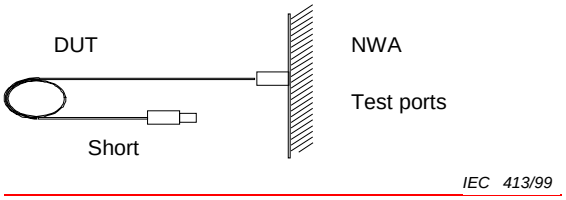
Figure 1 – Bending test: U shape assembly

Method 2

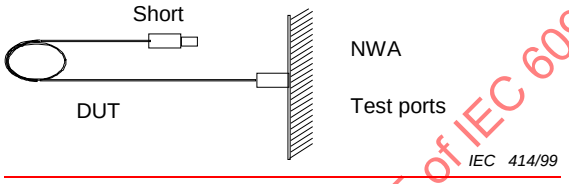
A cable assembly which is of a straight shape has to be terminated by a short at one end and connected to a suitable network analyser according to 8.1.2 at the other end. During the recording of the phase of the reflected signal, the cable is first wound clockwise around the mandrel for one half turn released to the starting position then wound anti-clockwise around the mandrel and again released to its starting position. See Figure 2.



~~Figure 2a – Start position~~



~~Figure 2b – First bend~~



~~Figure 2c – Second bend~~

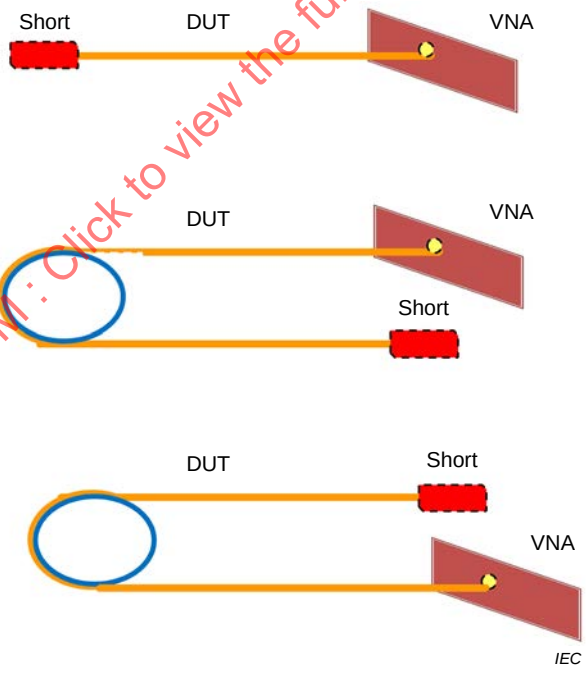
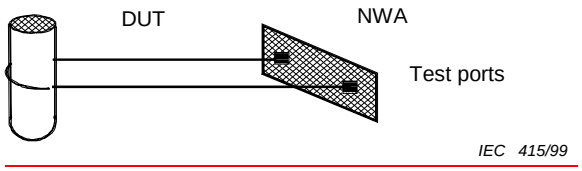


Figure 2 – Bending test: straight assembly

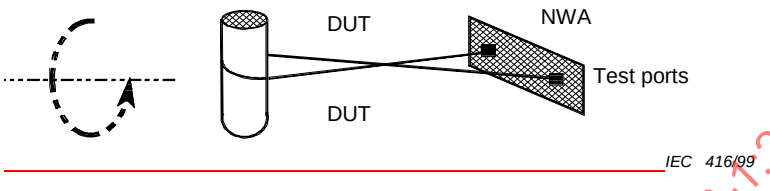
8.6.2.2 Twisting

A cable assembly which is of a U shape has to be connected to a suitable network analyser according to 8.1.2 (see Figure 3a). During the recording of the phase of the transmitting signal the mandrel in the middle of the cable is first twisted in a clockwise direction for 180° (see Figure 3b) then released to the starting position, twisted counter-clockwise for 180° (see Figure 3c) and again released to its starting position.

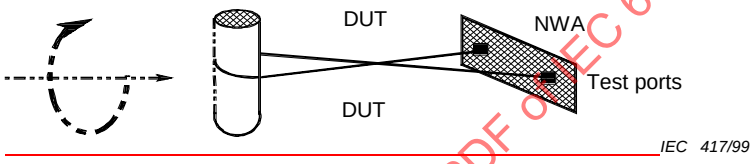
~~NOTE~~ Depending on the torsional rigidity and the maximum permissible torque at the cable connectors interface, the maximum twist angle may have to be restricted.

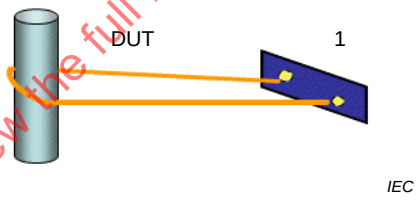


~~Figure 3a – Start position~~

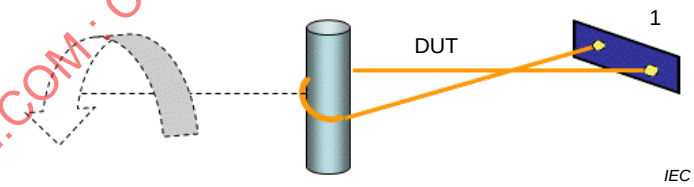


~~Figure 3b – First twist~~

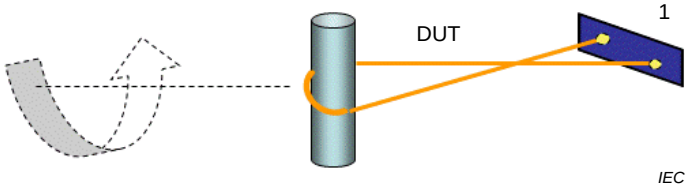




a) Starting position



b) Clockwise twist



c) Counter clockwise twist

Figure 3 – Twisting test: U shape assembly

8.6.3 Requirements

The phase difference shall not exceed the limits specified in the relevant detail specification.

8.6.4 Information to be given in the detail specification

a) radius of mandrel (usually dynamic bending radius of the cable);

b) test frequency;

c) maximum change of phase.

8.7 Phase difference

8.7.1 Object

To measure the phase difference between two or more cable assemblies.

8.7.2 Procedure

Measurements shall be made using a suitable network analyser of appropriate resolution according to 8.1.2. Alternatively, a slotted line may be used where frequency and accuracy requirements permit.

8.7.3 Requirements

The phase difference shall not exceed the limits specified in the relevant detail specification.

8.7.4 Information to be given in the detail specification

a) maximum phase difference or nominal phase difference with tolerances;

b) frequency.

8.8 Phase variation with temperature

8.8.1 Object

To determine the changes of phase caused by the change in the electrical length when the cable assembly is subjected to various temperatures within its operating temperature range.

When specified in the relevant detail specification, this test may be conducted on a specimen cable assembly rather than a finished cable assembly. The specimen cable assembly shall be identical to the finished cable assembly except for its length and its shape.

8.8.2 Procedure

Measurements shall be made using a suitable network analyser according to 8.1.2 with the cable assembly, including its connectors, in a controlled temperature chamber. Details of any cable supports shall be given in the relevant detail specification.

Where tests are made on a specimen cable assembly, the cable shall form one or more unsupported loops of a diameter at least ten or more times the minimum static bending radius.

Six temperature cycles shall be used. Alternatively, a slotted line can be used where frequency and accuracy requirements permit.

8.8.3 Requirements

During the test, the phase variation shall not exceed the limits specified in the relevant detail specification.

8.8.4 Information to be given in the detail specification

a) temperature range and temperature against time cycle;

b) measurement frequency;

c) method of presenting the results, for example ~~°el /°C~~ Δφ/°C;

d) admissible phase variation;

e) configuration of substitute specimen cable assembly, when allowed.

8.9 Screening effectiveness

8.9.1 Transfer impedance

The ~~screening effectiveness~~ transfer impedance shall be tested.

Applicable tests for transfer impedance are given in ~~annex C or in IEC 61726~~ IEC 62153-4-6 or IEC 62153-4-7.

The relevant detail specification shall identify the applicable test, the frequency range and the minimum value of ~~screening effectiveness~~ transfer impedance.

8.9.2 Screening attenuation

The screening attenuation shall be tested according to 62153-4-7.

The relevant detail specification shall identify the frequency range and the minimum value of screening attenuation.

8.10 Voltage proof

8.10.1 Procedure

Each cable assembly shall withstand, without breakdown or flashover, the voltage specified by the relevant detail specification. The minimum value of the test voltage derived from the rated working voltage U of the cable assembly and the test voltage E (both expressed as DC or AC peak) is given by:

E = 3 U for cable assemblies having a rated working voltage up to and including 1 kV,

or

E = 1,5 U with a minimum of 3 kV for cable assemblies having a rated working voltage exceeding 1 kV.

The peak AC voltage stated in the relevant detail specification, at a frequency between 40 Hz and 60 Hz, shall be applied between the inner and outer conductors of the cable assembly using a mated connector as an interface.

Alternatively, a DC voltage equal to the peak AC voltage may be applied.

The voltage shall be applied for a period of 1 min, unless otherwise stated in the relevant detail specification.

8.10.2 Requirements

There shall be no breakdown or flashover.

8.10.3 Information to be given in the detail specification

a) test voltage;

b) any special requirements.

8.11 Insulation resistance

8.11.1 Procedure

The insulation resistance shall be measured between the inner and outer conductor of the cable assembly with a direct voltage of 500 V ± 50 V or with the rated voltage of the cable assembly, whichever is less.

The insulation resistance shall be measured after a stabilisation time of 60 s ± 5 s, unless otherwise specified in the relevant detail specification.

8.11.2 Requirements

The value of the insulation resistance shall not be less than that indicated in the detail specification.

8.11.3 Information to be given in the detail specification

a) test voltage;

b) stabilization time;

c) resistance value.

8.12 Inner and outer conductor continuity

8.12.1 Object

To ensure the DC and low frequency continuity of the inner and outer conductors.

8.12.2 Procedure

Any appropriate method may be used.

8.12.3 Requirements

There shall be no undesired DC or low frequency discontinuity of the inner or outer conductor.

8.12.4 Information to be given in the detail specification

a) test voltage;

b) test current;

c) frequency.

~~**8.13 Void**~~

8.13 Power rating

8.13.1 Object

The power rating of a cable assembly is defined as the input power at any specified frequency, temperature and pressure, which can be handled continuously when the cable assembly is terminated by a load corresponding to the characteristic impedance.

A limitation may be either the maximum permissible operating voltage or the maximum inner conductor temperature of either the cable or the connector.

Thus, the power handling capability test is divided into two categories:

a) continuous power handling capability;

b) peak or pulsed power handling capability.

8.13.2 Procedure

The test shall be performed in accordance with ~~11.19 of~~ IEC 61196-1-119 taking into account any evidence of arcing and mechanical displacement of the solder or mechanical joint.

8.13.3 Requirements

There shall be no evidence of breakdown due to overheating, arcing or flashover throughout the application of the specified power related to the environmental conditions as stated in the relevant detail specification. After the test, the cable assembly shall show no visual damage and the electrical requirements shall be satisfied.

The temperature rating of the material components should not be exceeded.

8.13.4 Information to be given in the detail specification

a) temperature;

b) pressure;

c) relative humidity.

Peak power test

d) power level;

e) frequency;

f) pulse width and duty cycle.

CW power test

g) power level;

h) frequency.

8.14 Intermodulation level measurement

~~Under consideration.~~

8.14.1 Procedure

If required, the intermodulation level measurement shall be performed in accordance with IEC 62037-2.

8.14.2 Requirements

The maximum intermodulation level shall be recorded and shall not exceed the given intermodulation level in the relevant detail specification.

8.14.3 Information to be given in the detail specification

a) test signal power;

b) test signal frequencies.

9 Mechanical robustness tests

9.1 Tensile

9.1.1 Object

To determine the mechanical strength and, when required, electrical stability of the cable assembly when subjected to an axial force.

9.1.2 Procedure

A tensile force as stated in the relevant detail specification shall be applied to the two connectors along the common axis of the cable and connectors. When the length or shape of the cable makes this impossible, the force shall be applied between the cable and each connector in turn.

~~NOTE~~ When the force cannot be applied between the two connectors, these tests are normally destructive to the cable.

The application points of the force shall be given in the detail specification.

9.1.3 Requirements

There shall be no visual evidence of the movement of the cable relative to the connector.

Inner contact and insulator positions shall be in accordance with interface dimensions.

Electrical test requirements shall be complied with, if stated in the relevant detail specification.

9.1.4 Information to be given in the detail specification

a) value of the force;

b) duration and method of application of the force.

c) Electrical tests required.

9.2 Flexure

9.2.1 Object

To determine the ability of the cable assembly to withstand bending at the junction of the cable and connector.

9.2.2 Procedure

The test shall be performed using a fixture as shown in Figure 4.

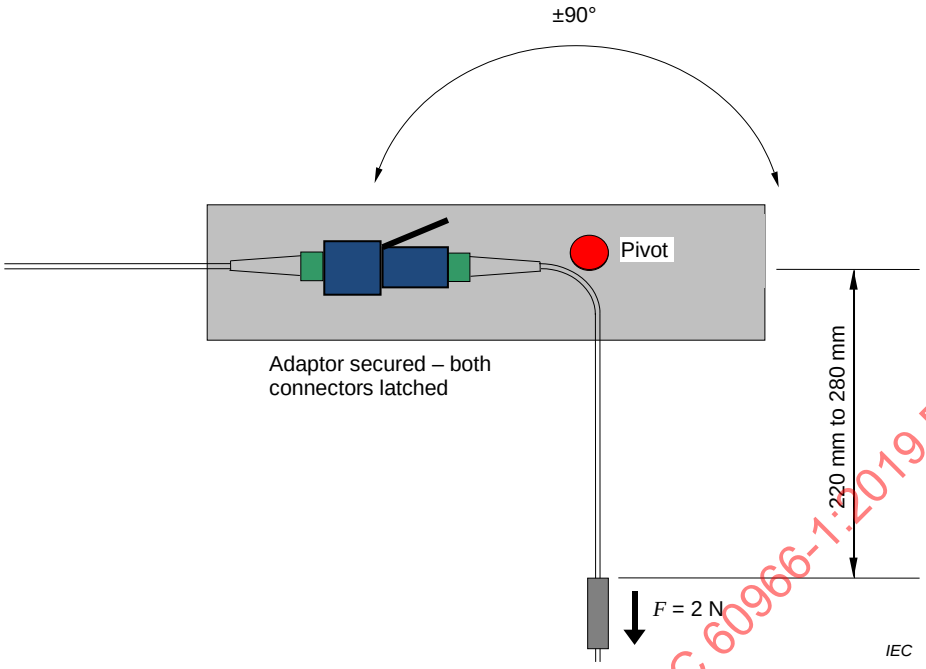


Figure 4 – Fixture for cable assembly flexure test

The length L is adjusted so that the cable is on the vertical axis and the connector in the horizontal position when the force F is applied. A flexure is a rotation of the fixture of 180°. The rate of flexure shall be 20 per minute or as stated in the relevant detail specification.

9.2.3 Requirements

After the test, the cable assembly interface dimensions shall be within the specified limits.

Electrical test requirements stated in the relevant detail specification shall be complied with.

9.2.4 Information to be given in the detail specification

a) value of the force F;

b) number of flexures, normally 500;

c) electrical tests required;

d) whether or not electrical tests shall be applied with the cable assembly still on the fixture.

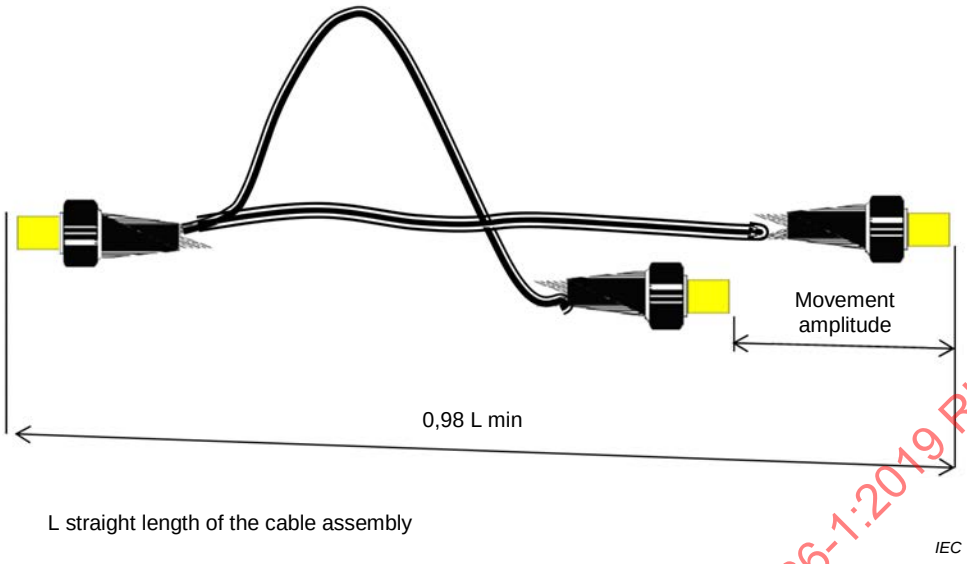
9.3 Flexing endurance

9.3.1 Object

To determine the acceptability of the cable assembly intended to withstand flexing in service.

9.3.2 Procedure

The cable assembly shall be placed on a horizontal table in an apparatus as illustrated in Figure 5. Whilst one connector is fixed, the other connector is moved back and forth in the direction of the cable axis.



Key

L min minimum length to be tested (in metres)

Figure 5 – Apparatus for cable assembly flexing endurance test

9.3.3 Requirements

After the test, the cable assembly shall show no visible damage and the interface dimensions shall be within the specified limits. Electrical requirements stated in the relevant detail specification shall be complied with.

9.3.4 Information to be given in the detail specification

a) movement amplitude, normally half the length of the assembly;

b) number of cycles, normally 500;

c) electrical tests to be applied, with requirements.

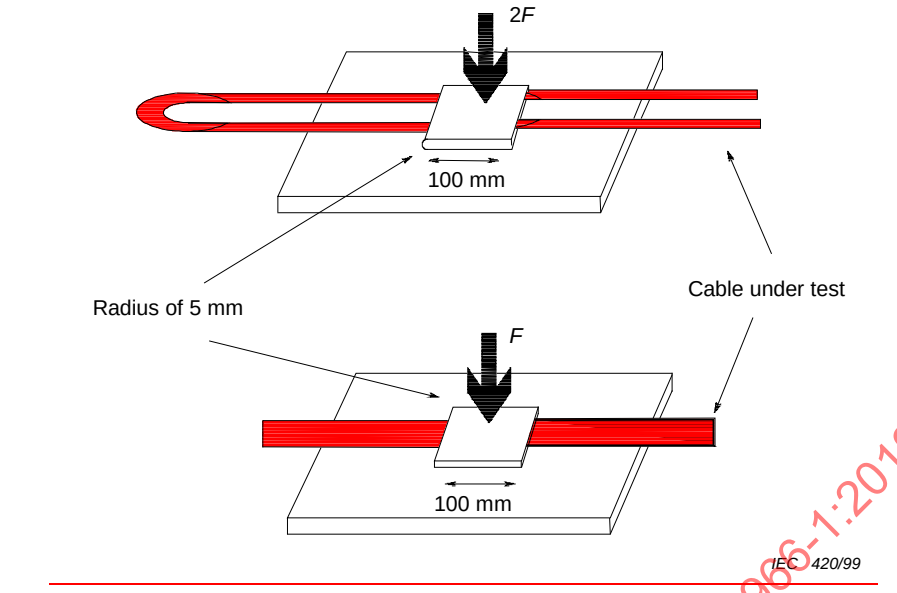
9.4 Cable assembly crushing

9.4.1 Object

To determine the ability of a cable assembly to withstand a transverse load (or a force) applied to any part of the cable.

9.4.2 Procedure

A force F shall be applied to a test fixture as shown in Figure 6 at the rate of 0,2F per second maximum. The force shall then be maintained for 60 s ± 10 s.



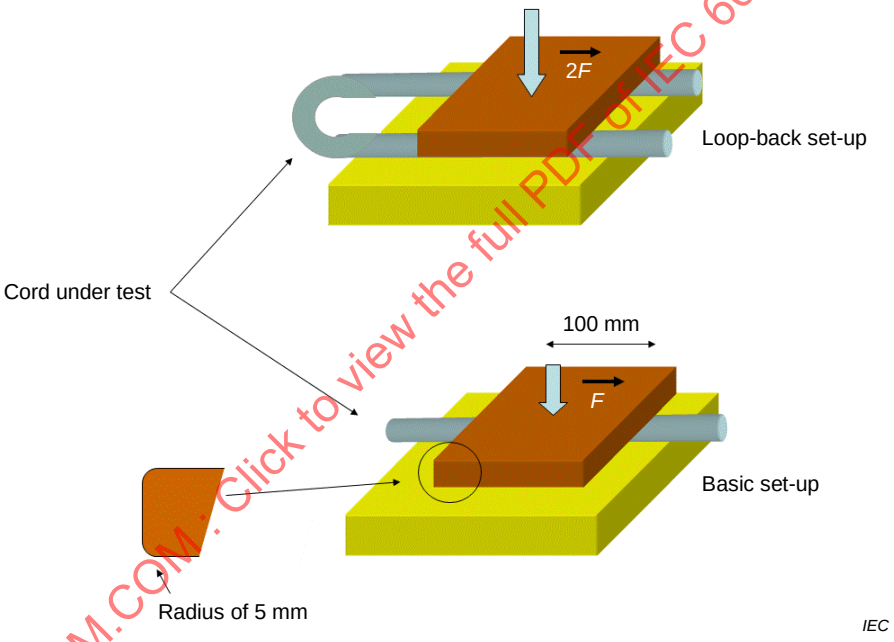


Figure 6 – Fixture for cable crushing test

9.4.3 Requirements

After the test, the reflection characteristics and insertion loss shall be within the limiting values specified in the relevant detail specification.

For some applications, the relevant detail specification shall indicate the uniformity of impedance according to 8.2.

9.4.4 Information to be given in the detail specification

a) value of the force F, normally 800 N;

b) distance from the test region to one of the connectors, normally 1 m maximum;

c) electrical tests and their requirements.

9.5 Torque

9.5.1 Procedure

The ability of the cable to resist torsion shall be tested by the application of a specific torque strictly axially to the interface of the cable to the connector. The torque shall be applied for at least 60 s in both clockwise and counter clockwise directions, see Figure 7.

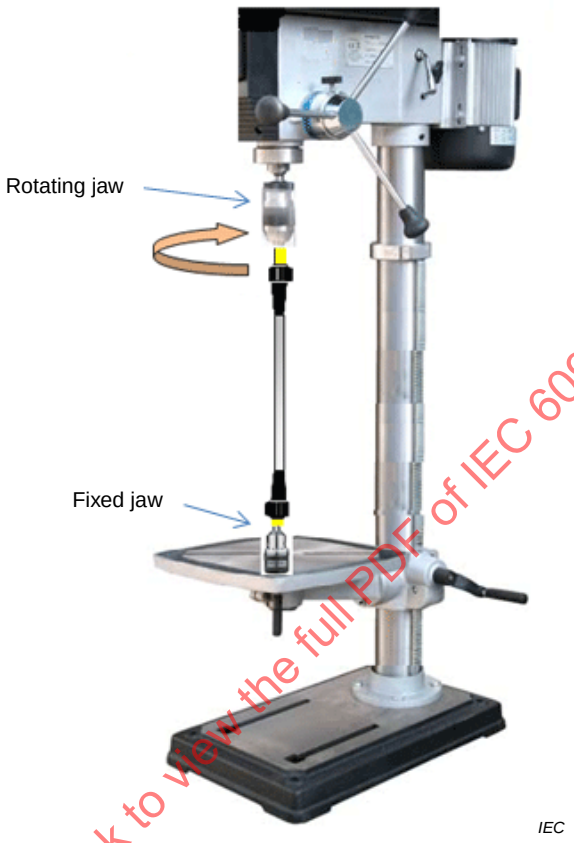


Figure 7 – Example of test fixture for torque

9.5.2 Requirements

After each 60 s application of the torque, the interface of the cable to the connector shall be visually examined. The cable assembly shall show no visual damage and the electrical requirements shall be satisfied. In addition, for semi-flexible and semi-rigid cables, there shall be no angular displacement between the cable and the connector.

9.5.3 Information to be given in the detail specification

Value of the torque.

9.6 Multiple bending

9.6.1 Object

To determine the ability of a cable assembly to withstand a number of reverse bends.

9.6.2 Procedure

The cable assembly is subjected to a certain number of reverse bends using a pulling "go and return" arrangement over its entire length. The radius of the two pulleys shall be in accordance with the minimum dynamic bending radius of the cable. The pulleys shall be

positioned so that the bending angle of the cable on each pulley is more than 90° as shown in Figure 8. The cable assembly is pulled forwards and backwards against a restraining force F_r which is set to ensure continuous contact between the cable and the pulleys.

9.6.3 Requirements

After the test, the cable assembly shall show no visual damage and the electrical requirements shall be satisfied.

9.6.4 Information to be given in the detail specification

a) number of cycles (normally 20);

b) electrical tests and their required limits to be applied.

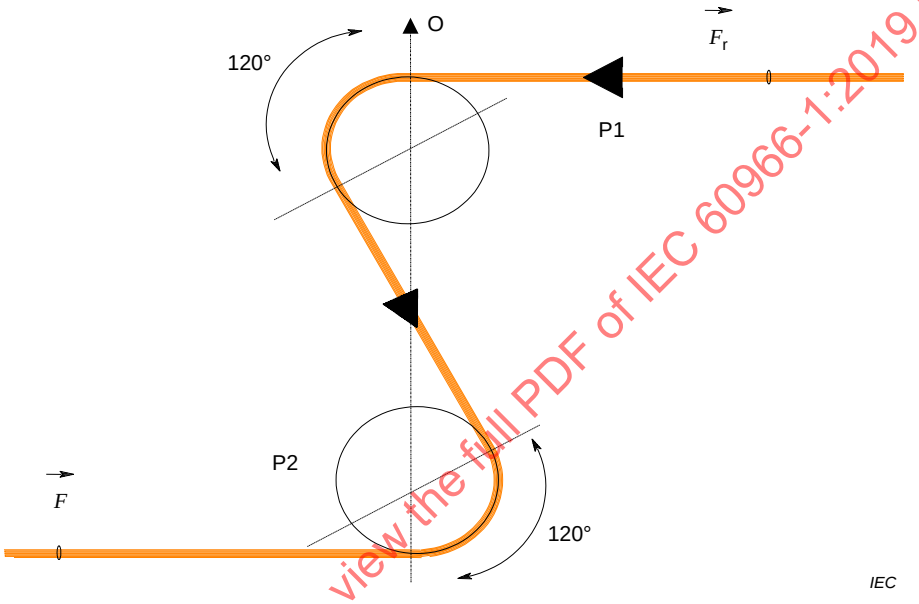


Figure 8 – Multiple bending test

9.7 Abrasion test of cable assembly

9.7.1 Object

To determine the resistance to abrasion of the cable assembly sheath.

9.7.2 Procedure

The cable assembly is subjected to test ~~10.10 of IEC 61196-1~~ given in IEC 61196-1-324.

9.8 Vibrations, shocks ~~and impact~~

If required, the test for vibrations and shocks shall be selected as defined in 10.2.

9.9 Impact test

This test shall be conducted in accordance with test 7b of ~~IEC 60512-5~~ IEC 60512-7-2.

9.10 Mechanical endurance

When this test is not performed on the connectors separately, it will be conducted in accordance with ~~9.5 of IEC 61169-1~~ IEC 61169-1:2013, 9.4.5 (High temperature endurance) and, 9.4.6 (Low temperature endurance).

10 Environmental tests

10.1 Recommended severities

For the recommended severities of environmental tests, see Annex C.

Recommended set of severities may also be found in ISO/IEC TR 29106.

10.2 Vibration, bumps and shock

When these tests are required, they shall be selected from IEC 60068 (all parts) (see Annex C).

10.3 Climatic sequence

10.3.1 Procedure

The test shall be performed in accordance with 9.4.2 of IEC 61169-1:2013.

Flexible cable assemblies shall be wound on a mandrel of minimum static bending radius. The number of full turns shall be three, unless otherwise stated in the relevant detail specification.

10.3.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) insulation resistance;

b) voltage proof;

c) insertion loss;

d) visual inspection.

The insulation resistance measurement and the voltage proof shall be carried out within 30 min of the end of the recovery period.

10.3.3 Information to be given in the detail specification

a) severity of each step of the climatic sequence;

b) number of turns on the mandrel if other than three;

c) electrical tests made during and after the sequence and their requirements;

d) whether connectors are unmated or protected.

10.4 Damp heat, steady state

10.4.1 Procedure

The flexible cable assembly shall be wound on a mandrel of minimum static bending radius. The number of full turns shall be three, unless otherwise stated in the relevant detail specification. The test shall be performed in accordance with 9.4.3 of IEC 61169-1:2013.

10.4.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) insulation resistance;

b) voltage proof;

c) insertion loss;

d) visual inspection.

The insulation resistance and the voltage proof measurements shall be carried out within 30 min of the end of the recovery period.

10.4.3 Information to be given in the detail specification

a) severity of the test;

b) number of turns on the mandrel if other than three;

c) electrical checks made immediately after conditioning and after recovery period and their requirements;

d) whether connectors are mated or unmated.

10.5 Rapid change of temperature

10.5.1 Procedure

The test shall be performed in accordance with 9.4.4 of IEC 61169-1:2013. Flexible cable assemblies shall be wound on a mandrel of minimum static bending radius. The number of full turns shall be three, unless otherwise stated in the relevant detail specification.

The coil turns should be spaced to avoid contact with each other.

10.5.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) insulation resistance;

b) voltage proof;

~~c) Insertion loss.~~

c) RL, IL, ZC, and electrical length;

d) visual inspection.

Centre contact and insulator positions shall be in accordance with the interface dimensions.

10.5.3 Information to be given in the detail specification

a) minimum and maximum temperature;

b) number of turns on the mandrel if other than three;

c) final tests and measurements and their requirements.

10.6 Resistance to solvents and contaminating fluids

10.6.1 Procedure

The test shall be performed in accordance with ~~9.7~~ 9.4.11 of IEC 61169-1:2013.

10.6.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) Insulation resistance;

b) Visual inspection;

c) Insertion loss.

10.6.3 Information to be given in the detail specification

a) conditioning fluids;

b) drying temperature, if different from 70 °C;

c) requirements for insulation resistance and insertion loss;

d) whether the connectors are mated or unmated.

10.7 Water immersion

10.7.1 Procedure

Details of the method shall be given in the relevant detail specification and shall be generally in accordance with ~~9.2.7~~ 9.4.9 of IEC 61169-1:2013.

10.7.2 Requirements

At the conclusion of the test duration, the cable assembly shall comply with the requirements of the following tests, unless otherwise specified in the relevant detail specification.

a) insulation resistance;

b) insertion loss.

10.7.3 Information to be given in the detail specification

a) requirements for insulation resistance and insertion loss;

b) whether the connectors are mated or unmated.

10.8 Salt mist and sulphur dioxide tests

10.8.1 Procedure

When these tests are required, they shall be ~~selected from IEC 60068~~ performed according to 9.4.10 (salt) and 9.4.12 (sulphur) of IEC 61169-1:2013. Severities are to be given in the relevant detail specification.

10.8.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification:

a) insulation resistance;

b) visual inspection;

c) insertion loss.

10.8.3 Information to be given in the detail specification

a) requirements for insulation resistance and insertion loss;

b) whether the connectors are mated or unmated.

10.9 Dust tests

10.9.1 Object

To determine whether the effects of exposure to dust impair the operational performance of the cable assembly and in particular the function of the coupling mechanism.

10.9.2 Procedure

~~Details of a typical test cabinet for carrying out this test are given in 10.9.5. The dust medium shall be fine powdered silica as detailed in 10.9.5.~~

~~The dry specimen(s) with connectors mated and with back-of-panel portion of fixed connectors and free ends of cable protected, when appropriate, against ingress of dust shall be placed in the cabinet simulating the normal operational altitude. (If the normal operational altitude is indefinite, the specimen(s) shall be positioned in the altitude most likely to prove adverse).~~

~~No relevant part of any specimen shall be closer than 150 mm to the sides, top or bottom of the cabinet or part of another specimen during the test.~~

~~Each test cycle shall be of 15 min duration, during which the air blast shall be operated for the first 2 s only.~~

~~The number of test cycles to which the specimens will be exposed will be dependent upon the severity of exposure to dust likely to be met in service. The following are the preferred test severities:~~

~~a) Severe dust conditions: 20 cycles.~~

~~b) Moderate dust conditions: 10 cycles.~~

~~c) Slight dust conditions: 2 cycles.~~

The cord will be submitted to the test defined by IEC 60529 for a classification IP 5X.

The details of the test (mated or unmated connector(s) shall be given in the detail specification.

10.9.3 Requirements

At the conclusion of the last cycle, the specimen(s) shall be carefully removed from the chamber and any surplus dust removed by a light shaking or blowing. Before uncoupling the connector, any measurements required by the detail specification to check for deterioration in performance shall be made.

10.9.4 Information to be given in the detail specification

a) duration of test cycle if other than 15 min;

b) the equivalent altitude if other than that covered by the standard atmospheric conditions for testing;

c) number of test cycles;

d) details of visual, mechanical and electric inspection and tests required at the conclusion of the conditioning including whether a special tool may be used to assist uncoupling of mated connector;

e) size of particles to be chosen from ~~6.1.4.2 of IEC 60068-2-68~~ IEC 60529.

~~**10.9.5 Test chamber**~~

~~The cabinet used shall be based on the typical details given below. The essential features are:~~

~~a) A dense diffusion of the dust shall be achieved within 2 s.~~

~~b) A glass observation panel incorporated in an opening door (with externally hand-operated wiper).~~

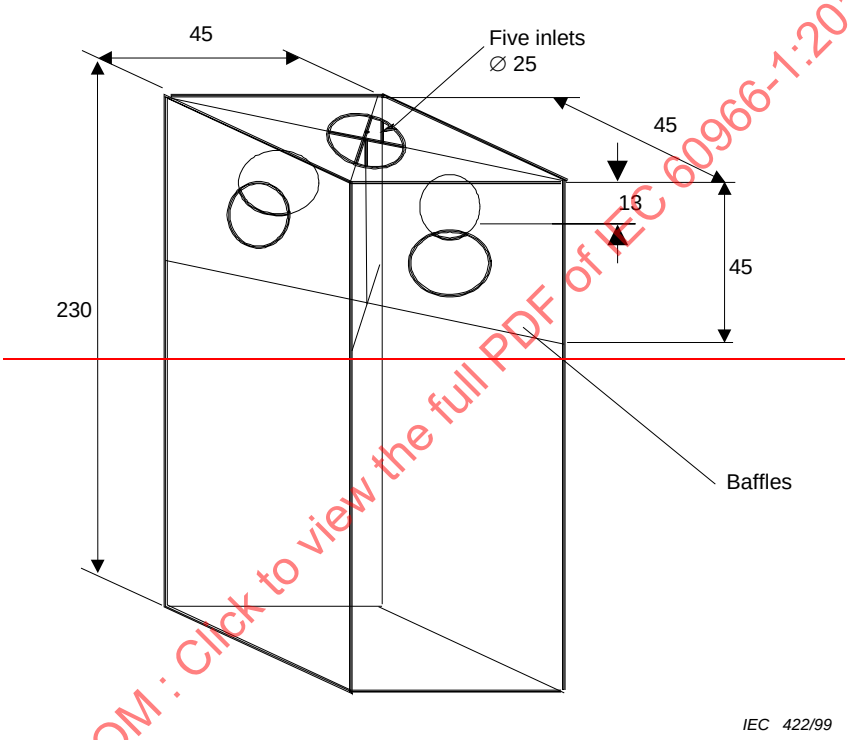
c) Means for holding the specimens in the cabinet in accordance with the requirements of this specification and the detail specification.

d) There shall be no increase in air pressure within the cabinet during the test and especially during the first 2 s of each cycle.

e) The test chamber temperature shall be capable of being raised to and maintained at a temperature of 35 °C ± 2 °C with a relative humidity not exceeding 60 %. It shall be adjustable so as to produce a dust concentration sufficient to deposit 25 g ± 5 g in the measuring device (see figure 8) over a period of 5 min.

f) Materials used for the construction of the cabinet shall be such that there shall be no contamination of the dust by foreign matter.

g) Details of the powdered medium to be as follows: dry silica with grains of 2,5 µm to 50 µm and grains of 50 µm to 150 µm (fifty/fifty).



Dimensions in millimetres

Figure 8 – Dust measuring device

10.10 Flammability

10.10.1 Procedure

The test shall normally be carried out in accordance with IEC 60332-1-2 on a finished cable assembly. Unless otherwise specified in the detail specification, the duration of flame application shall be derived from the formula given in clause 7 of IEC 60332-1 5.4.2 of IEC 60332-1-2:2004. In case of plastic components other than the cable itself, each one shall satisfy the requirements of the relevant specification.

10.10.2 Requirements

If ignition occurs, the cable shall not continue to burn for more than 15 s after removal from the flame.

At no time during the test shall burning particles become detached from the cable.

10.10.3 Information to be given in the detail specification

Any deviation from the standard procedure including regional or national regulations, if any.

11 Specialized test methods

Specialized test methods, applicable to a specific group of cable assemblies only, shall be specified in the relevant sectional specification.

12 Test schedules

Testing schedules shall be defined in sectional and relevant detail specifications.

NOTE Typical sub-families consist of RF cable assemblies manufactured from a specific type of cable, for example, flexible or semi-rigid, RF-connectors of an IEC standardized or proprietary design, and having specific characteristics, for example precision or super-screened.

Annex A
(normative)

Test methods for insertion loss determination

A.1 Purpose

To determine the insertion loss of an RF cable assembly.

A.2 Test methods

A.2.1 General

Three test methods for the determination of the insertion loss of an RF cable assembly are described in this Annex A. The test equipment should have the same nominal characteristic impedance as the cable assembly under test. If this is not possible, test methods 1 and 2, given in A.2.2 and A.2.3, may only be used with the application of the correction formula and procedures given in Clause A.3.

Test method 3 is only suitable for RF cable assemblies having an insertion loss smaller than their return loss.

Adapters may be required between the test equipment and the cable assembly under test. These shall be regarded as part of the test equipment and shall be left in the circuit when the cable assembly is removed as part of the test procedure. However, should a cable assembly have connectors such that the adapters cannot be coupled together when the cable assembly is removed, one or more of the adapters may be left on the cable assembly. In this case, an allowance for the adapter(s) shall be made in the relevant detail specification.

A.2.2 Test method 1

A.2.2.1 Procedure for inspection

The cable assembly is tested in the test equipment circuit as shown in Figure A.1.

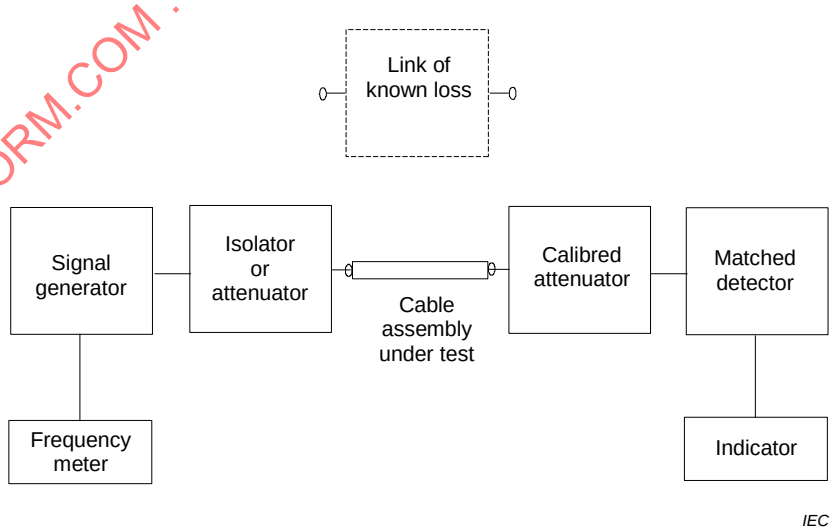


Figure A.1 – Circuit for the determination of insertion loss

First the cable assembly is either replaced by the link of known loss or the two test ports are coupled together and the indicator set to a suitable value (i.e. less than the maximum). The cable assembly is inserted between the test ports and the calibrated attenuator is then backed

off by an amount equal to the cable assembly limit, less the known loss of the link if used. The indicator reading shall not be less than the set value. This ensures that the insertion loss of the cable assembly is not more than the specified value.

A.2.2.2 Procedure for measurement

The cable assembly is tested in the test equipment circuit as shown in Figure A.1. The indicator is set to a suitable value (i.e. less than the maximum). The cable assembly is then removed and the indicator reading is returned to the set value using the calibrated attenuator and if necessary the link of known loss.

A.2.2.3 Acceptance

The insertion loss of the cable assembly shall be no greater than the specified value.

A.2.2.4 Precautions

a) The return losses at the two test ports may impair measurement and shall be taken into account (see Clause A.3).

b) Care shall be taken to ensure that too much power does not damage the detector.

c) The oscillator shall be sufficiently pure or filtered, to ensure that neither harmonics nor spurious signals compromise the tests.

d) See A.2.1 regarding the use of adapters.

A.2.3 Test method 2

A.2.3.1 General

This test method may be used for cable assemblies having the same nominal characteristic impedance as the test equipment (i.e. for high return loss cases) as well as for cable assemblies having different nominal characteristic impedances (i.e. for low return loss cases).

A.2.3.2 Procedure

The test circuit is shown in Figure A.2 whereby the detector V is connected to the output of the directional coupler or bridge through adapters as necessary.

Depending upon the test port return losses, calibration is made either by amplitude or by amplitude and phase (high return loss requires amplitude calibration only, while low return loss requires amplitude and phase calibration in accordance with Clause A.3). The cable assembly is inserted between the output of the directional coupler or bridge and the detector V, using adapters if necessary. The attenuation is determined on the swept amplitude analyser.

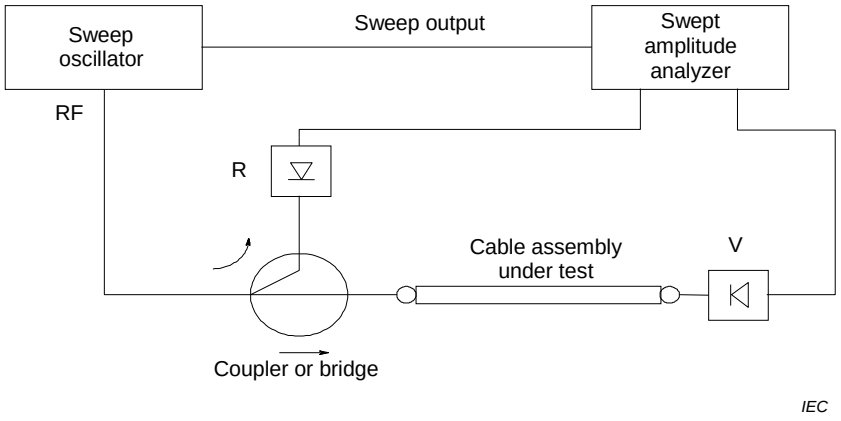


Figure A.2 – Circuit for the determination of insertion loss – principle

If sufficient power is available or if there is sufficient sensitivity in the systems, the alternative circuit shown in Figure A.3 may be used.

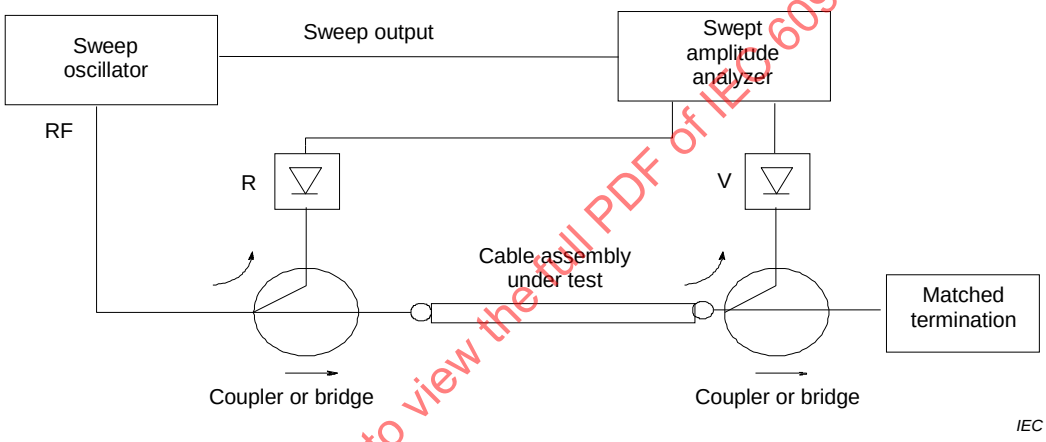


Figure A.3 – Alternative circuit for the determination of insertion loss

A.2.3.3 Acceptance

The insertion loss of the cable assembly shall be no greater than that specified.

A.2.3.4 Precautions

a) The return losses at the two test ports may impair measurement and shall be taken into account (see Clause A.3). In particular, an attenuator having a low reflection may be required in front of the detector V.

b) The calibration of the system shall take into account the power dependence of the coupler.

c) The oscillator shall be sufficiently pure or filtered, to ensure that neither harmonics nor spurious signals compromise the tests.

d) In analogue-swept systems, the frequency scan rate of the sweep oscillator shall be sufficiently slow in relation to the amplitude analyser response to obtain an accurate determination of the insertion loss. In particular, it shall be slow enough for cable assemblies in which there are:

   1) resonances, which can be very sharp, associated with structural return loss in the cable assembly;

   2) multiple reflections between the ends of the cable assembly or the test ports.

e) In digitally stepped frequency systems, the steps shall be sufficiently fine for an accurate determination of the insertion loss. In particular, they shall be fine enough for the cases described in item d).

f) See A.2.1 regarding the use of adapters.

A.2.4 Test method 3

A.2.4.1 General

A double-pass method of test may be used if the insertion loss of the cable assembly is smaller than its return loss and the test bandwidth is sufficient. This requirement precludes the testing of unmatched cable assemblies.

A.2.4.2 Procedure

The layout of the test circuit is shown in Figure A.4.

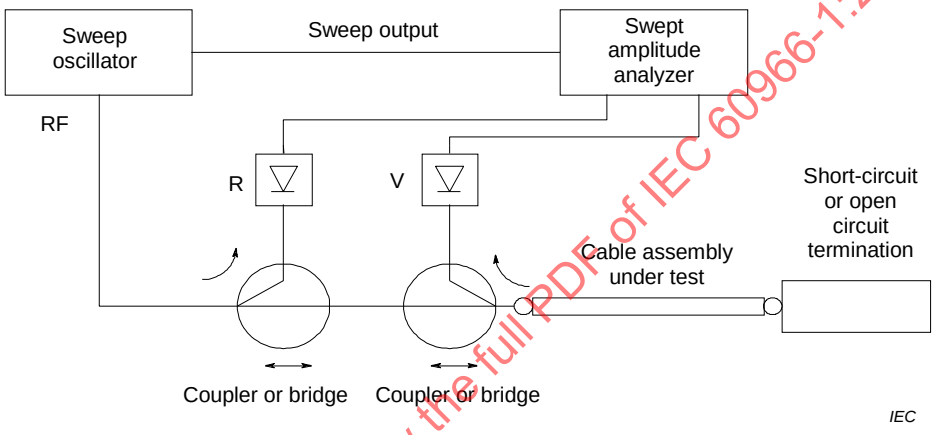


Figure A.4 – Double-pass circuit for the determination of insertion loss

Levels for V/R at 0 dB and for any other required attenuation are established over the required frequency range with terminations on the directional coupler port or adapters as follows:

a) short-circuit;

b) open-circuit.

The decibel average of these two levels a) and b) shall be deemed the reference level.

The cable assembly is then coupled to the directional coupler using adapters as necessary and attenuation levels are obtained with the short- and open-circuit terminations. The decibel average of the two plots obtained with the different terminations is twice the insertion loss of the cable assembly under test.

A.2.4.3 Acceptance

The insertion loss of the cable assembly shall be no greater than the specified value.

A.2.4.4 Precautions

a) The return loss at the test port and the directivity of the directional coupler or the apparent directivity of the bridge impair the measurement and shall be taken into account (see Clause A.3).

b) The test bandwidth shall be sufficient to provide confidence in averaging plots.

c) The calibration of the system shall take into account the power dependence of the coupler.

d) The oscillator shall be sufficiently pure or filtered, to ensure that neither harmonics nor spurious signals compromise the tests.

e) In analogue-swept systems, the frequency scan rate of the sweep oscillator shall be sufficiently slow in relation to the amplitude analyzer response to obtain an accurate determination of the insertion loss. In particular, it shall be slow enough for cable assemblies in which there are:

   1) resonances, which can be very sharp, associated with structural return loss in the cable assembly;

   2) multiple reflections between the ends of the cable assembly or the test ports,

f) In digitally stepped frequency systems, the steps shall be sufficiently fine for an accurate determination of the insertion loss. In particular they shall be fine enough for the cases described in item e).

g) The insertion loss of the cable assembly shall permit resolution of the reflections from the cable assembly and its terminations.

h) In open-circuit tests, radiation from the connector centre contacts shall not compromise accuracy. If necessary, precision open-circuit terminations (i.e. shielded or closed-end open-circuit terminations) shall be used.

i) See A.2.1 regarding the use of adapters.

A.3 Correction for characteristic impedance differences

When the characteristic impedance of the test equipment and the cable assembly differ, test methods 1 and 2 may be used with the following correction formula:

$$A = A' - \left[20 \cdot \log \frac{\left(Z_g + Z_0\right)}{\left(2 \cdot \sqrt{Z_g \cdot Z_0}\right)}\right] - \left[20 \cdot \log \frac{\left(Z_1 + Z_0\right)}{\left(2 \cdot \sqrt{Z_g \cdot Z_1}\right)}\right] - \left[20 \cdot \log \left[1 - \left(\frac{Z_g - Z_0}{Z_g + Z_0} \cdot \frac{Z_1 - Z_0}{Z_1 + Z_0} \cdot e^{-2(\alpha+\beta)L}\right)\right]\right] \quad \text{(A.1)}$$

where

A is the true insertion loss of the cable assembly under test (dB);

A' is the measured insertion loss of the cable assembly (dB);

Z_g is the nominal output impedance of the generator's isolator/attenuator (test method 1) or the coupler or bridge (test method 2) (Ω);

Z_0 is the nominal characteristic impedance of the cable assembly (Ω);

Z_1 is the nominal input impedance of the calibrated attenuator (test method 1) or the detector or coupler/bridge (test method 2) (Ω);

α is the attenuation constant of the cable assembly (neper/m);

β is the phase constant of the cable assembly (radian/m);

L is the physical length of the cable assembly (m).

When the attenuation against frequency shows a consistent ripple resulting from the multiple reflections between the two test ports, β may be obtained from:

$$\beta = \frac{\pi \cdot f}{\Delta f \cdot L} \quad \text{(A.2)}$$

where

Δf is the frequency difference between either two successive maxima or two successive minima in the attenuation ripple at approximately frequency f.

Further to this, α is approximately equal to α' which is obtained from:

$$\alpha = A'/8{,}686L \text{ neper/m} \quad \text{(A.3)}$$

However, for greater accuracy, this formula may be used iteratively by substituting α for α' in the above equation.

Annex B
(informative)

Measuring methods for propagation time

B.1 ~~Introduction~~ General

Methods for both long and short cable assemblies are needed. For long cable assemblies a method based on resonance of forward and backward waves is recommended. This resonance method is described in Clause B.2. For short cable assemblies the time domain method described in Clause B.3 is recommended.

B.2 Resonance method for propagation time measurement

The frequencies f_i of the voltage minima at the near end of a short-circuited cable assembly and/or the frequencies f_j of the voltage maxima of an open-circuited cable assembly are measured. The frequency of the first maximum or minimum is designated as f_1, the second as f_2, etc.

A suitable equipment arrangement is given in Figure B.1.

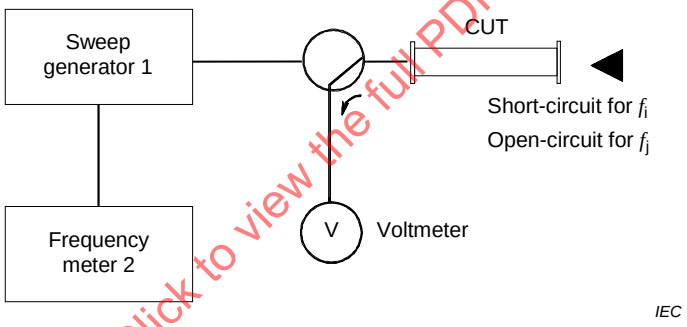


Figure B.1 – Arrangement of test equipment

The propagation time $T_{p,n}$ at frequency f_i or f_j is given by the formula:

$$T_{p,n} = \frac{n}{f_n}$$

where $n = i$ or j.

~~NOTE~~ The electrical length of the coupling device and the adapter should be taken into account.

The accuracy can be improved by taking the mean values:

$$f_n = \frac{f_i + f_j}{2}$$

$$T_{pn} = \frac{T_{pi} + T_{pj}}{2}$$

where $n = i = j$.

For best accuracy, the cable shall be terminated with a short-circuited or open-circuited connector of the same electrical length.

At other than the above resonance frequencies, the following formula may be used. The coefficients are determined from measurement at several resonance frequencies f_n.

$$T_p = B_o + B_{1f}\,^{-½} + B_{2f}\,^{-¼} + \ldots.$$

B.3 Time domain method for propagation time measurement

For a short or very short cable assembly the propagation time can be determined by the time delay of an echo through the cable.

A time domain reflectometer (TDR) or a pulse echo test set can be used. The rise time of the system and the width of the pulse should be in accordance with the resolution needed.

The measured echo delay time should be divided by a factor of 2 to obtain the propagation time of the cable assembly. Allowance should be made for the electrical length of the short-circuit or open-circuit.

Annex C
(informative)

Measurement method for screening effectiveness

C.1 Introduction

The screening effectiveness of a coaxial cable assembly is determined by the screening properties of its cable, its connectors and the joints between them. The transfer impedance may be measured by the line injection method depicted in figure C.1.

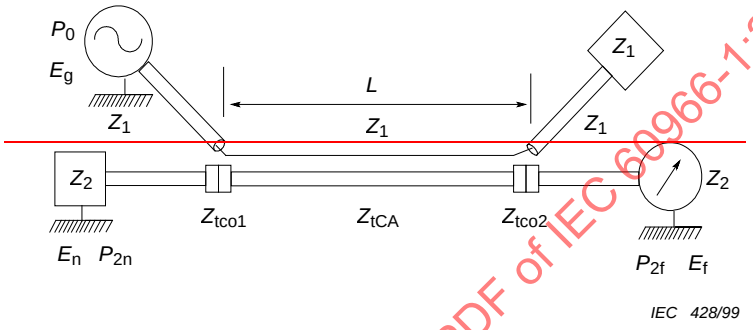


Figure C.1 – Line injection test circuit for coaxial cable assemblies

$$T_n = \sqrt{\frac{P_{2n}}{P_0}} \qquad T_j = \sqrt{\frac{P_{2j}}{P_0}}$$

In these formulae, P_0 is the power input to the cable assembly; P_{2n} and P_{2f} are the measured powers from the near and far ends of the cable assembly, respectively.

When $Z_f = 0$, the measured coupling transfer functions are:

$$T_j = \left[\left(\frac{Z_{tCA}}{2 \times Z_{12}} \times S_j(f)\right) + \left(\frac{Z_{tco1} + Z_{tco2}}{2 \times Z_{12}}\right)\right]$$

where $Z_{12} = \sqrt{Z_1 \times Z_2}$

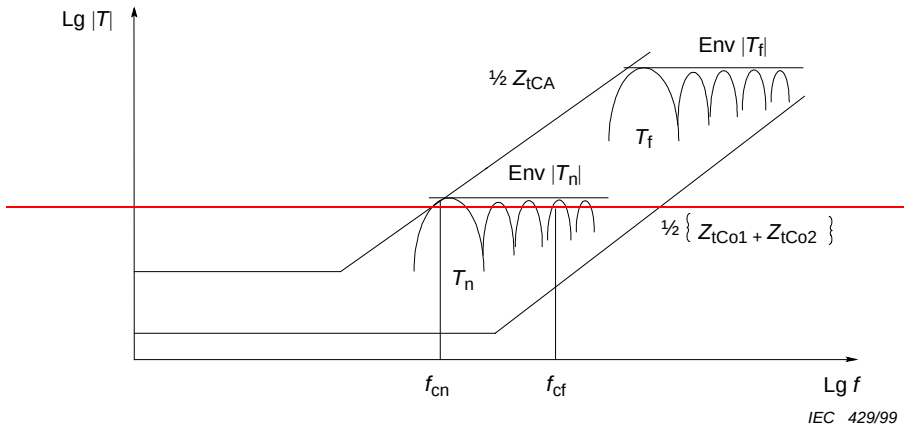


Figure C.2 – Schematic transfer functions of a coaxial cable assembly

In figure C.2, the cable is electrically long above frequency f_{cn}. The connectors are considered electrically short over the whole frequency range and the sum of their transfer impedances is assumed to be smaller than that of the cable. The transfer impedances of the joints are included in the transfer impedances of the connectors.

In spite of the fact that the cable is electrically long at higher frequencies, the transfer impedances can be added together without taking into account the phase shift of the cable.

In practice, the magnitude of the transfer impedances of the connectors and cable create difficulties in both describing and measuring the screening effectiveness of the complete cable assembly if:

a) the transfer impedances of the connectors dominate, the transfer function and transfer impedance of a cable assembly will normally increase linearly with the frequency; or

b) the transfer impedance of the cable dominates, the linearly increasing transfer function has a cut off frequency f_c above which resonances occur. The cut off frequencies for the near and far end transfer functions are different as shown in figure C.2.

When the transfer impedance of the cable dominates, the envelopes (Env) of the transfer functions are:

$$\mathrm{Env}\left(\left|T_j\right|\right) \approx \frac{\left|Z_f + Z_t\right|}{2 \times Z_{12} \times \left(1 + \frac{1}{f_{cf}^{n}}\right)}$$

where

$$f_{cf}^{n} = \frac{C}{\left|\sqrt{\varepsilon_{r2}} \pm \sqrt{\varepsilon_{r1}}\right| \times \pi L} = \frac{\nu\pm}{\pi \times L} \quad \text{and} \quad \nu\pm = \frac{C}{\left|\frac{1}{\nu_{r2}} \pm \frac{1}{\nu_{r1}}\right|}$$

It should be noted that both the effective transfer impedance and the screening attenuation include the effect of the cable length.

In the formulae above, it is assumed that the transfer impedance of the cable is always dominant.

C.2 Test method

The line injection method, which is satisfactory for coaxial cables, can also be used for measuring the screening effectiveness of a coaxial cable assembly. The full circuit for a coaxial cable assembly is given in figure C.3.

For measurements at frequencies above 100 MHz, the injection circuit needs to fulfil three well-defined conditions:

– constant characteristic impedance over the length of the test section;

– characteristic impedance matched to test instruments; and

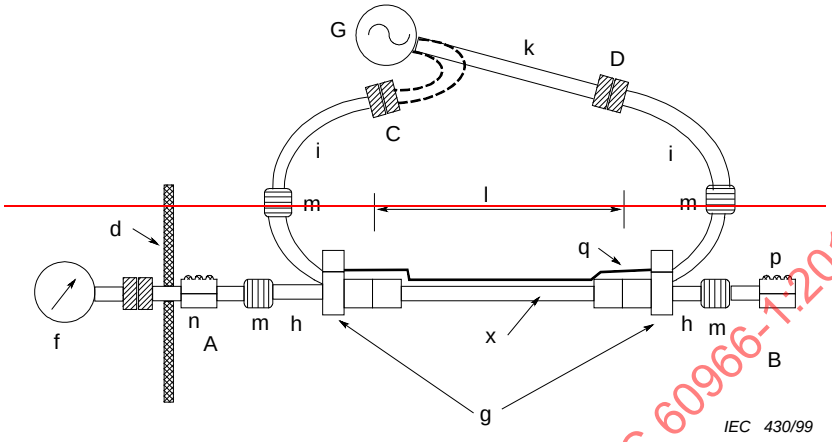
– low or measurable insertion loss.

For the construction of the injection line, one or several parallel wires may be used with both ends of all wires connected to the central conductors of the coaxial feeder cables.

The characteristic impedance of the injection line shall be equal to that of the feeder cables, the generator and the load.

~~With the arrangement described, the generator and matched load on the injection circuit may be exchanged to perform either near or far end measurements, i.e. no manipulation of the cable assembly under test is required.~~

~~The full details related to this test method are given in clause 12 of IEC 61196-1.~~



~~A – is the cable assembly test circuit far end relative to input at D (alternatively, near end relative to input at C)~~

~~B – is the cable assembly test circuit near end relative to input at D (alternatively, far end relative to input at C)~~

~~C – is the injection circuit far end (alternatively, near end)~~

~~D – is the injection circuit near end (alternatively, far end)~~

~~x – is the cable assembly under test~~

~~d – is the screened room wall with well-screened coaxial feed-through~~

~~G – is the generator (synthesizer, tracking generator, etc.)~~

~~f – is the test receiver (spectrum analyzer, network analyzer, etc.)~~

~~g – is the connection to injection wires~~

~~h – is a brass tube for additional screening of the cables fitted to the cable assembly under test~~

~~i – are injection wire feeder cables (length approximately 0,5 m each, low loss)~~

~~k – is the feeder cable from generator~~

~~l – is the length of cable assembly~~

~~m – are ferrite rings (length of each block approximately 100 mm)~~

~~n – is additional screening for the connection between screened room and cable assembly under test~~

~~p – is additional screening for terminating resistance of cable assembly under test~~

~~q – is the injection line~~

~~Figure C.3 – Complete installation for practical screening effectiveness measurements~~

Annex C
(informative)

Recommended severities for environmental tests

C.1 Introduction to the relationship between environmental conditions and severities of testing

C.1.1 General

The purpose of environmental engineering is to render the product and the environment compatible. It should take all economic and technical aspects into consideration and thereby choose the best test methods and correct severities for the evaluation of the product's ability to withstand the environment. A test program for the product is defined whereby the test sequence together with the test methods and limits are specified.

C.1.2 Environmental conditions

The environmental conditions shall be evaluated by measurements or by other information available so that statistically accurate characteristic values can be established corresponding to the highest possible constraints. Each situation has an environment of its own, but it is not reasonable to prescribe individual products having slightly different withstand properties for each individual situation. It is necessary to combine these environments into a class forming an envelope of related environments. It is only necessary to take into account those parameters that influence the performance of the product. The environment shall cover all the conditions that occur during the life of the product, i.e. storage, transportation, use and handling.

C.1.3 Environmental testing

The purpose of an environmental test is to demonstrate that a product under defined environmental conditions can survive without permanent failure and continue to function according to specification. The severity of the test to be selected will depend on the characteristic values obtained for the parameters, the failure mechanism, the ageing factor if known, and the consequences of failure. The latter will have been studied by the utilization of the particular product and depends on its application. This means that the severity of the test can be raised or lowered according to the criticality of the product. If the sampling of the product suggests wide variations in its ability to withstand the specified environment, the level of testing should be increased. If the distributions of environmental constraints and the resistance to the environment of a lot tested are suspected to partially overlap, the test levels can be raised to clarify this weakness.

The performance requirements should also be considered. Normal performance is usually specified for all primary functions but, for secondary functions, requirements may be relaxed during extreme conditions to avoid unnecessary over-specification.

An environmental test may be performed for many purposes. In this generic specification, the environmental tests are one part of the qualification approval tests. In this case, a test of resistance to the environment demonstrates the ability of the product to function under constraints or withstand stated constraints. There are, however, inherent limitations due to the fact that the tests are usually carried out on a few samples.

The results give protection to a particular design, but not to an individual product. The successful test will ensure that the product, as a type, is capable of withstanding the expected environments. Different kinds of tests and severity levels are necessary for product reliability and endurance.

An outline of the action needed for the preparation of an environmental test specification is given in Figure C.1.

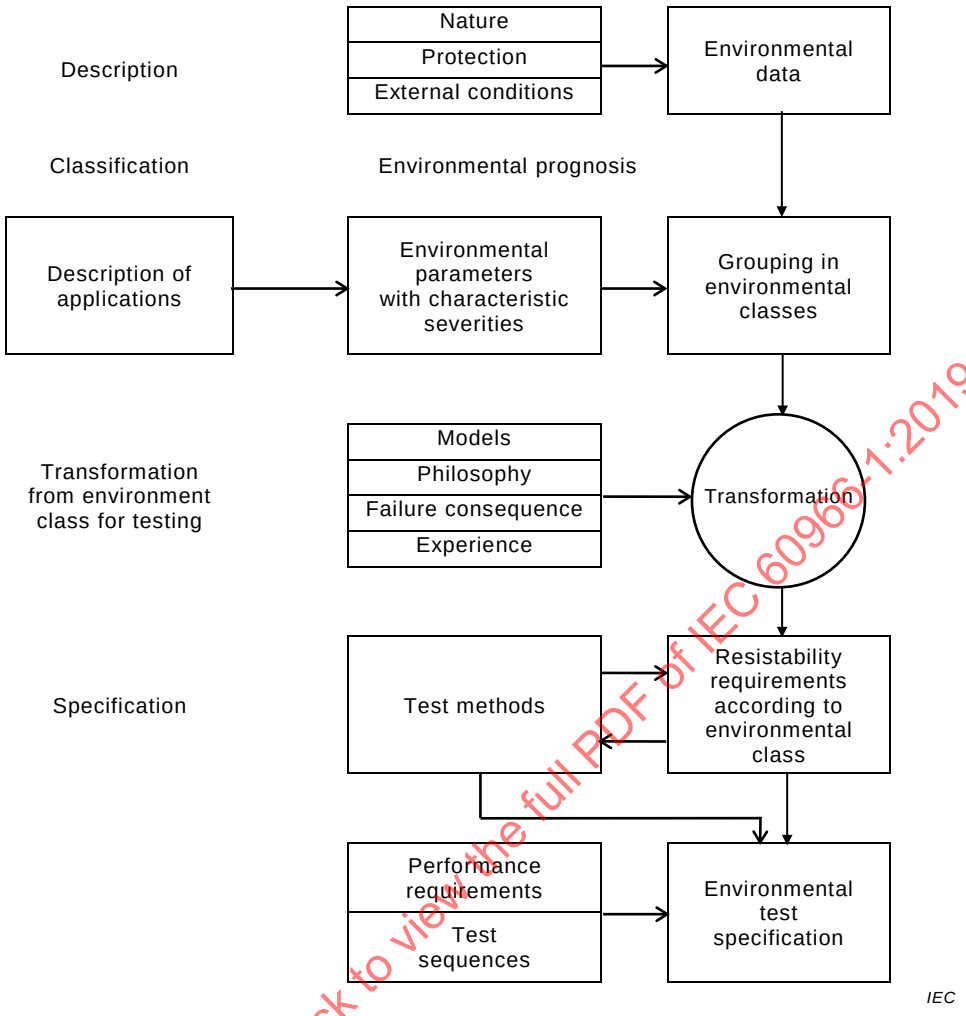


Figure C.1 – Description of action needed for the preparation of the environmental test specification

C.2 Recommended severities for environmental tests

C.2.1 Vibration

This test shall be carried out in accordance with test Fc of IEC 60068-2-6, as specified in 9.3.3 of IEC 61169-1:2013, which includes details on continuity monitoring and on the information which should be given in the relevant sectional and detail specifications.

The vibration severity shall be defined by a combination of three parameters: range of frequency, vibration amplitude and duration in terms of the number of cycles. The relevant specification shall select the appropriate requirement for each parameter from the following recommended values:

Swept frequency range: 10 Hz to 150 Hz

10 Hz to 500 Hz

10 Hz to 2 000 Hz

Vibration amplitude: . . . . . .

Vibration amplitude shall be specified below 57 Hz to 62 Hz and at frequencies higher than acceleration amplitude, see Table C.1.

Table C.1 – Relationship between displacement and acceleration

Displacement amplitude	Acceleration amplitude	
mm	m/s^2	g
0,75	98	10
1,0	147	15
1,5	196	20

Duration: . . . . . .

Number of swept cycles in each axis: 2, 5, 10 or 20.

C.2.2 Bump

This test shall be carried out in accordance with test ~~Eb of IEC 60068-2-29~~ 6b of IEC 60512-6-2. Unless otherwise required in the sectional or relevant detail specification, one of the following recommended severities shall be selected:

Number of bumps: 1 000 ± 10

C.2.3 Shock

This test shall be carried out in accordance with test Ea of IEC 60068-2-27.

Unless otherwise required in the sectional or relevant detail specification, one of the recommended pulse shapes given in the table below shall be selected. The shock severity is given by a combination of the peak acceleration and the duration of the nominal pulse, see Table C.2.

Table C.2 – Relationship between peak acceleration and velocity change

			Corresponding velocity change		
Peak acceleration		Corresponding duration of pulse	Final peak saw tooth	Half sine	Trapezoidal
m/s^2	g	ms	m/s	m/s	m/s
147	15	11	0,81	1,03	1,46
294	30	18	2,65	3,37	4,77
490	50	11	2,69	3,43	4,86
981	100	6	2,94	3,74	5,30
4 900	500	1	2,45	3,12	4,42
14 700	1 500	0,5	3,68	4,68	6,62

C.2.4 Climatic sequence

Unless otherwise required in the sectional or relevant detail specification, one of the following recommended severities shall be selected:

Low temperature: –40 °C to –55 °C

High temperature: +70 °C, +85 °C, +125 °C, +155 °C, +200 °C

Duration: 4, 10, 21 or 56 days

C.2.5 Damp heat, steady state

This test shall be carried out in accordance with test Cab of ~~IEC 60068-2-3~~ IEC 60068-2-78.

Unless otherwise required in the sectional or relevant detail specification, one of the following recommended severities shall be selected:

Duration: 4, 10, 21 or 56 days

C.2.6 Rapid change of temperature

This test shall be carried out in accordance with test ~~Nc~~ Na of IEC 60068-2-14. The range of temperatures shall be selected in accordance with the test of climatic sequence.

~~Velocity of change: 1 °C ± 0,2 °C/min~~

Transfer time between temperature: <2 minutes

Number of cycles: 2, unless otherwise specified

C.2.7 Salt mist

This test shall be carried out in accordance with test Ka of IEC 60068-2-11. The duration of the test shall be either 96 h or 168 h.

C.2.8 Sulphur dioxide test

This test shall be carried out in accordance with test Kc of IEC 60068-2-42. The duration of the test shall be of four days.

C.2.9 Dust test

Under consideration, taking into account IEC 60068-2-68, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*.

Annex D
(normative)

Quality ~~assessment~~ management

D.1 ~~Introduction~~ General

The purpose is to give general procedures on how to achieve a quality ~~assessment~~ management for RF cable assemblies.

~~According to 3.1 of IEC 60096-1~~ An RF cable assembly is a combination of a cable and connectors with specified performance, used as a single unit.

The cables should be preferably chosen from IEC 61196 (all parts) and the connectors from IEC 61169 sectional and detail specifications, (see Clause 1, Note 1), in many cases they will be customer-built products.

Quality assurance for connectors and cables is described in IEC 61169 sectional and detail specifications and IEC 61196 (all parts) respectively and does not form part of this document.

D.2 Object

This ~~part of the generic specification for radio frequency coaxial cable assemblies~~ Annex D specifies qualification approval and capability approval procedures.

D.3 ~~General~~ Basic aspects

D.3.1 Related documents

See Clause 2.

D.3.2 Standards and preferred values

Whenever possible, standards and preferred values according to this generic specification and the relevant sectional specification shall be used.

D.3.3 Marking of the cable assembly and packaging (see 5.2)

Unless otherwise specified in the detail specification (DS) or customer detail specification (CDS), each cable assembly shall be marked with as many of the following items, as space permits, given in the order of preference:

- type number;
- lot identification and/or date code and/or serial number;
- factory identification code;
- detail specification number.

All this information shall be marked on the primary package of the cable assemblies; all markings shall be legible and indelible.

D.3.4 Terminology

D.3.4.1 Capability manual (CM)

The capability manual (CM) of a manufacturer is a complete description of design rules, manufacturer processes and test procedures including the limits and the verification procedures. The capability manual is the basic document for granting a capability approval.

D.3.4.2 Quality manual (QM)

The quality manual (QM) describes either directly or by reference to the manufacturer's internal documents, the procedures used by the manufacturer to ensure conformity of his products with the applicable specifications. It is needed for both qualification and capability approval.

D.3.4.3 Capability qualifying components (CQCs)

CQCs are test specimens specially designed or taken from production, used for verifying capability limits in accordance with the capability manual (CM).

D.3.4.4 Primary stage of manufacture

The primary stage of manufacture is the first activity under the control of the manufacturer, according to the capability manual.

D.4 Quality ~~assessment~~ management procedures

D.4.1 Procedures for qualification approval

D.4.1.1 ~~Introduction~~ General

Qualification approval is appropriate when the cable assemblies are made to standard patterns and usually in continuous production.

Qualification approval can only be achieved for existing detail specifications.

The relevant specifications state the requirements for the qualification approval of the cable assembly (test schedule, number of specimens, number of defectives permitted, etc.).

D.4.1.2 How to obtain qualification approval

To obtain qualification approval, the following steps shall be performed:

a) Approval of the manufacturer on the basis of his ability to produce and inspect components in conformance with the specifications and the agreed rules of procedure, limited to specified organisation and facilities, verified by audits on QM ~~by the NSI~~ for example according to ISO 9001 or ISO 9002.

NOTE A valid approval according to the relevant ISO 9000 is recognized.

b) Successful completion of qualification tests usually made on production items according to the relevant specification.

D.4.1.3 How to maintain qualification approval

To maintain a qualification approval, the manufacturer shall comply with the following conditions to the satisfaction of ~~the NSI~~ national or regional requirements:

a) The results of the periodic audits by the ~~NSI~~ national or regional authorized body at intervals no greater than one year on the quality manual shall be satisfactory.

b) The delivered products shall fulfill the quality assurance requirements.

c) An inspection of the current production is carried out in accordance with the specifications. The cable assemblies from lots which do not fulfill the specifications are not permitted to be delivered.

d) Successful completion of periodic tests according to the detail specification.

D.4.1.4 Modifications likely to affect qualification approval

~~These shall be in accordance with the requirements of rules of procedure in 11.4 of IEC QC 001002-3.~~

The manufacturer shall report to the ~~NSI~~ authorized regional or national body any technical modifications, including changes of place of manufacture, which could affect the results obtained where the qualification approval was delivered.

The ~~NSI~~ authorized regional or national body shall then decide whether it is necessary to repeat all or some of the qualification approval tests before any components subject to the modifications are delivered under the system.

The ~~NSI~~ authorized regional or national body shall, as a part of its surveillance, ensure that the reporting of modifications has taken place.

D.4.2 Procedures for capability approval

D.4.2.1 ~~Introduction~~ General

When the total volume of cable assemblies being manufactured for a particular customer order is less than the quantity of assemblies to be tested for a capability study based on the manufacturer's capability manual, then the capability study is not required to obtain capability approval.

As capability approval is process orientated, it is appropriate when the cable assembling technologies are fully controlled and the requirements of the customers with respect to design variants change to reflect final use.

Capability approval is valid for all existing and future detail specifications within the capability limits.

The capability manual states the requirements for the capability approval of all cable assemblies within the capability limits.

D.4.2.2 How to obtain a capability approval

To obtain a capability approval, the following steps shall be performed:

a) Approval of the manufacturer on the basis of his ability to produce and inspect components according to the specifications and the agreed rules of procedure, limited to specified organisation and facilities checked by audit on the QM ~~by the NSI~~ for example according to ISO 9001 or ISO 9002.

NOTE A valid approval according to the relevant ISO 9000 is recognized.

b) Approval of the manufacturer on the basis of his capability manual by the ~~NSI~~ authorized regional or national body.

c) Successful completion of qualification tests on CQCs specified by the chief inspector according to the CM and the relevant specifications.

D.4.2.3 How to maintain a capability approval

To maintain the capability approval, the manufacturer shall comply with the following conditions to the satisfaction of the ~~NSI~~ authorized regional or national body:

a) He shall give evidence that the capability limits stay valid by periodic testing of the CQCs according to the CM.

b) The results of the periodic audits on the QM led by the ~~NSI~~ authorized regional or national body at intervals no greater than one year shall be satisfactory.

c) The delivered products shall fulfill the quality assurance requirements.

d) The capability manual shall be continuously updated.

e) The register of the associated products shall be kept up to date.

D.4.2.4 Procedure for reduction, extension or change of capability

Where an approved manufacturer wishes to reduce, extend or change the domain of his capability, it is the responsibility of the chief inspector to decide whether the reduction, extension or change is significant or not.

Where the reduction, extension or change is not significant, it shall be recorded by the manufacturer who may proceed without the approval of the ~~NSI~~ authorized regional or national body.

Where the reduction, extension or change is significant, the manufacturer shall notify the ~~NSI~~ authorized regional or national body in advance.

The results of the tests carried out to demonstrate the effect of the change on the products shall be made available to the ~~NSI~~ authorized regional or national body.

D.4.3 Quality conformance inspection

D.4.3.1 General

After qualification approval or capability approval has been obtained, the manufacturer is responsible for ensuring that no technical changes likely to affect the approval are introduced for the products without re-approval, and that the quality conformance inspection required by the specifications is carried out with success.

The quality conformance inspection is divided into two parts:

a) A first group of tests that is carried out lot by lot and serves to accept the individual production lots that it is based on.

b) A second group of tests, containing the time consuming and more expensive tests, that are carried out on a periodic basis.

Under qualification approval, the full test programme is given in the detail specification.

Under capability approval, periodic tests shall be performed on CQCs as prescribed in the CM.

D.4.3.2 Formation of inspection lots

An inspection lot may be formed by the aggregation of several production lots, provided that:

a) The production lots are manufactured under essentially the same conditions, without significant interruption.

b) All the production lots are assembled with the same piece parts.

D.4.3.3 Lot-by-lot tests

Lot-by-lot tests are carried out on each inspection lot.

Generally, lot-by-lot tests cover the visual and dimensional inspections and the principal characteristics of the cable assemblies.

D.4.3.4 Periodic tests

Periodic tests are carried out at fixed intervals on samples taken from lots which have already satisfied the lot-by-lot tests or on CQCs in case of capability approval. The periodicity and the number of samples are given in DS.

Generally, the periodic tests cover structural characteristics. They are time consuming and rather expensive.

D.4.3.5 Release or rejection of lots

~~This shall be in accordance with the requirements in 12.5 of IEC QC 001002-3.~~

Unless otherwise stated in the relevant specification, the lots shall be released or rejected on the basis of the lot-by-lot tests. Normally the failure of the sample submitted to one of the periodic tests shall entail the rejection of the lot from which the sample came.

~~**E.3.3.5 Procedure in the event of failure in a periodic test**~~

~~This shall be in accordance with the requirements in 12.6 of IEC QC 001002-3.~~

D.5 Capability manual and approval

D.5.1 Responsibilities

It is the responsibility of the chief inspector to access the capability manual as well as to select and define CQCs.

To assure that the manufacturer's organization, processes and products are correctly documented in his quality and capability manuals and effectively implemented in accordance with the requirements, an audit shall be performed under the responsibility of the NSI.

The NSI shall verify the following items:

- capability manual;
- quality ~~assessment~~ management;
- organization;
- design control;
- manufacturing inspections;
- control of equipment used for inspection, measuring and testing;
- control of non-conforming parts, material, products;
- handling, storage and delivery;
- change control;
- traceability.

D.5.2 Contents of the capability manual

D.5.2.1 Object

This section of the capability manual shall give the range of specifications covered by the capability approval.

D.5.2.2 List of revisions

The validation of an updated capability manual is part of the audit procedure.

Revisions shall be identified by an index and the date. When a revision takes place, a complete list of all changes shall be made which occurred during the preceding period.

D.5.2.3 Related documents

The capability manual shall make reference to all mentioned relevant documents.

D.5.2.4 Capability domain, capability limits and their related CQCs

(see Tables D.1, D.2 and D.3.)

This section shall give the identification of the domain in terms of:

a) connectors;
b) cables;
c) main assembly techniques;
d) other piece parts (sleeves, caps, armours, etc.);
e) test facilities.

This section shall also give a reference list of the capability limits and the CQCs chosen to assess these limits from the primary stage of manufacture to the final product.

D.5.2.5 Flow chart, including process parameters (see Table D.4)

This section shall include:

a) General flow chart(s) giving the full sequence of manufacturing and inspection processes, from the primary stage of manufacture to the delivery and the corresponding CQCs.
b) Working instructions and inspection procedures for all processes contained in the flow chart, generally by reference to in-house documentation.
c) Flow charts for CQCs.

D.5.2.6 Purchased raw materials and piece parts

This section shall identify purchasing specifications for the raw materials and piece parts used in the manufacturing processes.

D.5.2.7 Design rules

Unless covered by quality manual, the manufacturer's design rules shall be stated either directly or by reference to the manufacturer's internal documents.

D.5.2.8 Register of associated products

This section shall give the list of products which are, or can be, delivered under capability approval generally by reference to an annex.

D.5.3 Criteria for capability limits

The sectional specifications shall preferably give guidance for capability limits, technology, processes, performances and their related CQCs. The CM may include one or several sub-families from one or several sectional specifications.

Table D.1 – Example of capability limits for cable assemblies

Technology	Capability domain	Capability limits
Cable	Flexible (subfamily) Semi-rigid (subfamily) Semi-flexible (subfamily) Super-screened (subfamily)	Purchased according to IEC 61196-XX or other standards or manufactured according to processes described in the CM ~~(see table E.2)~~
Connectors	Series SMA, N, BNC, F, etc. Customer-built	Purchased according to IEC 61169-YY, IEC 60339 or other standards, or manufactured according to processes described in the CM ~~(see table E.3)~~
Other piece parts	Sleeves, armour, etc.	
Assembly techniques	Crimping Soldering, etc.	
Mechanical Electrical Environmental	Test group Mn Eb and/or Eh Vc and/or Vv	

Table D.2 – Example of capability limits for flexible cables

Inner conductor	Solid wire (range of diameters) Stranded wire Plated wire
Insulation	Extrusion (function of the material) Tape lapping Sintering
Outer conductor	Braid Foil plus braid Tape lapping
Jacket	Braid Extrusion (materials)

Table D.3 – Example of capability limits for connectors

Slicing
Molding
CNC machining
Electroforming
Electroerosion
Embossing
Plating, etc.

In this case, Tables D.2 and D.3 have been combined with Table D.1 concerning environmental, mechanical and electrical requirements.

Table D.4 – Example of flow chart (see D.5.2.5)

Operations	Limits	CQC	Specifications
Cable manufacture	Purchased according to IEC 61196-XX	NA	Purchasing specification Incoming inspection
Connector manufacture	Purchased according to IEC 61169-YY	NA	Purchasing specification Incoming inspection
Cable preparation	Accuracy 2 mm	CQC n° 001	Procedure n° 1001
Connector crimping	For outer cable diameter 5 mm to 15 mm	CQC n° 002	Procedure n° 1002
Connector soldering	For inner cable diameter of 0,5 mm to 4 mm	CQC n° 003	Procedure n° 1003
Tests Eh, Ez, Mn, Vt	12,5 GHz; –40/125 °C	CQC n° 004	Procedure n° 1004
Packaging			Procedure n° 1005

Bibliography

IEC 60339 (all parts), *General purpose rigid coaxial transmission lines and their associated flange connectors*

IEC 61196-1-324, *Coaxial communication cables – Part 1-324: Mechanical test methods – Test for abrasion resistance of cable*

ISO/IEC TR 29106, *Information technology – Generic cabling – Introduction to the MICE environmental classification*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

ISO 9001:2015, *Quality management systems – Requirements*

ISO 9002, *Quality management systems – Guidelines for the application of ISO 9001:2015*

IEC 60966-1

Edition 3.0 2019-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Radio frequency and coaxial cable assemblies – Part 1: Generic specification – General requirements and test methods

Cordons coaxiaux et cordons pour fréquences radioélectriques – Partie 1: Spécification générique – Exigences générales et méthodes d'essai

IEC 60966-1:2019-02(en-fr)

CONTENTS

FOREWORD 7
1 Scope 9
2 Normative references 9
3 Terms and definitions 10
4 Design and manufacturing requirements 12
4.1 Cable design and construction 12
4.2 Connector design and construction 12
4.3 Outline and interface dimensions 13
5 Workmanship, marking and packaging 13
5.1 Workmanship 13
5.2 Marking 13
5.3 End caps 13
5.4 Packaging and labelling 13
6 Quality management 13
7 Test methods – General 13
7.1 Standard atmospheric conditions for testing 13
7.2 Visual inspection 14
7.3 Dimensions inspection 14
7.3.1 Interface dimensions 14
7.3.2 Outline dimensions 14
8 Electrical tests 15
8.1 Reflection properties 15
8.1.1 Object 15
8.1.2 Test equipment 15
8.1.3 Procedure 15
8.1.4 Requirements 16
8.1.5 Information to be given in the detail specification 16
8.2 Uniformity of impedance 16
8.2.1 Object 16
8.2.2 Procedure 16
8.2.3 Requirements 16
8.2.4 Information to be given in the detail specification 16
8.3 Insertion loss 16
8.3.1 Procedure 16
8.3.2 Requirements 16
8.3.3 Information to be given in the detail specification 16
8.4 Insertion loss stability 17
8.4.1 Object 17
8.4.2 Procedure 17
8.4.3 Requirements 17
8.4.4 Information to be given in the detail specification 17
8.5 Propagation time 17
8.5.1 Procedure 17
8.5.2 Requirements 17
8.5.3 Information to be given in the detail specification 17

8.6 Stability of electrical length 17
8.6.1 Object 17
8.6.2 Procedures 17
8.6.3 Requirements 19
8.6.4 Information to be given in the detail specification 19
8.7 Phase difference 19
8.7.1 Object 19
8.7.2 Procedure 19
8.7.3 Requirements 19
8.7.4 Information to be given in the detail specification 20
8.8 Phase variation with temperature 20
8.8.1 Object 20
8.8.2 Procedure 20
8.8.3 Requirements 20
8.8.4 Information to be given in the detail specification 20
8.9 Screening effectiveness 20
8.9.1 Transfer impedance 20
8.9.2 Screening attenuation 20
8.10 Voltage proof 21
8.10.1 Procedure 21
8.10.2 Requirements 21
8.10.3 Information to be given in the detail specification 21
8.11 Insulation resistance 21
8.11.1 Procedure 21
8.11.2 Requirements 21
8.11.3 Information to be given in the detail specification 21
8.12 Inner and outer conductor continuity 22
8.12.1 Object 22
8.12.2 Procedure 22
8.12.3 Requirements 22
8.12.4 Information to be given in the detail specification 22
8.13 Power rating 22
8.13.1 Object 22
8.13.2 Procedure 22
8.13.3 Requirements 22
8.13.4 Information to be given in the detail specification 22
8.14 Intermodulation level measurement 23
8.14.1 Procedure 23
8.14.2 Requirements 23
8.14.3 Information to be given in the detail specification 23
9 Mechanical robustness tests 23
9.1 Tensile 23
9.1.1 Object 23
9.1.2 Procedure 23
9.1.3 Requirements 23
9.1.4 Information to be given in the detail specification 23
9.2 Flexure 24
9.2.1 Object 24
9.2.2 Procedure 24

9.2.3 Requirements 24
9.2.4 Information to be given in the detail specification 24
9.3 Flexing endurance 24
9.3.1 Object 24
9.3.2 Procedure 25
9.3.3 Requirements 25
9.3.4 Information to be given in the detail specification 25
9.4 Cable assembly crushing 25
9.4.1 Object 25
9.4.2 Procedure 25
9.4.3 Requirements 26
9.4.4 Information to be given in the detail specification 26
9.5 Torque 26
9.5.1 Procedure 26
9.5.2 Requirements 27
9.5.3 Information to be given in the detail specification 27
9.6 Multiple bending 27
9.6.1 Object 27
9.6.2 Procedure 27
9.6.3 Requirements 28
9.6.4 Information to be given in the detail specification 28
9.7 Abrasion test of cable assembly 28
9.7.1 Object 28
9.7.2 Procedure 28
9.8 Vibrations, shocks 28
9.9 Impact test 28
9.10 Mechanical endurance 28
10 Environmental tests 29
10.1 Recommended severities 29
10.2 Vibration, bumps and shock 29
10.3 Climatic sequence 29
10.3.1 Procedure 29
10.3.2 Requirements 29
10.3.3 Information to be given in the detail specification 29
10.4 Damp heat, steady state 29
10.4.1 Procedure 29
10.4.2 Requirements 29
10.4.3 Information to be given in the detail specification 30
10.5 Rapid change of temperature 30
10.5.1 Procedure 30
10.5.2 Requirements 30
10.5.3 Information to be given in the detail specification 30
10.6 Resistance to solvents and contaminating fluids 30
10.6.1 Procedure 30
10.6.2 Requirements 30
10.6.3 Information to be given in the detail specification 31
10.7 Water immersion 31
10.7.1 Procedure 31
10.7.2 Requirements 31

10.7.3 Information to be given in the detail specification 31
10.8 Salt mist and sulphur dioxide tests 31
10.8.1 Procedure 31
10.8.2 Requirements 31
10.8.3 Information to be given in the detail specification 31
10.9 Dust tests 31
10.9.1 Object 31
10.9.2 Procedure 31
10.9.3 Requirements 32
10.9.4 Information to be given in the detail specification 32
10.10 Flammability 32
10.10.1 Procedure 32
10.10.2 Requirements 32
10.10.3 Information to be given in the detail specification 32
11 Specialized test methods 32
12 Test schedules 32
Annex A (normative) Test methods for insertion loss determination 33
A.1 Purpose 33
A.2 Test methods 33
A.2.1 General 33
A.2.2 Test method 1 33
A.2.3 Test method 2 34
A.2.4 Test method 3 36
A.3 Correction for characteristic impedance differences 37
Annex B (informative) Measuring methods for propagation time 39
B.1 General 39
B.2 Resonance method for propagation time measurement 39
B.3 Time domain method for propagation time measurement 40
Annex C (informative) Recommended severities for environmental tests 41
C.1 Introduction to the relationship between environmental conditions and severities of testing 41
C.1.1 General 41
C.1.2 Environmental conditions 41
C.1.3 Environmental testing 41
C.2 Recommended severities for environmental tests 42
C.2.1 Vibration 42
C.2.2 Bump 43
C.2.3 Shock 43
C.2.4 Climatic sequence 43
C.2.5 Damp heat, steady state 44
C.2.6 Rapid change of temperature 44
C.2.7 Salt mist 44
C.2.8 Sulphur dioxide test 44
C.2.9 Dust test 44
Annex D (normative) Quality management 45
D.1 General 45
D.2 Object 45
D.3 Basic aspects 45

D.3.1 Related documents 45
D.3.2 Standards and preferred values 45
D.3.3 Marking of the cable assembly and packaging (see 5.2) 45
D.3.4 Terminology 46
D.4 Quality management procedures 46
D.4.1 Procedures for qualification approval 46
D.4.2 Procedures for capability approval 47
D.4.3 Quality conformance inspection 48
D.5 Capability manual and approval 49
D.5.1 Responsibilities 49
D.5.2 Contents of the capability manual 49
D.5.3 Criteria for capability limits 50
Bibliography 53

Figure 1 – Bending test: U shape assembly 18
Figure 2 – Bending test: straight assembly 18
Figure 3 – Twisting test: U shape assembly 19
Figure 4 – Fixture for cable assembly flexure test 24
Figure 5 – Apparatus for cable assembly flexing endurance test 25
Figure 6 – Fixture for cable crushing test 26
Figure 7 – Example of test fixture for torque 27
Figure 8 – Multiple bending test 28
Figure A.1 – Circuit for the determination of insertion loss 33
Figure A.2 – Circuit for the determination of insertion loss – principle 35
Figure A.3 – Alternative circuit for the determination of insertion loss 35
Figure A.4 – Double-pass circuit for the determination of insertion loss 36
Figure B.1 – Arrangement of test equipment 39
Figure C.1 – Description of action needed for the preparation of the environmental test specification 42

Table 1 – Standard range of atmospheric conditions 14
Table C.1 – Relationship between displacement and acceleration 43
Table C.2 – Relationship between peak acceleration and velocity change 43
Table D.1 – Example of capability limits for cable assemblies 51
Table D.2 – Example of capability limits for flexible cables 51
Table D.3 – Example of capability limits for connectors 51
Table D.4 – Example of flow chart (see D.5.2.5) 52

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RADIO FREQUENCY AND COAXIAL CABLE ASSEMBLIES –

Part 1: Generic specification – General requirements and test methods

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60966-1 has been prepared by technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

This third edition cancels and replaces the second edition published in 1999. This edition constitutes a technical revision.

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

a) Annex C (informative) Measurement method for screening effectiveness was cancelled;
b) Subclause 8.9 gives references to relevant test procedures.

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

FDIS	Report on voting
46/700A/FDIS	46/704/RVD

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

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

A list of all parts in the IEC 60966 series, published under the general title *Radio frequency and coaxial cable assemblies*, can be found on the IEC website.

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

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

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.

RADIO FREQUENCY AND COAXIAL CABLE ASSEMBLIES –

Part 1: Generic specification – General requirements and test methods

1 Scope

This part of IEC 60966 specifies requirements for radio frequency coaxial cable assemblies operating in the transverse electromagnetic mode (TEM) and establishes general requirements for testing the electrical, mechanical and environmental properties of radio frequency coaxial cable assemblies composed of cables and connectors. Additional requirements relating to specific families of cable assemblies are given in the relevant sectional specifications.

The design of the cables and connectors used will preferably conform to the applicable parts of IEC 61196 and IEC 61169 respectively.

NOTE 1 This document does not include tests which are normally performed on the cables and connectors separately. These tests are described in IEC 61196-1 (all parts) and IEC 61169-1 respectively.

NOTE 2 Wherever possible, cables and connectors used in cable assemblies, even if they are not described in the IEC 61196 or IEC 61169 series, are tested separately according to the tests given in the relevant generic specification.

NOTE 3 Where additional protection is applied to a cable assembly, the mechanical and environmental tests described in this document are applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068 (all parts), *Environmental testing*

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

IEC 60068-2-11, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-42, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60068-2-68, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*

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

IEC 60332-1-2:2004, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed* flame

IEC 60512-6-2, *Connectors for electronic equipment –Tests and measurements – Part 6-2: Dynamic stress tests – Test 6b: Bump*

IEC 60512-7-2, *Connectors for electronic equipment – Tests and measurements – Part 7-2: Impact tests (free components) – Test 7b: Mechanical strength impact*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60966-2 (all parts), *Radio frequency and coaxial cable assemblies*

IEC 60966-3 (all parts), *Radio frequency and coaxial cable assemblies*

IEC 60966-4 (all parts), *Radio frequency and coaxial cable assemblies*

IEC 61169 (all parts), *Radio-frequency connectors*

IEC 61169-1:2013, *Radio-frequency connectors – Part 1: Generic specification – General requirements and measuring methods*

IEC 61196 (all parts), *Coaxial communication cables*

IEC 61196-1-119, *Coaxial communication cables – Part 1-119: Electrical test methods – RF power rating*

IEC 62037-2, *Passive RF and microwave devices, intermodulation level measurement – Part 2: Measurement of passive intermodulation in coaxial cable assemblies*

IEC 62153-4-6, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method*

IEC 62153-4-7:2015, *Metallic communication cable test methods – Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring of transfer impedance Z_T and screening attenuation a_s or coupling attenuation a_C of connectors and assemblies up to and above 3 GHz – Triaxial tube in tube method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
cable assembly
combination of cable(s) and connector(s) with or without any additional protection and with specified performance, used as a single unit

3.2
flexible cable assembly
cable assembly where the cable is capable of repeated flexure

Note 1 to entry: The cable usually has a braid outer conductor.

3.3
semi-flexible cable assembly
cable assembly not intended for applications requiring repeated flexure of the cable in service, but bending or forming is permissible to facilitate installation

3.4
semi-rigid cable assembly
cable assembly not intended to be bent or flexed after manufacture

Note 1 to entry: Any bending or flexing during installation or use may degrade the performance of the cable assembly.

3.5
insertion loss
loss introduced by inserting a cable assembly into a system

Note 1 to entry: In this standard, it is the ratio, expressed in decibels, of the power (P_1) delivered to a load connected directly to a source and the power (P_2) delivered to a load when the cable assembly is inserted between the source and the load.

$$Insertion\ loss = 10 \times \log\left(\frac{P_1}{P_2}\right)$$

3.6
reflection factor
ratio of the complex wave amplitude of the reflected wave to the complex wave amplitude of the incident wave at a port or transverse cross-section of a transmission line

3.7
electrical length
equivalent free-space length of the cable assembly

3.8
electrical length difference
difference in electrical length between cable assemblies

3.9
phase difference
difference in phase between a transverse electromagnetic mode (TEM) wave which has traversed the cable assembly and an identical wave which has traversed another cable assembly

3.10
propagation time
time taken for the propagation of a TEM wave between the reference planes of the two connectors

3.11
minimum static bending radius
radius used in climatic tests

Note 1 to entry: It is the minimum permissible radius for fixed installation of the cable.

3.12
dynamic bending radius
radius used for the insertion loss stability, stability of electrical length and flexing endurance tests

Note 1 to entry: It is the minimum bending radius for applications where the cable assembly is flexed. Larger bending radii will allow the increase of the maximum number of flexures.

3.13
transfer impedance
quotient of the induced voltage on the inside of the cable assembly and the inducing current outside the assembly

Note 1 to entry: In practice, this is between defined points on connectors mated to the connectors of the cable assembly

3.14
screening attenuation
ratio of the signal power inside the cable assembly to the total power that radiates outside the cable assembly

3.15
power rating
input power which may be handled continuously by the cable assembly when terminated by its characteristic impedance

Note 1 to entry: For practical application, the maximum power that may be handled is dependent upon the return loss.

Note 2 to entry: Power rating is dependent on mounting details, ambient temperature, air pressure and circulation. It is normally specified at an ambient temperature of 40 °C.

3.16
artificial ageing
process used to improve the stability of phase attenuation and expansion with temperature

Note 1 to entry: This process normally consists of submitting the complete cable assembly to a number of temperature cycles. Unless otherwise specified in the relevant detail specification, submitting the complete cable assembly to artificial ageing is optional, at the discretion of the supplier.

4 Design and manufacturing requirements

4.1 Cable design and construction

Cables in accordance with, or conforming to, IEC 61196 sectional or detail specifications should be specified wherever possible. Where cable designs deviating from IEC 61196 sectional or detail specifications are required, these cables shall comply with the requirements of the relevant sectional or detail specification of the manufacturer.

According to local regulation, raw material of the cable as well as those of additional protection shall be chosen to comply with regional or national Directives and Regulations such as RoHS and REACH in Europe.

4.2 Connector design and construction

Connector types conforming to the relevant part of IEC 61169 shall be specified wherever possible, but where a special connector design is required, the interface shall conform to the relevant part of IEC 61169, where available, and the connector construction shall comply with the requirements of the relevant detail specification.

According to local regulation, raw material of the connector as well as those of additional protection shall be chosen to comply with RoHS and other environmental regulation such as REACH in Europe.

4.3 Outline and interface dimensions

Outline dimensions shall be in accordance with the relevant detail specification of the cable assembly.

Interface dimensions shall be in accordance with the relevant detail specification.

5 Workmanship, marking and packaging

5.1 Workmanship

There shall be no observable defects in the cable assembly. It shall be clean and in good condition.

5.2 Marking

Marking shall be legible and in accordance with the relevant detail specification. It shall identify the manufacturer of the cable assembly.

5.3 End caps

Unless otherwise specified in the relevant detail specification, disposable end caps of suitable material for transport and storage shall be fitted to the connectors to protect at least each interface from damage and dirt.

5.4 Packaging and labelling

Packaging and labelling shall be in accordance with the relevant detail specification, unless otherwise specified.

6 Quality management

A guide for quality management including capability approval as well as qualification approval is given in Annex D.

7 Test methods – General

7.1 Standard atmospheric conditions for testing

Standard atmospheric conditions need to be controlled within some range to ensure proper correlation of data obtained from measurements and test conducted in various facilities. Conduct measurement and test conditions under the following atmospheric conditions, unless otherwise specified. In some cases, special ambient conditions may be needed and be specified in the detail specification.

Table 1 gives the standard range of atmospheric conditions for carrying out measurements and tests.

Table 1 – Standard range of atmospheric conditions

Conditions	Standard
Temperature	23 °C ± 5 °C
Relative humidity	(45 ± 25) %
Atmospheric pressure (Limits are inclusive)	Site ambient

Keep variations in ambient temperature and humidity to a minimum during a series of measurements.

Where it is impracticable to carry out tests under the standard atmospheric conditions for testing, a note to this effect, stating the actual conditions of tests, shall be added to the test report.

7.2 Visual inspection

The specimen shall be visually examined to ensure that:

a) the condition, workmanship and finish are satisfactory;

b) the marking is in accordance with 5.2 of this document;

c) there is no mechanical damage, undesired movement or displacement of parts;

d) no pitting or flaking of materials or finishes is apparent.

Examination may generally be carried out using an instrument with up to three times magnification.

7.3 Dimensions inspection

7.3.1 Interface dimensions

The interface dimensions shall be tested for compliance with the relevant detail specification with the appropriate test equipment.

Where connectors conforming to IEC 61169 sectional and detail specifications are used, inspection of interface dimensions may be limited to those features likely to vary as a result of incorrect assembly, for example the axial dimensions from reference plane to dielectric, and to inner contact features.

Where other connectors are used or where special requirements exist, details shall be given in the relevant detail specification.

7.3.2 Outline dimensions

Outline dimensions shall be measured according to the sketches of IEC 60966-2 (all parts), IEC 60966-3 (all parts) or IEC 60966-4 (all parts) as relevant.

Any special requirements for the measurement of cable assembly outline dimensions shall be given in the relevant detail specification.

8 Electrical tests

8.1 Reflection properties

8.1.1 Object

To determine the amount of signal that is reflected back to the signal source by the cable assembly under test in a matched system. The reflection behaviour is preferably expressed in terms of 'dB return loss'.

8.1.2 Test equipment

A vector network analyzer (VNA) capable of performing s-parameter measurements using calibration standards (open, short, load) that enables the RF performance of radio frequency (RF) and microwave devices to be characterized in terms of network scattering parameters or S parameters.

The return loss of the cords under test shall be measured with the VNA over the specified range of interest.

A detailed description of the error correction (calibration) procedure is given in the manual of the VNA.

Precision test adaptors (or test leads) with small inherent reflections shall be fitted on both ends of the cord under test to allow direct connection to the VNA and terminating load.

8.1.3 Procedure

For the measurement of the reflection characteristics of cable assemblies, special care shall be given to the following:

- ensure that the sweep speed is slow enough for the reflected signal to remain in the centre of the IF-filter of the receiver system. The longer the cable, the slower the sweep speed that shall be chosen;
- cable assemblies might have narrow return loss spikes. For continuous network analyser-systems, the sweep rate shall be low enough and for digital network analyser-systems, the number of measurement points shall be high enough for resolving eventual return loss spikes.

For example, for digital systems, the number of points should be:

$$n \geq 3(f_2 - f_1)\ L\ /\ (120)$$

where

n is the number of sampling points in the frequency range f_1 to f_2 forming the response curve;

f_1 is the lowest frequency in the range, in MHz;

f_2 is the highest frequency in the range, in MHz;

L is the physical length of the test specimen, in m.

Failing to apply these criteria may result in too wide a distance between the frequency sampling points, thus leading to considerable measuring failures.

The return loss of cable assemblies is not necessarily symmetrical for both sides, and measurements from both sides might be required. Unless otherwise stated in the relevant detail specification, the worst case has to be within the specification.

The system has to be calibrated with the appropriate connector types. If these are not available, then adapters have to be used. The adapters will give a deterioration in the measured return loss, but, the result shall not be corrected for the adapters. The combined return loss, including the adapters, shall be within the specification.

Other techniques for measuring the reflection characteristics of a cable assembly may be used if agreed by the customer.

8.1.4 Requirements

The measured return loss values shall be within the specified limits.

8.1.5 Information to be given in the detail specification

a) minimum return loss, as a function of frequency, if appropriate;

b) frequency range;

c) required frequency resolution.

Measurements to be made from one or both ends.

8.2 Uniformity of impedance

8.2.1 Object

To determine the variation of local characteristic impedance of the cable assembly.

8.2.2 Procedure

Measurement is made using a time domain reflectometer (TDR) with input step applied to the cable assembly through an air line acting as an impedance reference (see IEC 61196-1-112 and 61169-1:2013, 9.2.1.2.2). Impedance variation along the assembly shall be observed.

Alternatively, a system using frequency domain to time domain conversion may be used.

8.2.3 Requirements

To be as specified in the relevant detail specification.

8.2.4 Information to be given in the detail specification

a) rise time of the TDR system;

b) limits of impedance variation.

8.3 Insertion loss

8.3.1 Procedure

The insertion loss shall be inspected in accordance with Annex A.

8.3.2 Requirements

The insertion loss shall not exceed the specified limits at any frequency within the frequency band indicated in the relevant detail specification.

8.3.3 Information to be given in the detail specification

a) maximum insertion loss, if appropriate, as a function of frequency;

b) frequency range.

8.4 Insertion loss stability

8.4.1 Object

To determine the change of attenuation at a given frequency when the cable assembly is subjected to dynamic bending.

8.4.2 Procedure

During insertion loss measurement according to 8.3, the cable is wound on a mandrel of radius equal to the dynamic bending radius and using the number of turns indicated in the relevant detail specification.

8.4.3 Requirements

During and after the test, the specified change of insertion loss given in the relevant detail specification shall not be exceeded.

8.4.4 Information to be given in the detail specification

a) dynamic bending radius of the cable (radius of the mandrel);

b) number of turns and portion of the cable assembly on the mandrel;

c) test frequencies.

d) maximum change of insertion loss.

8.5 Propagation time

8.5.1 Procedure

The propagation time is inspected in accordance with Annex B.

8.5.2 Requirements

The propagation time shall not exceed the limits indicated in the relevant detail specification.

8.5.3 Information to be given in the detail specification

a) frequency band in which the measurement is carried out (see Clause B.1) or rise time of the system (see Clause B.2);

b) propagation time and tolerance.

8.6 Stability of electrical length

8.6.1 Object

To determine the change of phase caused by the change in electrical length when the cable assembly is subjected either to bending or twisting.

8.6.2 Procedures

8.6.2.1 Bending

Method 1

A cable assembly which is of a U shape shall be connected to a suitable network analyser according to 8.1.2 (see Figure 1). During recording of the phase of the transmitting signal, the cable is wound around the mandrel for 180° (see Figure 1), unwound to the starting position, wound counter-clockwise for 180° around the mandrel (see Figure 1) and again unwound to its starting position. The initial position of the mandrel shall be chosen so that only the straight parts of the U will be bent during the test.

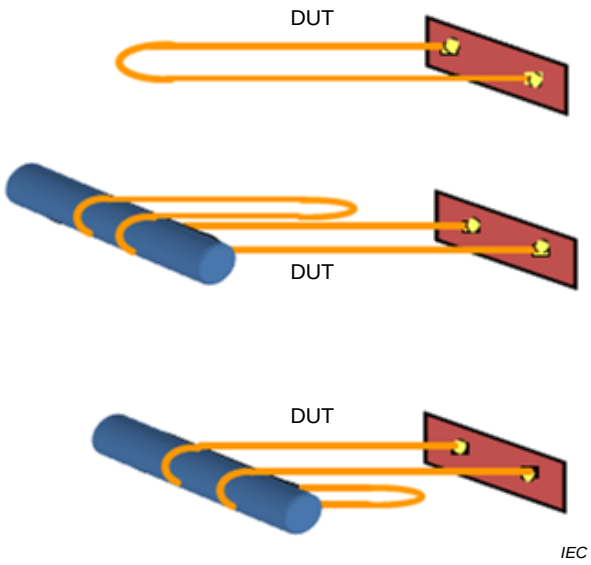


Figure 1 – Bending test: U shape assembly

Method 2

A cable assembly which is of a straight shape has to be terminated by a short at one end and connected to a suitable network analyser according to 8.1.2 at the other end. During the recording of the phase of the reflected signal, the cable is first wound clockwise around the mandrel for one half turn released to the starting position then wound anti-clockwise around the mandrel and again released to its starting position. See Figure 2.

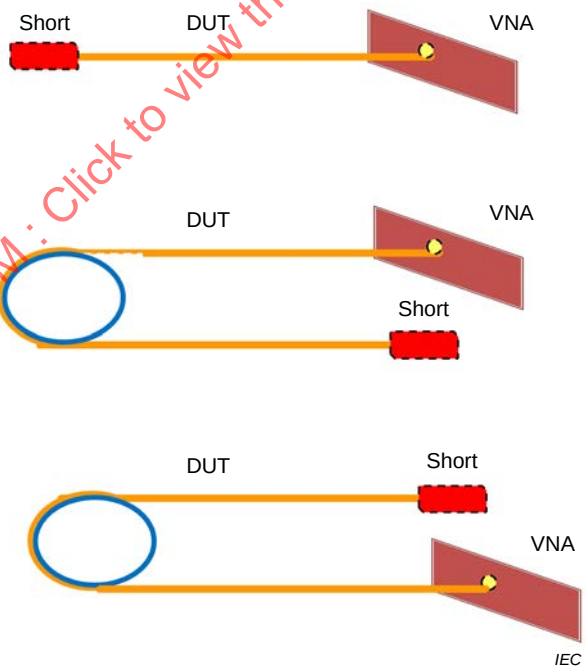


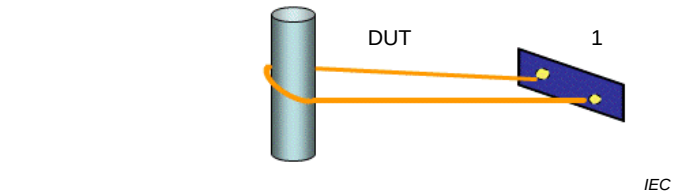
Figure 2 – Bending test: straight assembly

8.6.2.2 Twisting

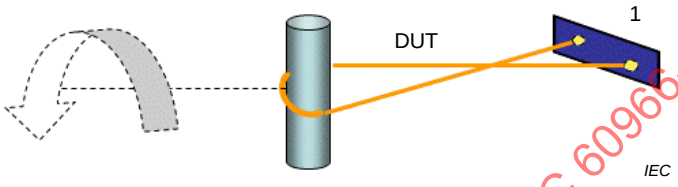
A cable assembly which is of a U shape has to be connected to a suitable network analyser according to 8.1.2 (see Figure 3a). During the recording of the phase of the transmitting signal the mandrel in the middle of the cable is first twisted in a clockwise direction for 180°

(see Figure 3b) then released to the starting position, twisted counter-clockwise for 180° (see Figure 3c) and again released to its starting position.

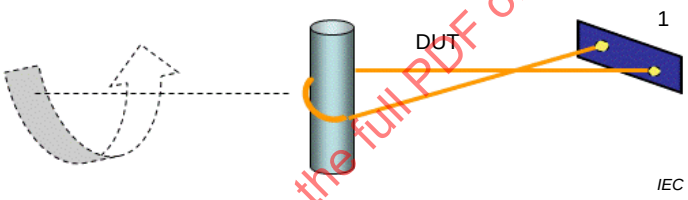
Depending on the torsional rigidity and the maximum permissible torque at the cable connectors interface, the maximum twist angle may have to be restricted.



a) Starting position



b) Clockwise twist



c) Counter clockwise twist

Figure 3 – Twisting test: U shape assembly

8.6.3 Requirements

The phase difference shall not exceed the limits specified in the relevant detail specification.

8.6.4 Information to be given in the detail specification

a) radius of mandrel (usually dynamic bending radius of the cable);

b) test frequency;

c) maximum change of phase.

8.7 Phase difference

8.7.1 Object

To measure the phase difference between two or more cable assemblies.

8.7.2 Procedure

Measurements shall be made using a suitable network analyser of appropriate resolution according to 8.1.2. Alternatively, a slotted line may be used where frequency and accuracy requirements permit.

8.7.3 Requirements

The phase difference shall not exceed the limits specified in the relevant detail specification.

8.7.4 Information to be given in the detail specification

a) maximum phase difference or nominal phase difference with tolerances;

b) frequency.

8.8 Phase variation with temperature

8.8.1 Object

To determine the changes of phase caused by the change in the electrical length when the cable assembly is subjected to various temperatures within its operating temperature range.

When specified in the relevant detail specification, this test may be conducted on a specimen cable assembly rather than a finished cable assembly. The specimen cable assembly shall be identical to the finished cable assembly except for its length and its shape.

8.8.2 Procedure

Measurements shall be made using a suitable network analyser according to 8.1.2 with the cable assembly, including its connectors, in a controlled temperature chamber. Details of any cable supports shall be given in the relevant detail specification.

Where tests are made on a specimen cable assembly, the cable shall form one or more unsupported loops of a diameter at least ten or more times the minimum static bending radius.

Six temperature cycles shall be used. Alternatively, a slotted line can be used where frequency and accuracy requirements permit.

8.8.3 Requirements

During the test, the phase variation shall not exceed the limits specified in the relevant detail specification.

8.8.4 Information to be given in the detail specification

a) temperature range and temperature against time cycle;

b) measurement frequency;

c) method of presenting the results, for example $\Delta\varphi$/°C;

d) admissible phase variation;

e) configuration of substitute specimen cable assembly, when allowed.

8.9 Screening effectiveness

8.9.1 Transfer impedance

The transfer impedance shall be tested.

Applicable tests for transfer impedance are given in IEC 62153-4-6 or IEC 62153-4-7.

The relevant detail specification shall identify the applicable test, the frequency range and the minimum value of transfer impedance.

8.9.2 Screening attenuation

The screening attenuation shall be tested according to 62153-4-7.

The relevant detail specification shall identify the frequency range and the minimum value of screening attenuation.

8.10 Voltage proof

8.10.1 Procedure

Each cable assembly shall withstand, without breakdown or flashover, the voltage specified by the relevant detail specification. The minimum value of the test voltage derived from the rated working voltage U of the cable assembly and the test voltage E (both expressed as DC or AC peak) is given by:

E = 3 U for cable assemblies having a rated working voltage up to and including 1 kV,

or

E = 1,5 U with a minimum of 3 kV for cable assemblies having a rated working voltage exceeding 1 kV.

The peak AC voltage stated in the relevant detail specification, at a frequency between 40 Hz and 60 Hz, shall be applied between the inner and outer conductors of the cable assembly using a mated connector as an interface.

Alternatively, a DC voltage equal to the peak AC voltage may be applied.

The voltage shall be applied for a period of 1 min, unless otherwise stated in the relevant detail specification.

8.10.2 Requirements

There shall be no breakdown or flashover.

8.10.3 Information to be given in the detail specification

a) test voltage;

b) any special requirements.

8.11 Insulation resistance

8.11.1 Procedure

The insulation resistance shall be measured between the inner and outer conductor of the cable assembly with a direct voltage of 500 V ± 50 V or with the rated voltage of the cable assembly, whichever is less.

The insulation resistance shall be measured after a stabilisation time of 60 s ± 5 s, unless otherwise specified in the relevant detail specification.

8.11.2 Requirements

The value of the insulation resistance shall not be less than that indicated in the detail specification.

8.11.3 Information to be given in the detail specification

a) test voltage;

b) stabilization time;

c) resistance value.

8.12 Inner and outer conductor continuity

8.12.1 Object

To ensure the DC and low frequency continuity of the inner and outer conductors.

8.12.2 Procedure

Any appropriate method may be used.

8.12.3 Requirements

There shall be no undesired DC or low frequency discontinuity of the inner or outer conductor.

8.12.4 Information to be given in the detail specification

a) test voltage;

b) test current;

c) frequency.

8.13 Power rating

8.13.1 Object

The power rating of a cable assembly is defined as the input power at any specified frequency, temperature and pressure, which can be handled continuously when the cable assembly is terminated by a load corresponding to the characteristic impedance.

A limitation may be either the maximum permissible operating voltage or the maximum inner conductor temperature of either the cable or the connector.

Thus, the power handling capability test is divided into two categories:

a) continuous power handling capability;

b) peak or pulsed power handling capability.

8.13.2 Procedure

The test shall be performed in accordance with IEC 61196-1-119 taking into account any evidence of arcing and mechanical displacement of the solder or mechanical joint.

8.13.3 Requirements

There shall be no evidence of breakdown due to overheating, arcing or flashover throughout the application of the specified power related to the environmental conditions as stated in the relevant detail specification. After the test, the cable assembly shall show no visual damage and the electrical requirements shall be satisfied.

The temperature rating of the material components should not be exceeded.

8.13.4 Information to be given in the detail specification

a) temperature;

b) pressure;

c) relative humidity.

Peak power test

d) power level;

e) frequency;

f) pulse width and duty cycle.

CW power test

g) power level;

h) frequency.

8.14 Intermodulation level measurement

8.14.1 Procedure

If required, the intermodulation level measurement shall be performed in accordance with IEC 62037-2.

8.14.2 Requirements

The maximum intermodulation level shall be recorded and shall not exceed the given intermodulation level in the relevant detail specification.

8.14.3 Information to be given in the detail specification

a) test signal power;

b) test signal frequencies.

9 Mechanical robustness tests

9.1 Tensile

9.1.1 Object

To determine the mechanical strength and, when required, electrical stability of the cable assembly when subjected to an axial force.

9.1.2 Procedure

A tensile force as stated in the relevant detail specification shall be applied to the two connectors along the common axis of the cable and connectors. When the length or shape of the cable makes this impossible, the force shall be applied between the cable and each connector in turn.

When the force cannot be applied between the two connectors, these tests are normally destructive to the cable.

The application points of the force shall be given in the detail specification.

9.1.3 Requirements

There shall be no visual evidence of the movement of the cable relative to the connector.

Inner contact and insulator positions shall be in accordance with interface dimensions.

Electrical test requirements shall be complied with, if stated in the relevant detail specification.

9.1.4 Information to be given in the detail specification

a) value of the force;

b) duration and method of application of the force.

c) Electrical tests required.

9.2 Flexure

9.2.1 Object

To determine the ability of the cable assembly to withstand bending at the junction of the cable and connector.

9.2.2 Procedure

The test shall be performed using a fixture as shown in Figure 4.

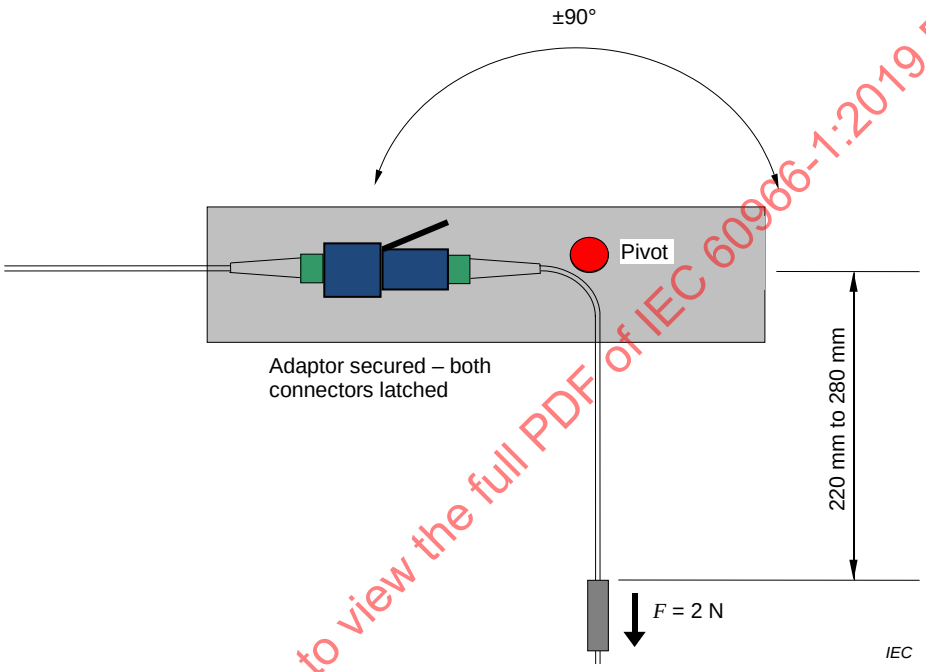


Figure 4 – Fixture for cable assembly flexure test

The length L is adjusted so that the cable is on the vertical axis and the connector in the horizontal position when the force F is applied. A flexure is a rotation of the fixture of 180°. The rate of flexure shall be 20 per minute or as stated in the relevant detail specification.

9.2.3 Requirements

After the test, the cable assembly interface dimensions shall be within the specified limits.

Electrical test requirements stated in the relevant detail specification shall be complied with.

9.2.4 Information to be given in the detail specification

a) value of the force F;

b) number of flexures, normally 500;

c) electrical tests required;

d) whether or not electrical tests shall be applied with the cable assembly still on the fixture.

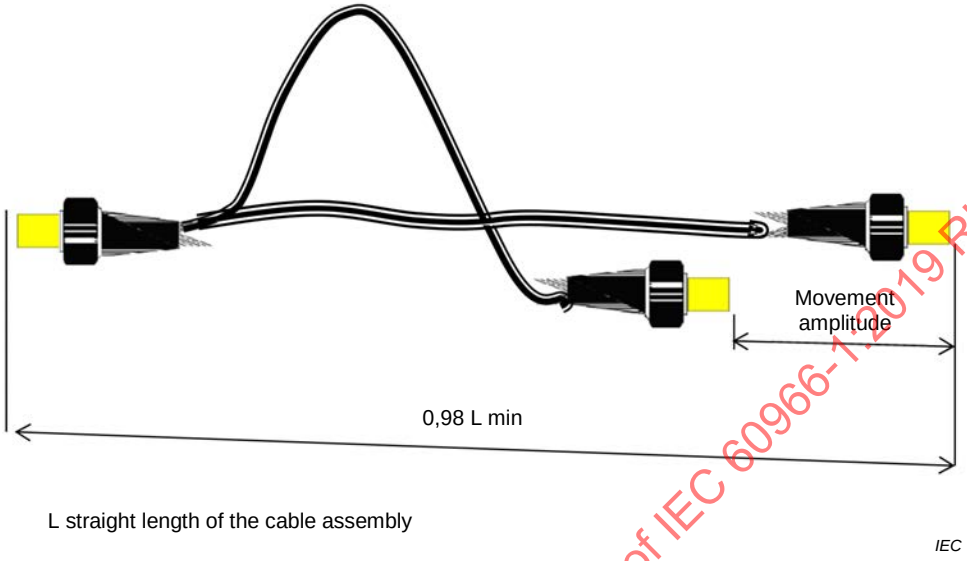
9.3 Flexing endurance

9.3.1 Object

To determine the acceptability of the cable assembly intended to withstand flexing in service.

9.3.2 Procedure

The cable assembly shall be placed on a horizontal table in an apparatus as illustrated in Figure 5. Whilst one connector is fixed, the other connector is moved back and forth in the direction of the cable axis.



Key

L min minimum length to be tested (in metres)

Figure 5 – Apparatus for cable assembly flexing endurance test

9.3.3 Requirements

After the test, the cable assembly shall show no visible damage and the interface dimensions shall be within the specified limits. Electrical requirements stated in the relevant detail specification shall be complied with.

9.3.4 Information to be given in the detail specification

a) movement amplitude, normally half the length of the assembly;

b) number of cycles, normally 500;

c) electrical tests to be applied, with requirements.

9.4 Cable assembly crushing

9.4.1 Object

To determine the ability of a cable assembly to withstand a transverse load (or a force) applied to any part of the cable.

9.4.2 Procedure

A force F shall be applied to a test fixture as shown in Figure 6 at the rate of 0,2F per second maximum. The force shall then be maintained for 60 s ± 10 s.

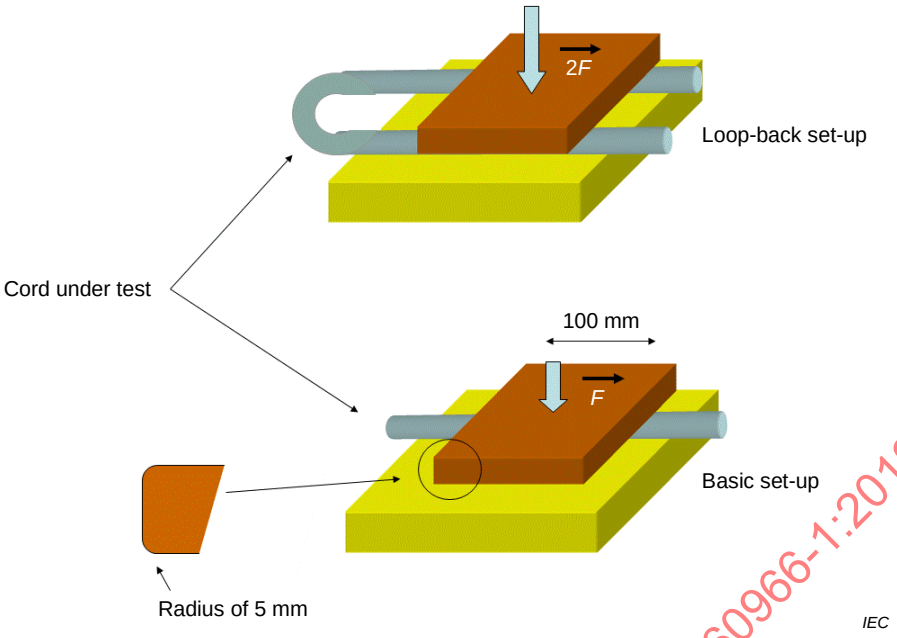


Figure 6 – Fixture for cable crushing test

9.4.3 Requirements

After the test, the reflection characteristics and insertion loss shall be within the limiting values specified in the relevant detail specification.

For some applications, the relevant detail specification shall indicate the uniformity of impedance according to 8.2.

9.4.4 Information to be given in the detail specification

a) value of the force F, normally 800 N;

b) distance from the test region to one of the connectors, normally 1 m maximum;

c) electrical tests and their requirements.

9.5 Torque

9.5.1 Procedure

The ability of the cable to resist torsion shall be tested by the application of a specific torque strictly axially to the interface of the cable to the connector. The torque shall be applied for at least 60 s in both clockwise and counter clockwise directions, see Figure 7.

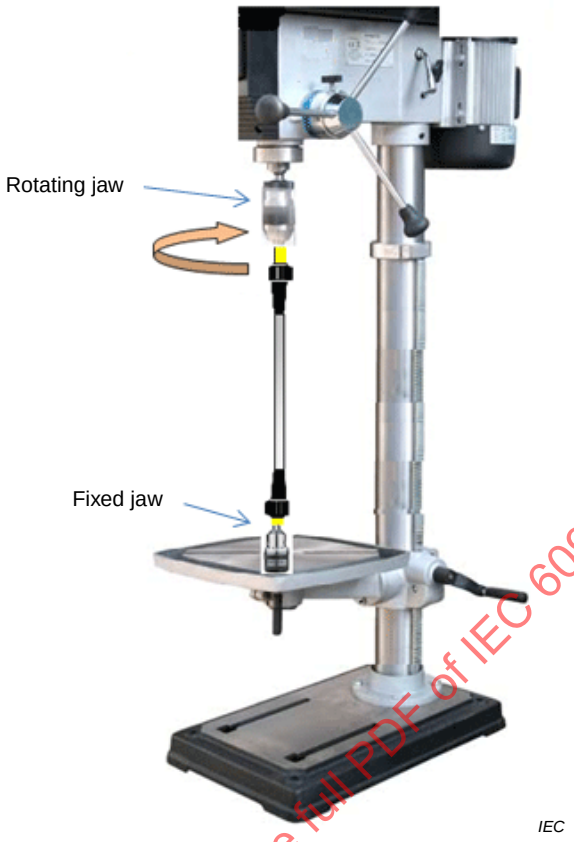


Figure 7 – Example of test fixture for torque

9.5.2 Requirements

After each 60 s application of the torque, the interface of the cable to the connector shall be visually examined. The cable assembly shall show no visual damage and the electrical requirements shall be satisfied. In addition, for semi-flexible and semi-rigid cables, there shall be no angular displacement between the cable and the connector.

9.5.3 Information to be given in the detail specification

Value of the torque.

9.6 Multiple bending

9.6.1 Object

To determine the ability of a cable assembly to withstand a number of reverse bends.

9.6.2 Procedure

The cable assembly is subjected to a certain number of reverse bends using a pulling "go and return" arrangement over its entire length. The radius of the two pulleys shall be in accordance with the minimum dynamic bending radius of the cable. The pulleys shall be positioned so that the bending angle of the cable on each pulley is more than 90° as shown in Figure 8. The cable assembly is pulled forwards and backwards against a restraining force F_r which is set to ensure continuous contact between the cable and the pulleys.

9.6.3 Requirements

After the test, the cable assembly shall show no visual damage and the electrical requirements shall be satisfied.

9.6.4 Information to be given in the detail specification

a) number of cycles (normally 20);

b) electrical tests and their required limits to be applied.

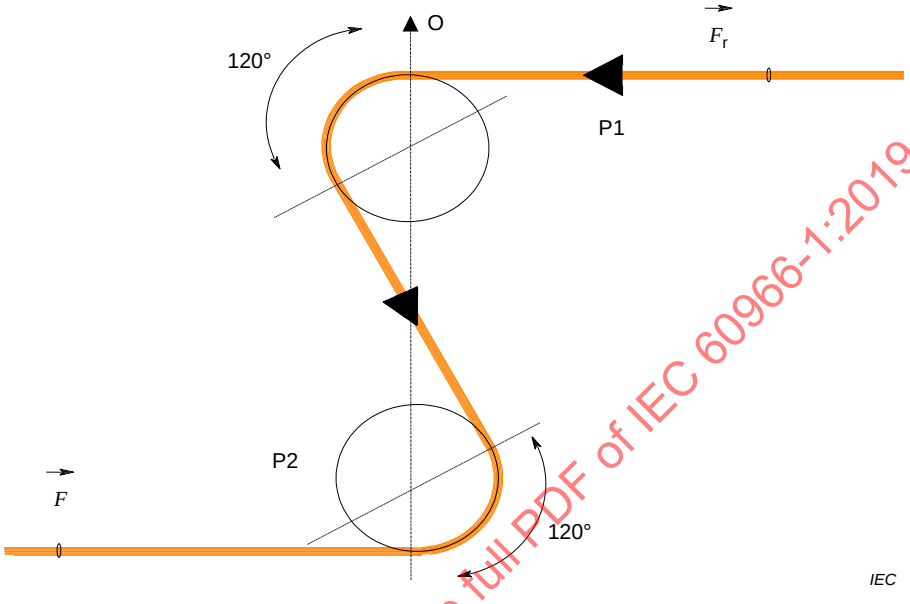


Figure 8 – Multiple bending test

9.7 Abrasion test of cable assembly

9.7.1 Object

To determine the resistance to abrasion of the cable assembly sheath.

9.7.2 Procedure

The cable assembly is subjected to test given in IEC 61196-1-324.

9.8 Vibrations, shocks

If required, the test for vibrations and shocks shall be selected as defined in 10.2.

9.9 Impact test

This test shall be conducted in accordance with test 7b of IEC 60512-7-2.

9.10 Mechanical endurance

When this test is not performed on the connectors separately, it will be conducted in accordance with IEC 61169-1:2013, 9.4.5 (High temperature endurance) and, 9.4.6 (Low temperature endurance).

10 Environmental tests

10.1 Recommended severities

For the recommended severities of environmental tests, see Annex C.

Recommended set of severities may also be found in ISO/IEC TR 29106.

10.2 Vibration, bumps and shock

When these tests are required, they shall be selected from IEC 60068 (all parts) (see Annex C).

10.3 Climatic sequence

10.3.1 Procedure

The test shall be performed in accordance with 9.4.2 of IEC 61169-1:2013.

Flexible cable assemblies shall be wound on a mandrel of minimum static bending radius. The number of full turns shall be three, unless otherwise stated in the relevant detail specification.

10.3.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) insulation resistance;

b) voltage proof;

c) insertion loss;

d) visual inspection.

The insulation resistance measurement and the voltage proof shall be carried out within 30 min of the end of the recovery period.

10.3.3 Information to be given in the detail specification

a) severity of each step of the climatic sequence;

b) number of turns on the mandrel if other than three;

c) electrical tests made during and after the sequence and their requirements;

d) whether connectors are unmated or protected.

10.4 Damp heat, steady state

10.4.1 Procedure

The flexible cable assembly shall be wound on a mandrel of minimum static bending radius. The number of full turns shall be three, unless otherwise stated in the relevant detail specification. The test shall be performed in accordance with 9.4.3 of IEC 61169-1:2013.

10.4.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) insulation resistance;

b) voltage proof;

c) insertion loss;

d) visual inspection.

The insulation resistance and the voltage proof measurements shall be carried out within 30 min of the end of the recovery period.

10.4.3 Information to be given in the detail specification

a) severity of the test;

b) number of turns on the mandrel if other than three;

c) electrical checks made immediately after conditioning and after recovery period and their requirements;

d) whether connectors are mated or unmated.

10.5 Rapid change of temperature

10.5.1 Procedure

The test shall be performed in accordance with 9.4.4 of IEC 61169-1:2013. Flexible cable assemblies shall be wound on a mandrel of minimum static bending radius. The number of full turns shall be three, unless otherwise stated in the relevant detail specification.

The coil turns should be spaced to avoid contact with each other.

10.5.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) insulation resistance;

b) voltage proof;

c) RL, IL, ZC, and electrical length;

d) visual inspection.

Centre contact and insulator positions shall be in accordance with the interface dimensions.

10.5.3 Information to be given in the detail specification

a) minimum and maximum temperature;

b) number of turns on the mandrel if other than three;

c) final tests and measurements and their requirements.

10.6 Resistance to solvents and contaminating fluids

10.6.1 Procedure

The test shall be performed in accordance with 9.4.11 of IEC 61169-1:2013.

10.6.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification.

a) Insulation resistance;

b) Visual inspection;

c) Insertion loss.

10.6.3 Information to be given in the detail specification

a) conditioning fluids;

b) drying temperature, if different from 70 °C;

c) requirements for insulation resistance and insertion loss;

d) whether the connectors are mated or unmated.

10.7 Water immersion

10.7.1 Procedure

Details of the method shall be given in the relevant detail specification and shall be generally in accordance with 9.4.9 of IEC 61169-1:2013.

10.7.2 Requirements

At the conclusion of the test duration, the cable assembly shall comply with the requirements of the following tests, unless otherwise specified in the relevant detail specification.

a) insulation resistance;

b) insertion loss.

10.7.3 Information to be given in the detail specification

a) requirements for insulation resistance and insertion loss;

b) whether the connectors are mated or unmated.

10.8 Salt mist and sulphur dioxide tests

10.8.1 Procedure

When these tests are required, they shall be performed according to 9.4.10 (salt) and 9.4.12 (sulphur) of IEC 61169-1:2013. Severities are to be given in the relevant detail specification.

10.8.2 Requirements

At the conclusion of the recovery period, the cable assembly shall comply with the requirements of the following tests, unless otherwise stated in the relevant detail specification:

a) insulation resistance;

b) visual inspection;

c) insertion loss.

10.8.3 Information to be given in the detail specification

a) requirements for insulation resistance and insertion loss;

b) whether the connectors are mated or unmated.

10.9 Dust tests

10.9.1 Object

To determine whether the effects of exposure to dust impair the operational performance of the cable assembly and in particular the function of the coupling mechanism.

10.9.2 Procedure

The cord will be submitted to the test defined by IEC 60529 for a classification IP 5X.

The details of the test (mated or unmated connector(s) shall be given in the detail specification.

10.9.3 Requirements

At the conclusion of the last cycle, the specimen(s) shall be carefully removed from the chamber and any surplus dust removed by a light shaking or blowing. Before uncoupling the connector, any measurements required by the detail specification to check for deterioration in performance shall be made.

10.9.4 Information to be given in the detail specification

a) duration of test cycle if other than 15 min;

b) the equivalent altitude if other than that covered by the standard atmospheric conditions for testing;

c) number of test cycles;

d) details of visual, mechanical and electric inspection and tests required at the conclusion of the conditioning including whether a special tool may be used to assist uncoupling of mated connector;

e) size of particles to be chosen from IEC 60529.

10.10 Flammability

10.10.1 Procedure

The test shall normally be carried out in accordance with IEC 60332-1-2 on a finished cable assembly. Unless otherwise specified in the detail specification, the duration of flame application shall be derived from the formula given in 5.4.2 of IEC 60332-1-2:2004. In case of plastic components other than the cable itself, each one shall satisfy the requirements of the relevant specification.

10.10.2 Requirements

If ignition occurs, the cable shall not continue to burn for more than 15 s after removal from the flame.

At no time during the test shall burning particles become detached from the cable.

10.10.3 Information to be given in the detail specification

Any deviation from the standard procedure including regional or national regulations, if any.

11 Specialized test methods

Specialized test methods, applicable to a specific group of cable assemblies only, shall be specified in the relevant sectional specification.

12 Test schedules

Testing schedules shall be defined in sectional and relevant detail specifications.

NOTE Typical sub-families consist of RF cable assemblies manufactured from a specific type of cable, for example, flexible or semi-rigid, RF-connectors of an IEC standardized or proprietary design, and having specific characteristics, for example precision or super-screened.

Annex A
(normative)

Test methods for insertion loss determination

A.1 Purpose

To determine the insertion loss of an RF cable assembly.

A.2 Test methods

A.2.1 General

Three test methods for the determination of the insertion loss of an RF cable assembly are described in this Annex A. The test equipment should have the same nominal characteristic impedance as the cable assembly under test. If this is not possible, test methods 1 and 2, given in A.2.2 and A.2.3, may only be used with the application of the correction formula and procedures given in Clause A.3.

Test method 3 is only suitable for RF cable assemblies having an insertion loss smaller than their return loss.

Adapters may be required between the test equipment and the cable assembly under test. These shall be regarded as part of the test equipment and shall be left in the circuit when the cable assembly is removed as part of the test procedure. However, should a cable assembly have connectors such that the adapters cannot be coupled together when the cable assembly is removed, one or more of the adapters may be left on the cable assembly. In this case, an allowance for the adapter(s) shall be made in the relevant detail specification.

A.2.2 Test method 1

A.2.2.1 Procedure for inspection

The cable assembly is tested in the test equipment circuit as shown in Figure A.1.

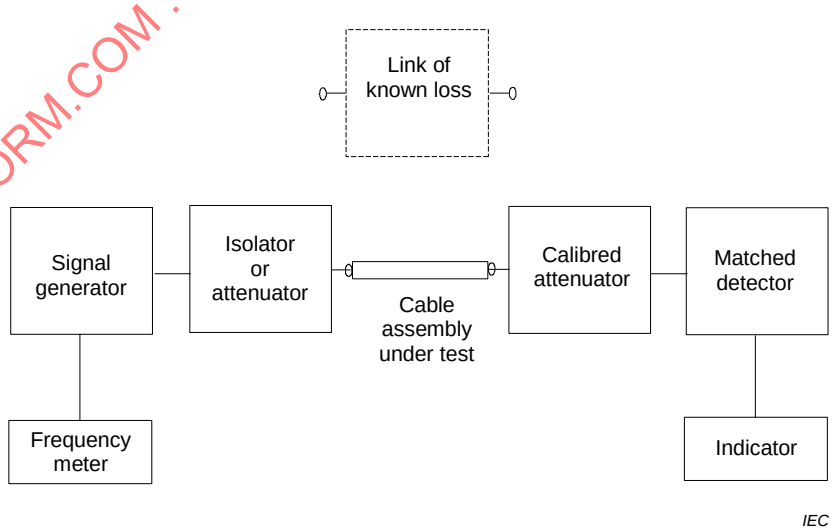


Figure A.1 – Circuit for the determination of insertion loss

First the cable assembly is either replaced by the link of known loss or the two test ports are coupled together and the indicator set to a suitable value (i.e. less than the maximum). The cable assembly is inserted between the test ports and the calibrated attenuator is then backed

off by an amount equal to the cable assembly limit, less the known loss of the link if used. The indicator reading shall not be less than the set value. This ensures that the insertion loss of the cable assembly is not more than the specified value.

A.2.2.2 Procedure for measurement

The cable assembly is tested in the test equipment circuit as shown in Figure A.1. The indicator is set to a suitable value (i.e. less than the maximum). The cable assembly is then removed and the indicator reading is returned to the set value using the calibrated attenuator and if necessary the link of known loss.

A.2.2.3 Acceptance

The insertion loss of the cable assembly shall be no greater than the specified value.

A.2.2.4 Precautions

a) The return losses at the two test ports may impair measurement and shall be taken into account (see Clause A.3).

b) Care shall be taken to ensure that too much power does not damage the detector.

c) The oscillator shall be sufficiently pure or filtered, to ensure that neither harmonics nor spurious signals compromise the tests.

d) See A.2.1 regarding the use of adapters.

A.2.3 Test method 2

A.2.3.1 General

This test method may be used for cable assemblies having the same nominal characteristic impedance as the test equipment (i.e. for high return loss cases) as well as for cable assemblies having different nominal characteristic impedances (i.e. for low return loss cases).

A.2.3.2 Procedure

The test circuit is shown in Figure A.2 whereby the detector V is connected to the output of the directional coupler or bridge through adapters as necessary.

Depending upon the test port return losses, calibration is made either by amplitude or by amplitude and phase (high return loss requires amplitude calibration only, while low return loss requires amplitude and phase calibration in accordance with Clause A.3). The cable assembly is inserted between the output of the directional coupler or bridge and the detector V, using adapters if necessary. The attenuation is determined on the swept amplitude analyser.

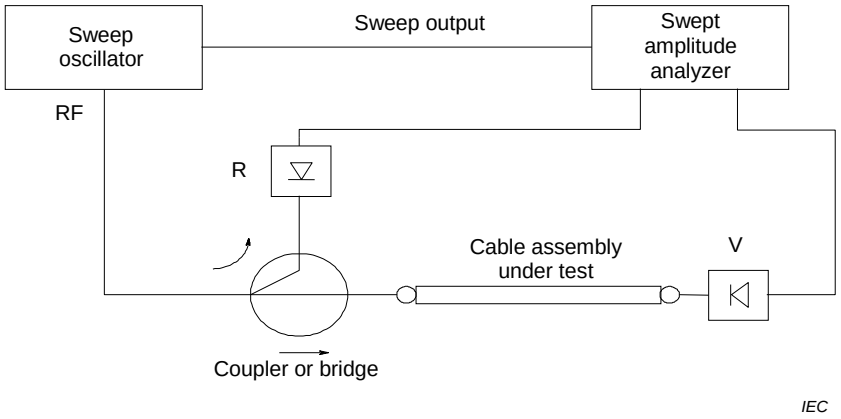


Figure A.2 – Circuit for the determination of insertion loss – principle

If sufficient power is available or if there is sufficient sensitivity in the systems, the alternative circuit shown in Figure A.3 may be used.

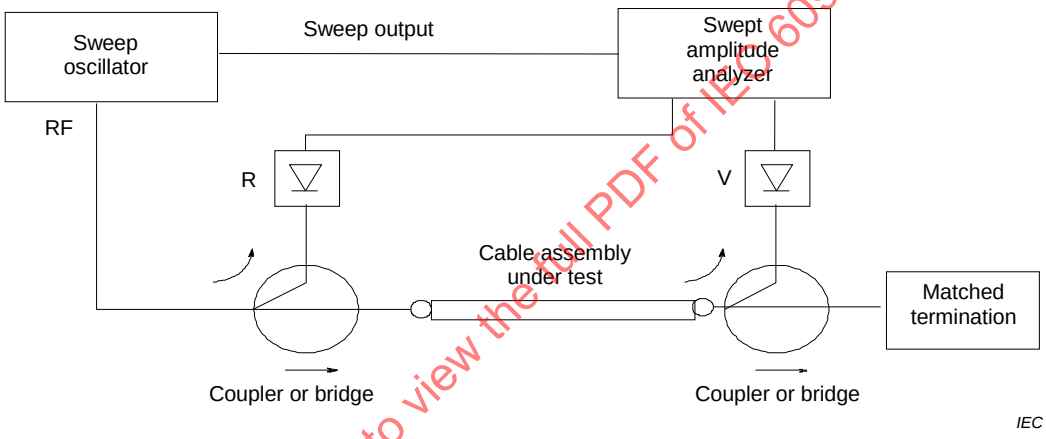


Figure A.3 – Alternative circuit for the determination of insertion loss

A.2.3.3 Acceptance

The insertion loss of the cable assembly shall be no greater than that specified.

A.2.3.4 Precautions

a) The return losses at the two test ports may impair measurement and shall be taken into account (see Clause A.3). In particular, an attenuator having a low reflection may be required in front of the detector V.

b) The calibration of the system shall take into account the power dependence of the coupler.

c) The oscillator shall be sufficiently pure or filtered, to ensure that neither harmonics nor spurious signals compromise the tests.

d) In analogue-swept systems, the frequency scan rate of the sweep oscillator shall be sufficiently slow in relation to the amplitude analyser response to obtain an accurate determination of the insertion loss. In particular, it shall be slow enough for cable assemblies in which there are:

   1) resonances, which can be very sharp, associated with structural return loss in the cable assembly;

   2) multiple reflections between the ends of the cable assembly or the test ports.

e) In digitally stepped frequency systems, the steps shall be sufficiently fine for an accurate determination of the insertion loss. In particular, they shall be fine enough for the cases described in item d).

f) See A.2.1 regarding the use of adapters.

A.2.4 Test method 3

A.2.4.1 General

A double-pass method of test may be used if the insertion loss of the cable assembly is smaller than its return loss and the test bandwidth is sufficient. This requirement precludes the testing of unmatched cable assemblies.

A.2.4.2 Procedure

The layout of the test circuit is shown in Figure A.4.

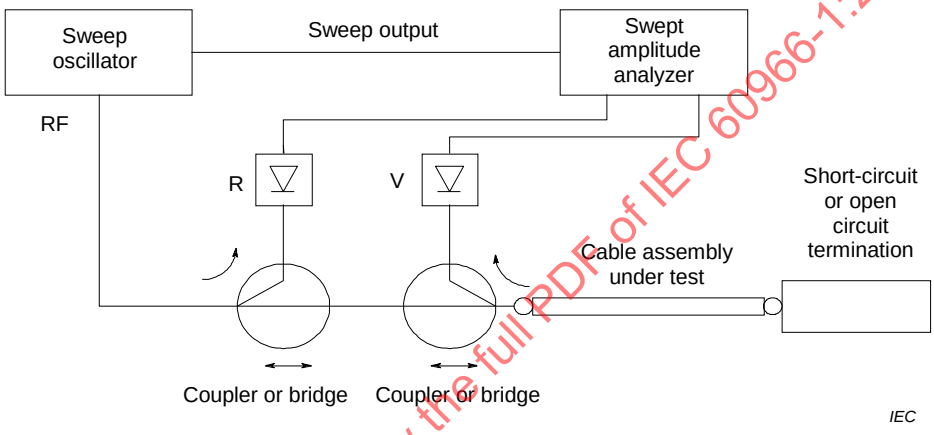


Figure A.4 – Double-pass circuit for the determination of insertion loss

Levels for V/R at 0 dB and for any other required attenuation are established over the required frequency range with terminations on the directional coupler port or adapters as follows:

a) short-circuit;

b) open-circuit.

The decibel average of these two levels a) and b) shall be deemed the reference level.

The cable assembly is then coupled to the directional coupler using adapters as necessary and attenuation levels are obtained with the short- and open-circuit terminations. The decibel average of the two plots obtained with the different terminations is twice the insertion loss of the cable assembly under test.

A.2.4.3 Acceptance

The insertion loss of the cable assembly shall be no greater than the specified value.

A.2.4.4 Precautions

a) The return loss at the test port and the directivity of the directional coupler or the apparent directivity of the bridge impair the measurement and shall be taken into account (see Clause A.3).

b) The test bandwidth shall be sufficient to provide confidence in averaging plots.

c) The calibration of the system shall take into account the power dependence of the coupler.

d) The oscillator shall be sufficiently pure or filtered, to ensure that neither harmonics nor spurious signals compromise the tests.

e) In analogue-swept systems, the frequency scan rate of the sweep oscillator shall be sufficiently slow in relation to the amplitude analyzer response to obtain an accurate determination of the insertion loss. In particular, it shall be slow enough for cable assemblies in which there are:

   1) resonances, which can be very sharp, associated with structural return loss in the cable assembly;

   2) multiple reflections between the ends of the cable assembly or the test ports,

f) In digitally stepped frequency systems, the steps shall be sufficiently fine for an accurate determination of the insertion loss. In particular they shall be fine enough for the cases described in item e).

g) The insertion loss of the cable assembly shall permit resolution of the reflections from the cable assembly and its terminations.

h) In open-circuit tests, radiation from the connector centre contacts shall not compromise accuracy. If necessary, precision open-circuit terminations (i.e. shielded or closed-end open-circuit terminations) shall be used.

i) See A.2.1 regarding the use of adapters.

A.3 Correction for characteristic impedance differences

When the characteristic impedance of the test equipment and the cable assembly differ, test methods 1 and 2 may be used with the following correction formula:

$$A = A' - \left[20 \cdot \log \frac{\left(Z_g + Z_0\right)}{\left(2 \cdot \sqrt{Z_g \cdot Z_0}\right)}\right] - \left[20 \cdot \log \frac{\left(Z_1 + Z_0\right)}{\left(2 \cdot \sqrt{Z_g \cdot Z_1}\right)}\right] - \left[20 \cdot \log \left[1 - \left(\frac{Z_g - Z_0}{Z_g + Z_0} \cdot \frac{Z_1 - Z_0}{Z_1 + Z_0} \cdot e^{-2(\alpha+\beta)L}\right)\right]\right] \quad \text{(A.1)}$$

where

A is the true insertion loss of the cable assembly under test (dB);

A' is the measured insertion loss of the cable assembly (dB);

Z_g is the nominal output impedance of the generator's isolator/attenuator (test method 1) or the coupler or bridge (test method 2) (Ω);

Z_0 is the nominal characteristic impedance of the cable assembly (Ω);

Z_1 is the nominal input impedance of the calibrated attenuator (test method 1) or the detector or coupler/bridge (test method 2) (Ω);

α is the attenuation constant of the cable assembly (neper/m);

β is the phase constant of the cable assembly (radian/m);

L is the physical length of the cable assembly (m).

When the attenuation against frequency shows a consistent ripple resulting from the multiple reflections between the two test ports, β may be obtained from:

$$\beta = \frac{\pi \cdot f}{\Delta f \cdot L} \quad \text{(A.2)}$$

where

Δf is the frequency difference between either two successive maxima or two successive minima in the attenuation ripple at approximately frequency f.

Further to this, α is approximately equal to α' which is obtained from:

$$\alpha = A'/8{,}686L \text{ neper/m} \quad \text{(A.3)}$$

However, for greater accuracy, this formula may be used iteratively by substituting α for α' in the above equation.

Annex B
(informative)

Measuring methods for propagation time

B.1 General

Methods for both long and short cable assemblies are needed. For long cable assemblies a method based on resonance of forward and backward waves is recommended. This resonance method is described in Clause B.2. For short cable assemblies the time domain method described in Clause B.3 is recommended.

B.2 Resonance method for propagation time measurement

The frequencies f_i of the voltage minima at the near end of a short-circuited cable assembly and/or the frequencies f_j of the voltage maxima of an open-circuited cable assembly are measured. The frequency of the first maximum or minimum is designated as f_1, the second as f_2, etc.

A suitable equipment arrangement is given in Figure B.1.

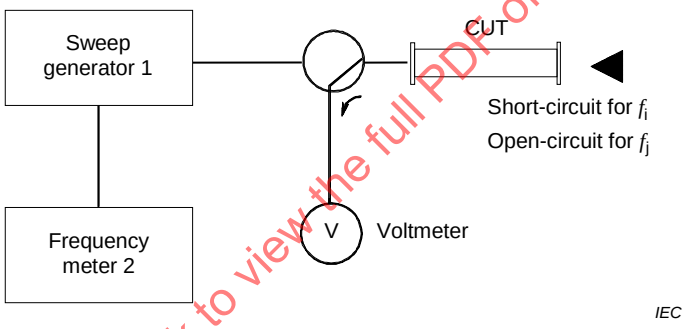


Figure B.1 – Arrangement of test equipment

The propagation time $T_{p,n}$ at frequency f_i or f_j is given by the formula:

$$T_{p,n} = \frac{n}{f_n}$$

where $n = i$ or j.

The electrical length of the coupling device and the adapter should be taken into account.

The accuracy can be improved by taking the mean values:

$$f_n = \frac{f_i + f_j}{2}$$

$$T_{pn} = \frac{T_{pi} + T_{pj}}{2}$$

where $n = i = j$.

For best accuracy, the cable shall be terminated with a short-circuited or open-circuited connector of the same electrical length.

At other than the above resonance frequencies, the following formula may be used. The coefficients are determined from measurement at several resonance frequencies f_n.

$$T_p = B_o + B_{1f}{}^{-½} + B_{2f}{}^{-¼} + \ldots.$$

B.3 Time domain method for propagation time measurement

For a short or very short cable assembly the propagation time can be determined by the time delay of an echo through the cable.

A time domain reflectometer (TDR) or a pulse echo test set can be used. The rise time of the system and the width of the pulse should be in accordance with the resolution needed.

The measured echo delay time should be divided by a factor of 2 to obtain the propagation time of the cable assembly. Allowance should be made for the electrical length of the short-circuit or open-circuit.

Annex C
(informative)

Recommended severities for environmental tests

C.1 Introduction to the relationship between environmental conditions and severities of testing

C.1.1 General

The purpose of environmental engineering is to render the product and the environment compatible. It should take all economic and technical aspects into consideration and thereby choose the best test methods and correct severities for the evaluation of the product's ability to withstand the environment. A test program for the product is defined whereby the test sequence together with the test methods and limits are specified.

C.1.2 Environmental conditions

The environmental conditions shall be evaluated by measurements or by other information available so that statistically accurate characteristic values can be established corresponding to the highest possible constraints. Each situation has an environment of its own, but it is not reasonable to prescribe individual products having slightly different withstand properties for each individual situation. It is necessary to combine these environments into a class forming an envelope of related environments. It is only necessary to take into account those parameters that influence the performance of the product. The environment shall cover all the conditions that occur during the life of the product, i.e. storage, transportation, use and handling.

C.1.3 Environmental testing

The purpose of an environmental test is to demonstrate that a product under defined environmental conditions can survive without permanent failure and continue to function according to specification. The severity of the test to be selected will depend on the characteristic values obtained for the parameters, the failure mechanism, the ageing factor if known, and the consequences of failure. The latter will have been studied by the utilization of the particular product and depends on its application. This means that the severity of the test can be raised or lowered according to the criticality of the product. If the sampling of the product suggests wide variations in its ability to withstand the specified environment, the level of testing should be increased. If the distributions of environmental constraints and the resistance to the environment of a lot tested are suspected to partially overlap, the test levels can be raised to clarify this weakness.

The performance requirements should also be considered. Normal performance is usually specified for all primary functions but, for secondary functions, requirements may be relaxed during extreme conditions to avoid unnecessary over-specification.

An environmental test may be performed for many purposes. In this generic specification, the environmental tests are one part of the qualification approval tests. In this case, a test of resistance to the environment demonstrates the ability of the product to function under constraints or withstand stated constraints. There are, however, inherent limitations due to the fact that the tests are usually carried out on a few samples.

The results give protection to a particular design, but not to an individual product. The successful test will ensure that the product, as a type, is capable of withstanding the expected environments. Different kinds of tests and severity levels are necessary for product reliability and endurance.

An outline of the action needed for the preparation of an environmental test specification is given in Figure C.1.

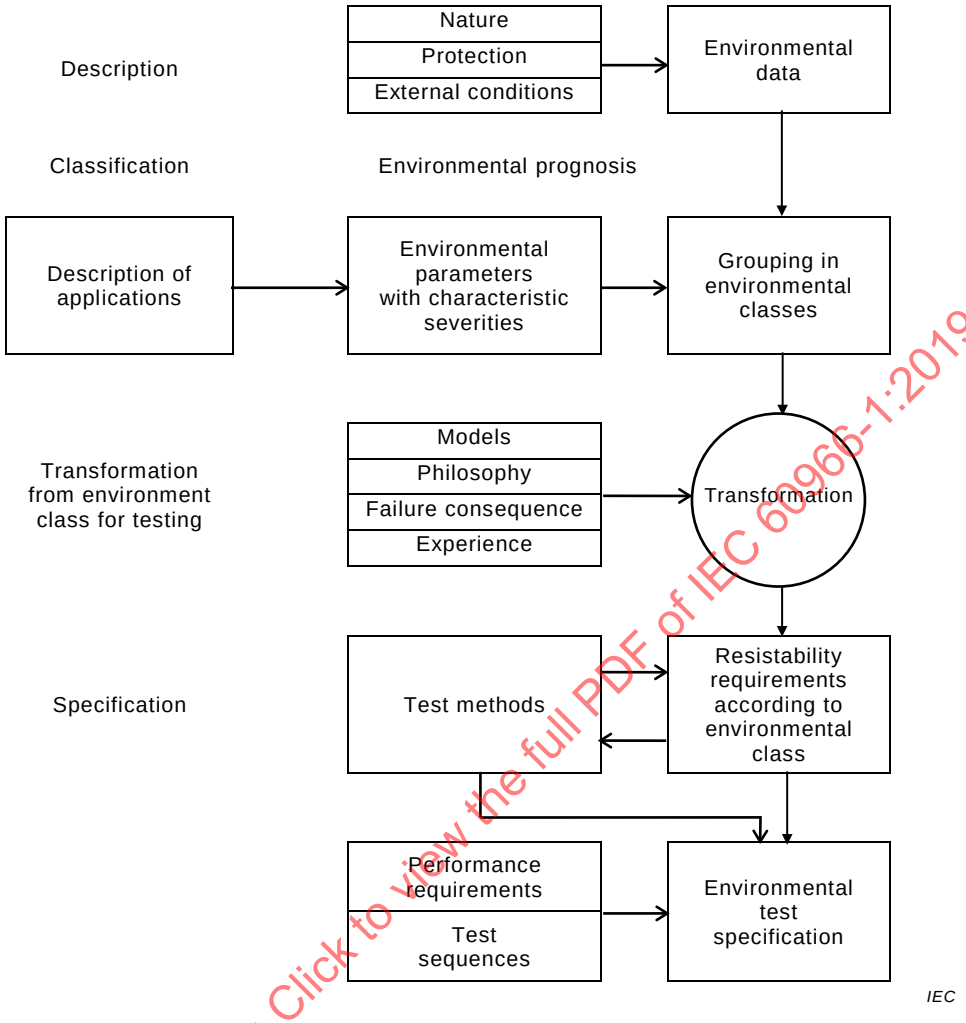


Figure C.1 – Description of action needed for the preparation of the environmental test specification

C.2 Recommended severities for environmental tests

C.2.1 Vibration

This test shall be carried out in accordance with test Fc of IEC 60068-2-6, as specified in 9.3.3 of IEC 61169-1:2013, which includes details on continuity monitoring and on the information which should be given in the relevant sectional and detail specifications.

The vibration severity shall be defined by a combination of three parameters: range of frequency, vibration amplitude and duration in terms of the number of cycles. The relevant specification shall select the appropriate requirement for each parameter from the following recommended values:

Swept frequency range: 10 Hz to 150 Hz
10 Hz to 500 Hz
10 Hz to 2 000 Hz

Vibration amplitude: . . . . . .

Vibration amplitude shall be specified below 57 Hz to 62 Hz and at frequencies higher than acceleration amplitude, see Table C.1.

Table C.1 – Relationship between displacement and acceleration

Displacement amplitude	Acceleration amplitude	
mm	m/s^2	g
0,75	98	10
1,0	147	15
1,5	196	20

Duration: . . . . . .

Number of swept cycles in each axis: 2, 5, 10 or 20.

C.2.2 Bump

This test shall be carried out in accordance with test 6b of IEC 60512-6-2. Unless otherwise required in the sectional or relevant detail specification, one of the following recommended severities shall be selected:

Number of bumps: 1 000 ± 10

C.2.3 Shock

This test shall be carried out in accordance with test Ea of IEC 60068-2-27.

Unless otherwise required in the sectional or relevant detail specification, one of the recommended pulse shapes given in the table below shall be selected. The shock severity is given by a combination of the peak acceleration and the duration of the nominal pulse, see Table C.2.

Table C.2 – Relationship between peak acceleration and velocity change

			Corresponding velocity change		
Peak acceleration		Corresponding duration of pulse	Final peak saw tooth	Half sine	Trapezoidal
m/s^2	g	ms	m/s	m/s	m/s
147	15	11	0,81	1,03	1,46
294	30	18	2,65	3,37	4,77
490	50	11	2,69	3,43	4,86
981	100	6	2,94	3,74	5,30
4 900	500	1	2,45	3,12	4,42
14 700	1 500	0,5	3,68	4,68	6,62

C.2.4 Climatic sequence

Unless otherwise required in the sectional or relevant detail specification, one of the following recommended severities shall be selected:

Low temperature: –40 °C to –55 °C

High temperature: +70 °C, +85 °C, +125 °C, +155 °C, +200 °C

Duration: 4, 10, 21 or 56 days

C.2.5 Damp heat, steady state

This test shall be carried out in accordance with test Cab of IEC 60068-2-78.

Unless otherwise required in the sectional or relevant detail specification, one of the following recommended severities shall be selected:

Duration: 4, 10, 21 or 56 days

C.2.6 Rapid change of temperature

This test shall be carried out in accordance with test Na of IEC 60068-2-14. The range of temperatures shall be selected in accordance with the test of climatic sequence.

Transfer time between temperature: <2 minutes

Number of cycles: 2, unless otherwise specified

C.2.7 Salt mist

This test shall be carried out in accordance with test Ka of IEC 60068-2-11. The duration of the test shall be either 96 h or 168 h.

C.2.8 Sulphur dioxide test

This test shall be carried out in accordance with test Kc of IEC 60068-2-42. The duration of the test shall be of four days.

C.2.9 Dust test

Under consideration, taking into account IEC 60068-2-68, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*.

Annex D
(normative)

Quality management

D.1 General

The purpose is to give general procedures on how to achieve a quality management for RF cable assemblies.

An RF cable assembly is a combination of a cable and connectors with specified performance, used as a single unit.

The cables should be preferably chosen from IEC 61196 (all parts) and the connectors from IEC 61169 sectional and detail specifications, (see Clause 1, Note 1), in many cases they will be customer-built products.

Quality assurance for connectors and cables is described in IEC 61169 sectional and detail specifications and IEC 61196 (all parts) respectively and does not form part of this document.

D.2 Object

This Annex D specifies qualification approval and capability approval procedures.

D.3 Basic aspects

D.3.1 Related documents

See Clause 2.

D.3.2 Standards and preferred values

Whenever possible, standards and preferred values according to this generic specification and the relevant sectional specification shall be used.

D.3.3 Marking of the cable assembly and packaging (see 5.2)

Unless otherwise specified in the detail specification (DS) or customer detail specification (CDS), each cable assembly shall be marked with as many of the following items, as space permits, given in the order of preference:

- type number;
- lot identification and/or date code and/or serial number;
- factory identification code;
- detail specification number.

All this information shall be marked on the primary package of the cable assemblies; all markings shall be legible and indelible.

D.3.4 Terminology

D.3.4.1 Capability manual (CM)

The capability manual (CM) of a manufacturer is a complete description of design rules, manufacturer processes and test procedures including the limits and the verification procedures. The capability manual is the basic document for granting a capability approval.

D.3.4.2 Quality manual (QM)

The quality manual (QM) describes either directly or by reference to the manufacturer's internal documents, the procedures used by the manufacturer to ensure conformity of his products with the applicable specifications. It is needed for both qualification and capability approval.

D.3.4.3 Capability qualifying components (CQCs)

CQCs are test specimens specially designed or taken from production, used for verifying capability limits in accordance with the capability manual (CM).

D.3.4.4 Primary stage of manufacture

The primary stage of manufacture is the first activity under the control of the manufacturer, according to the capability manual.

D.4 Quality management procedures

D.4.1 Procedures for qualification approval

D.4.1.1 General

Qualification approval is appropriate when the cable assemblies are made to standard patterns and usually in continuous production.

Qualification approval can only be achieved for existing detail specifications.

The relevant specifications state the requirements for the qualification approval of the cable assembly (test schedule, number of specimens, number of defectives permitted, etc.).

D.4.1.2 How to obtain qualification approval

To obtain qualification approval, the following steps shall be performed:

a) Approval of the manufacturer on the basis of his ability to produce and inspect components in conformance with the specifications and the agreed rules of procedure, limited to specified organisation and facilities, verified by audits on QM for example according to ISO 9001 or ISO 9002.

NOTE A valid approval according to the relevant ISO 9000 is recognized.

b) Successful completion of qualification tests usually made on production items according to the relevant specification.

D.4.1.3 How to maintain qualification approval

To maintain a qualification approval, the manufacturer shall comply with the following conditions to the satisfaction of national or regional requirements:

a) The results of the periodic audits by the national or regional authorized body at intervals no greater than one year on the quality manual shall be satisfactory.

b) The delivered products shall fulfill the quality assurance requirements.

c) An inspection of the current production is carried out in accordance with the specifications. The cable assemblies from lots which do not fulfill the specifications are not permitted to be delivered.

d) Successful completion of periodic tests according to the detail specification.

D.4.1.4 Modifications likely to affect qualification approval

The manufacturer shall report to the authorized regional or national body any technical modifications, including changes of place of manufacture, which could affect the results obtained where the qualification approval was delivered.

The authorized regional or national body shall then decide whether it is necessary to repeat all or some of the qualification approval tests before any components subject to the modifications are delivered under the system.

The authorized regional or national body shall, as a part of its surveillance, ensure that the reporting of modifications has taken place.

D.4.2 Procedures for capability approval

D.4.2.1 General

When the total volume of cable assemblies being manufactured for a particular customer order is less than the quantity of assemblies to be tested for a capability study based on the manufacturer's capability manual, then the capability study is not required to obtain capability approval.

As capability approval is process orientated, it is appropriate when the cable assembling technologies are fully controlled and the requirements of the customers with respect to design variants change to reflect final use.

Capability approval is valid for all existing and future detail specifications within the capability limits.

The capability manual states the requirements for the capability approval of all cable assemblies within the capability limits.

D.4.2.2 How to obtain a capability approval

To obtain a capability approval, the following steps shall be performed:

a) Approval of the manufacturer on the basis of his ability to produce and inspect components according to the specifications and the agreed rules of procedure, limited to specified organisation and facilities checked by audit on the QM for example according to ISO 9001 or ISO 9002.

NOTE A valid approval according to the relevant ISO 9000 is recognized.

b) Approval of the manufacturer on the basis of his capability manual by the authorized regional or national body.

c) Successful completion of qualification tests on CQCs specified by the chief inspector according to the CM and the relevant specifications.

D.4.2.3 How to maintain a capability approval

To maintain the capability approval, the manufacturer shall comply with the following conditions to the satisfaction of the authorized regional or national body:

a) He shall give evidence that the capability limits stay valid by periodic testing of the CQCs according to the CM.

b) The results of the periodic audits on the QM led by the authorized regional or national body at intervals no greater than one year shall be satisfactory.

c) The delivered products shall fulfill the quality assurance requirements.

d) The capability manual shall be continuously updated.

e) The register of the associated products shall be kept up to date.

D.4.2.4 Procedure for reduction, extension or change of capability

Where an approved manufacturer wishes to reduce, extend or change the domain of his capability, it is the responsibility of the chief inspector to decide whether the reduction, extension or change is significant or not.

Where the reduction, extension or change is not significant, it shall be recorded by the manufacturer who may proceed without the approval of the authorized regional or national body.

Where the reduction, extension or change is significant, the manufacturer shall notify the authorized regional or national body in advance.

The results of the tests carried out to demonstrate the effect of the change on the products shall be made available to the authorized regional or national body.

D.4.3 Quality conformance inspection

D.4.3.1 General

After qualification approval or capability approval has been obtained, the manufacturer is responsible for ensuring that no technical changes likely to affect the approval are introduced for the products without re-approval, and that the quality conformance inspection required by the specifications is carried out with success.

The quality conformance inspection is divided into two parts:

a) A first group of tests that is carried out lot by lot and serves to accept the individual production lots that it is based on.

b) A second group of tests, containing the time consuming and more expensive tests, that are carried out on a periodic basis.

Under qualification approval, the full test programme is given in the detail specification.

Under capability approval, periodic tests shall be performed on CQCs as prescribed in the CM.

D.4.3.2 Formation of inspection lots

An inspection lot may be formed by the aggregation of several production lots, provided that:

a) The production lots are manufactured under essentially the same conditions, without significant interruption.

b) All the production lots are assembled with the same piece parts.

D.4.3.3 Lot-by-lot tests

Lot-by-lot tests are carried out on each inspection lot.

Generally, lot-by-lot tests cover the visual and dimensional inspections and the principal characteristics of the cable assemblies.

D.4.3.4 Periodic tests

Periodic tests are carried out at fixed intervals on samples taken from lots which have already satisfied the lot-by-lot tests or on CQCs in case of capability approval. The periodicity and the number of samples are given in DS.

Generally, the periodic tests cover structural characteristics. They are time consuming and rather expensive.

D.4.3.5 Release or rejection of lots

Unless otherwise stated in the relevant specification, the lots shall be released or rejected on the basis of the lot-by-lot tests. Normally the failure of the sample submitted to one of the periodic tests shall entail the rejection of the lot from which the sample came.

D.5 Capability manual and approval

D.5.1 Responsibilities

It is the responsibility of the chief inspector to access the capability manual as well as to select and define CQCs.

To assure that the manufacturer's organization, processes and products are correctly documented in his quality and capability manuals and effectively implemented in accordance with the requirements, an audit shall be performed under the responsibility of the NSI.

The NSI shall verify the following items:

- capability manual;
- quality management;
- organization;
- design control;
- manufacturing inspections;
- control of equipment used for inspection, measuring and testing;
- control of non-conforming parts, material, products;
- handling, storage and delivery;
- change control;
- traceability.

D.5.2 Contents of the capability manual

D.5.2.1 Object

This section of the capability manual shall give the range of specifications covered by the capability approval.

D.5.2.2 List of revisions

The validation of an updated capability manual is part of the audit procedure.

Revisions shall be identified by an index and the date. When a revision takes place, a complete list of all changes shall be made which occurred during the preceding period.

D.5.2.3 Related documents

The capability manual shall make reference to all mentioned relevant documents.

D.5.2.4 Capability domain, capability limits and their related CQCs

(see Tables D.1, D.2 and D.3.)

This section shall give the identification of the domain in terms of:

a) connectors;
b) cables;
c) main assembly techniques;
d) other piece parts (sleeves, caps, armours, etc.);
e) test facilities.

This section shall also give a reference list of the capability limits and the CQCs chosen to assess these limits from the primary stage of manufacture to the final product.

D.5.2.5 Flow chart, including process parameters (see Table D.4)

This section shall include:

a) General flow chart(s) giving the full sequence of manufacturing and inspection processes, from the primary stage of manufacture to the delivery and the corresponding CQCs.
b) Working instructions and inspection procedures for all processes contained in the flow chart, generally by reference to in-house documentation.
c) Flow charts for CQCs.

D.5.2.6 Purchased raw materials and piece parts

This section shall identify purchasing specifications for the raw materials and piece parts used in the manufacturing processes.

D.5.2.7 Design rules

Unless covered by quality manual, the manufacturer's design rules shall be stated either directly or by reference to the manufacturer's internal documents.

D.5.2.8 Register of associated products

This section shall give the list of products which are, or can be, delivered under capability approval generally by reference to an annex.

D.5.3 Criteria for capability limits

The sectional specifications shall preferably give guidance for capability limits, technology, processes, performances and their related CQCs. The CM may include one or several sub-families from one or several sectional specifications.

Table D.1 – Example of capability limits for cable assemblies

Technology	Capability domain	Capability limits
Cable	Flexible (subfamily) Semi-rigid (subfamily) Semi-flexible (subfamily) Super-screened (subfamily)	Purchased according to IEC 61196-XX or other standards or manufactured according to processes described in the CM
Connectors	Series SMA, N, BNC, F, etc. Customer-built	Purchased according to IEC 61169-YY, IEC 60339 or other standards, or manufactured according to processes described in the CM
Other piece parts	Sleeves, armour, etc.	
Assembly techniques	Crimping Soldering, etc.	
Mechanical Electrical Environmental	Test group Mn Eb and/or Eh Vc and/or Vv	

Table D.2 – Example of capability limits for flexible cables

Inner conductor	Solid wire (range of diameters) Stranded wire Plated wire
Insulation	Extrusion (function of the material) Tape lapping Sintering
Outer conductor	Braid Foil plus braid Tape lapping
Jacket	Braid Extrusion (materials)

Table D.3 – Example of capability limits for connectors

Slicing
Molding
CNC machining
Electroforming
Electroerosion
Embossing
Plating, etc.

In this case, Tables D.2 and D.3 have been combined with Table D.1 concerning environmental, mechanical and electrical requirements.

Table D.4 – Example of flow chart (see D.5.2.5)

Operations	Limits	CQC	Specifications
Cable manufacture	Purchased according to IEC 61196-XX	NA	Purchasing specification Incoming inspection
Connector manufacture	Purchased according to IEC 61169-YY	NA	Purchasing specification Incoming inspection
Cable preparation	Accuracy 2 mm	CQC n° 001	Procedure n° 1001
Connector crimping	For outer cable diameter 5 mm to 15 mm	CQC n° 002	Procedure n° 1002
Connector soldering	For inner cable diameter of 0,5 mm to 4 mm	CQC n° 003	Procedure n° 1003
Tests Eh, Ez, Mn, Vt	12,5 GHz; –40/125 °C	CQC n° 004	Procedure n° 1004
Packaging			Procedure n° 1005

Bibliography

IEC 60339 (all parts), *General purpose rigid coaxial transmission lines and their associated flange connectors*

IEC 61196-1-324, *Coaxial communication cables – Part 1-324: Mechanical test methods – Test for abrasion resistance of cable*

ISO/IEC TR 29106, *Information technology – Generic cabling – Introduction to the MICE environmental classification*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

ISO 9001:2015, *Quality management systems – Requirements*

ISO 9002, *Quality management systems – Guidelines for the application of ISO 9001:2015*

SOMMAIRE

AVANT-PROPOS 59
1 Domaine d'application 61
2 Références normatives 61
3 Termes et définitions 62
4 Exigences de conception et de fabrication 64
4.1 Conception et construction des câbles 64
4.2 Conception et construction des connecteurs 65
4.3 Dimensions d'encombrement et dimensions de l'interface 65
5 Qualité d'exécution, marquage et emballage 65
5.1 Qualité d'exécution 65
5.2 Marquage 65
5.3 Protections d'extrémités 65
5.4 Emballage et étiquetage 65
6 Gestion de la qualité 65
7 Méthodes d'essai – Généralités 65
7.1 Conditions atmosphériques normalisées pour les essais 65
7.2 Examen visuel 66
7.3 Contrôle des dimensions 66
7.3.1 Dimensions d'interface 66
7.3.2 Dimensions d'encombrement 66
8 Essais électriques 67
8.1 Propriétés de réflexion 67
8.1.1 Objet 67
8.1.2 Matériel d'essai 67
8.1.3 Procédure 67
8.1.4 Exigences 68
8.1.5 Informations devant figurer dans la spécification particulière 68
8.2 Uniformité d'impédance 68
8.2.1 Objet 68
8.2.2 Procédure 68
8.2.3 Exigences 68
8.2.4 Informations devant figurer dans la spécification particulière 68
8.3 Pertes d'insertion 68
8.3.1 Procédure 68
8.3.2 Exigences 68
8.3.3 Informations devant figurer dans la spécification particulière 69
8.4 Stabilité des pertes d'insertion 69
8.4.1 Objet 69
8.4.2 Procédure 69
8.4.3 Exigences 69
8.4.4 Informations devant figurer dans la spécification particulière 69
8.5 Temps de propagation 69
8.5.1 Procédure 69
8.5.2 Exigences 69
8.5.3 Informations devant figurer dans la spécification particulière 69

8.6 Stabilité de la longueur électrique 69
8.6.1 Objet 69
8.6.2 Procédures 69
8.6.3 Exigences 72
8.6.4 Informations devant figurer dans la spécification particulière 72
8.7 Différence de phase 72
8.7.1 Objet 72
8.7.2 Procédure 72
8.7.3 Exigences 72
8.7.4 Informations devant figurer dans la spécification particulière 72
8.8 Variation de la phase avec la température 73
8.8.1 Objet 73
8.8.2 Procédure 73
8.8.3 Exigences 73
8.8.4 Informations devant figurer dans la spécification particulière 73
8.9 Efficacité d'écran 73
8.9.1 Impédance de transfert 73
8.9.2 Affaiblissement d'écran 73
8.10 Tenue en tension 74
8.10.1 Procédure 74
8.10.2 Exigences 74
8.10.3 Informations devant figurer dans la spécification particulière 74
8.11 Résistance d'isolement 74
8.11.1 Procédure 74
8.11.2 Exigences 74
8.11.3 Informations devant figurer dans la spécification particulière 74
8.12 Continuité des conducteurs intérieur et extérieur 75
8.12.1 Objet 75
8.12.2 Procédure 75
8.12.3 Exigences 75
8.12.4 Informations devant figurer dans la spécification particulière 75
8.13 Puissance assignée 75
8.13.1 Objet 75
8.13.2 Procédure 75
8.13.3 Exigences 75
8.13.4 Informations devant figurer dans la spécification particulière 75
8.14 Mesurage du niveau d'intermodulation 76
8.14.1 Procédure 76
8.14.2 Exigences 76
8.14.3 Informations devant figurer dans la spécification particulière 76
9 Essais de robustesse mécanique 76
9.1 Traction 76
9.1.1 Objet 76
9.1.2 Procédure 76
9.1.3 Exigences 76
9.1.4 Informations devant figurer dans la spécification particulière 77
9.2 Flexion 77
9.2.1 Objet 77
9.2.2 Procédure 77

9.2.3 Exigences 77
9.2.4 Informations devant figurer dans la spécification particulière 77
9.3 Endurance de la flexion 78
9.3.1 Objet 78
9.3.2 Procédure 78
9.3.3 Exigences 78
9.3.4 Informations devant figurer dans la spécification particulière 78
9.4 Ecrasement de cordon 78
9.4.1 Objet 78
9.4.2 Procédure 79
9.4.3 Exigences 79
9.4.4 Informations devant figurer dans la spécification particulière 79
9.5 Couple 79
9.5.1 Procédure 79
9.5.2 Exigences 80
9.5.3 Informations devant figurer dans la spécification particulière 80
9.6 Courbures multiples 80
9.6.1 Objet 80
9.6.2 Procédure 80
9.6.3 Exigences 81
9.6.4 Informations devant figurer dans la spécification particulière 81
9.7 Essai d'abrasion de cordon 81
9.7.1 Objet 81
9.7.2 Procédure 81
9.8 Vibrations et chocs 81
9.9 Essai d'impact 81
9.10 Endurance mécanique 81
10 Essais d'environnement 82
10.1 Sévérités recommandées 82
10.2 Vibrations, secousses et chocs 82
10.3 Séquence climatique 82
10.3.1 Procédure 82
10.3.2 Exigences 82
10.3.3 Informations devant figurer dans la spécification particulière 82
10.4 Chaleur humide, essai continu 82
10.4.1 Procédure 82
10.4.2 Exigences 82
10.4.3 Informations devant figurer dans la spécification particulière 83
10.5 Variations rapides de température 83
10.5.1 Procédure 83
10.5.2 Exigences 83
10.5.3 Informations devant figurer dans la spécification particulière 83
10.6 Résistance aux solvants et aux fluides contaminants 83
10.6.1 Procédure 83
10.6.2 Exigences 83
10.6.3 Informations devant figurer dans la spécification particulière 84
10.7 Immersion dans l'eau 84
10.7.1 Procédure 84
10.7.2 Exigences 84

10.7.3 Informations devant figurer dans la spécification particulière 84
10.8 Essais au brouillard salin et à l'anhydride sulfureux 84
10.8.1 Procédure 84
10.8.2 Exigences 84
10.8.3 Informations devant figurer dans la spécification particulière 84
10.9 Essais à la poussière 84
10.9.1 Objet 84
10.9.2 Procédure 85
10.9.3 Exigences 85
10.9.4 Informations devant figurer dans la spécification particulière 85
10.10 Inflammabilité 85
10.10.1 Procédure 85
10.10.2 Exigences 85
10.10.3 Informations devant figurer dans la spécification particulière 85
11 Méthodes d'essai spécialisées 85
12 Programmes d'essais 85
Annexe A (normative) Méthodes d'essai pour la détermination des pertes d'insertion 87
A.1 But 87
A.2 Méthodes d'essai 87
A.2.1 Généralités 87
A.2.2 Méthode d'essai 1 87
A.2.3 Méthode d'essai 2 88
A.2.4 Méthode d'essai 3 90
A.3 Correction de différences d'impédance caractéristique 91
Annexe B (informative) Méthodes de mesurage du temps de propagation 93
B.1 Généralités 93
B.2 Méthode de la résonance pour le mesurage du temps de propagation 93
B.3 Méthode du domaine temporel pour le mesurage du temps de propagation 94
Annexe C (informative) Sévérités recommandées pour les essais d'environnement 95
C.1 Introduction à la relation entre les conditions d'environnement et les sévérités d'essai 95
C.1.1 Généralités 95
C.1.2 Conditions d'environnement 95
C.1.3 Essais d'environnement 95
C.2 Sévérités recommandées pour les essais d'environnement 96
C.2.1 Vibrations 96
C.2.2 Secousses 97
C.2.3 Chocs 97
C.2.4 Séquence climatique 98
C.2.5 Essai continu de chaleur humide 98
C.2.6 Variations rapides de température 98
C.2.7 Brouillard salin 98
C.2.8 Essai au dioxyde de soufre 98
C.2.9 Essai de poussière 98
Annexe D (normative) Gestion de la qualité 99
D.1 Généralités 99
D.2 Objet 99
D.3 Aspects fondamentaux 99

D.3.1 Documents associés 99
D.3.2 Normes et valeurs préférentielles 99
D.3.3 Marquage et emballage des cordons (voir 5.2) 99
D.3.4 Terminologie 100
D.4 Procédures de gestion de la qualité 100
D.4.1 Procédures pour l'homologation 100
D.4.2 Procédures d'agrément de savoir-faire 101
D.4.3 Contrôle de conformité de la qualité 102
D.5 Manuel et agrément de savoir-faire 103
D.5.1 Responsabilités 103
D.5.2 Contenu du manuel de savoir-faire 104
D.5.3 Critères pour les limites du savoir-faire 105
Bibliographie 107

Figure 1 – Essai de courbure: cordon en forme de U 70
Figure 2 – Essai de courbure: cordon droit 71
Figure 3 – Essai de torsion: cordon en forme de U 72
Figure 4 – Montage d'essai de flexion du cordon 77
Figure 5 – Appareil pour l'essai d'endurance à la flexion du cordon 78
Figure 6 – Montage d'essai d'écrasement du câble 79
Figure 7 – Exemple de montage d'essai pour le couple 80
Figure 8 – Essai de courbures multiples 81
Figure A.1 – Circuit permettant de déterminer les pertes d'insertion 87
Figure A.2 – Circuit permettant de déterminer les pertes d'insertion – principe 89
Figure A.3 – Circuit de remplacement permettant de déterminer les pertes d'insertion 89
Figure A.4 – Circuit à double flux permettant de déterminer les pertes d'insertion 90
Figure B.1 – Disposition du matériel d'essai 93
Figure C.1 – Description de la démarche nécessaire à la préparation d'une spécification d'essais d'environnement 96

Tableau 1 – Plage normalisée de conditions atmosphériques 66
Tableau C.1 – Relation entre déplacement et accélération 97
Tableau C.2 – Relation entre accélération de crête et variation de vitesse 98
Tableau D.1 – Exemple de limites du savoir-faire pour cordons 105
Tableau D.2 – Exemple de limites du savoir-faire pour câbles souples 105
Tableau D.3 – Exemple de limites du savoir-faire pour connecteurs 105
Tableau D.4 – Exemple de diagramme (voir D.5.2.5) 106

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

CORDONS COAXIAUX ET CORDONS POUR FRÉQUENCES RADIOÉLECTRIQUES –

Partie 1: Spécification générique – Exigences générales et méthodes d'essai

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence

La Norme internationale IEC 60966-1 a été établie par le comité d'études 46 de l'IEC: Câbles, fils, guides d'ondes, connecteurs, composants passifs pour micro-onde et accessoires.

Cette troisième édition annule et remplace la deuxième édition parue en 1999. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) L'Annexe C (informative) Méthode de mesure de l'efficacité d'écran a été retirée;
b) Le paragraphe 8.9 donne les références aux procédures d'essai applicables.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
46/700A/FDIS	46/704/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60966, publiées sous le titre général *Cordons coaxiaux et cordons pour fréquences radioélectriques*, peut être consultée sur site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

IMPORTANT – Le logo *"colour inside"* qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

CORDONS COAXIAUX ET CORDONS POUR FRÉQUENCES RADIOÉLECTRIQUES –

Partie 1: Spécification générique – Exigences générales et méthodes d'essai

1 Domaine d'application

La présente partie de l'IEC 60966 définit les exigences relatives aux cordons coaxiaux et aux cordons pour fréquences radioélectriques travaillant en mode électromagnétique transversal (TEM: *Transverse Electromagnetic Mode*). Elle fixe des exigences générales pour contrôler les propriétés électriques, mécaniques et environnementales des cordons coaxiaux pour fréquences radioélectriques composés de câbles et de connecteurs. Des exigences supplémentaires relatives à des familles spécifiques de cordons figurent dans les spécifications intermédiaires applicables.

La conception des câbles et des connecteurs utilisés sera de préférence conforme aux différentes parties applicables de l'IEC 61196 et de l'IEC 61169, respectivement.

NOTE 1 Le présent document ne comprend pas les essais qui sont normalement effectués séparément sur les câbles et les connecteurs. Ces essais sont décrits dans l'IEC 61196-1 (toutes les parties) et l'IEC 61169-1, respectivement.

NOTE 2 Dans la mesure du possible, les câbles et connecteurs utilisés dans les cordons, même s'ils ne sont pas décrits dans la série IEC 61196 ou dans la série IEC 61169, sont soumis aux essais séparément conformément aux essais indiqués dans la spécification générique applicable.

NOTE 3 Lorsqu'un cordon possède une protection supplémentaire, les essais mécaniques et d'environnement décrits dans le présent document sont applicables.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068 (toutes les parties), *Essais d'environnement*

IEC 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-11, *Essais fondamentaux climatiques et de robustesse mécanique – Partie 2-11: Essais – Essai Ka: Brouillard salin*

IEC 60068-2-14, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60068-2-27, *Essais d'environnement – Partie 2-27: Essais – Essai Ea et guide: Chocs*

IEC 60068-2-42, *Essais d'environnement – Partie 2-42: Essais – Essai Kc: Essai à l'anhydride sulfureux pour contacts et connexions*

IEC 60068-2-68, *Essais d'environnement – Partie 2-68: Essais – Essai L: Poussière et sable*

IEC 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: chaleur humide, essai continu*

IEC 60332-1-2:2004, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour flamme à prémélange de 1 kW*

IEC 60512-6-2, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 6-2: Essais de contraintes dynamiques – Essai 6b: Secousses*

IEC 60512-7-2, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 7-2: Essais d'impact (fiches) – Essai 7b: Résistance mécanique aux chocs*

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60966-2 (toutes les parties), *Cordons coaxiaux et cordons pour fréquences radioélectriques*

IEC 60966-3 (toutes les parties), *Cordons coaxiaux et cordons pour fréquences radioélectriques*

IEC 60966-4 (toutes les parties), *Cordons coaxiaux et cordons pour fréquences radioélectriques*

IEC 61169 (toutes les parties), *Connecteurs pour fréquences radioélectriques*

IEC 61169-1:2013, *Connecteurs pour fréquences radioélectriques – Partie 1: Spécification générique – Prescriptions générales et méthodes de mesure*

IEC 61196 (toutes les parties), *Câbles coaxiaux de communication*

IEC 61196-1-119, *Coaxial communication cables – Part 1-119: Electrical test methods – RF power rating* (disponible en anglais seulement)

IEC 62037-2, *Dispositifs RF et à micro-ones passifs, mesure du niveau d'intermodulation – Partie 2: Mesure de l'intermodulation passive dans les cordons coaxiaux*

IEC 62153-4-6, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method* (disponible en anglais seulement)

IEC 62153-4-7:2015, *Méthodes d'essai des câbles métalliques de communication – Partie 4-7: Compatibilité électromagnétique (CEM) – Méthode d'essai pour mesurer l'impédance de transfert Z_T et l'affaiblissement d'écrantage a_S ou l'affaiblissement de couplage a_C des connecteurs et des cordons jusqu'à 3 GHz et au-dessus – Méthode triaxiale en tubes concentriques*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/

- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
cordon
association de câble(s) et connecteur(s), avec ou sans protection supplémentaire et présentant des performances spécifiées, utilisée comme un ensemble

3.2
cordon souple
cordon dont le câble peut supporter des flexions répétées

Note 1 à l'article: Le câble comporte généralement un conducteur extérieur tressé.

3.3
cordon semi-flexible
cordon non destiné à des applications nécessitant des flexions répétées du câble en service, mais supportant des courbures ou déformations afin de faciliter l'installation

3.4
cordon semi-rigide
cordon non destiné à subir des courbures ou flexions après sa fabrication

Note 1 à l'article: Toute courbure ou flexion durant l'installation ou l'utilisation peut dégrader les performances du cordon.

3.5
perte d'insertion
pertes produites par l'insertion d'un cordon dans un système

Note 1 à l'article: Dans la présente norme, c'est le rapport, exprimé en décibels, entre la puissance (P_1) délivrée à une charge raccordée directement à une source et la puissance (P_2) délivrée à une charge lorsque le cordon est inséré entre la source et la charge.

$$Insertion\ loss = 10 \times \log\left(\frac{P_1}{P_2}\right)$$

3.6
facteur de réflexion
rapport entre la valeur complexe de l'amplitude de l'onde réfléchie et la valeur complexe de l'amplitude de l'onde incidente au bout d'une ligne de transmission ou sur une section transversale de cette ligne

3.7
longueur électrique
longueur équivalente en espace libre d'un cordon

3.8
différence de longueur électrique
différence entre les longueurs électriques de cordons

3.9
différence de phase
différence de phase entre une onde électromagnétique transverse (TEM) qui a traversé le cordon et une onde identique qui a traversé un autre cordon

3.10
temps de propagation
temps nécessaire à la propagation d'une onde électromagnétique transverse (TEM) entre les plans de référence des deux connecteurs

3.11
rayon de courbure statique minimal
rayon utilisé dans les essais climatiques

Note 1 à l'article: C'est le rayon minimal admissible pour les installations fixes du câble.

3.12
rayon de courbure dynamique
rayon utilisé pour les essais de stabilité des pertes d'insertion, les essais de stabilité de la longueur électrique et les essais d'endurance à la flexion

Note 1 à l'article: C'est le rayon minimal de courbure pour les applications dans lesquelles les cordons sont soumis à des flexions. Des rayons de courbure plus grands permettent d'augmenter le nombre maximal de flexions.

3.13
impédance de transfert
rapport entre la tension induite à l'intérieur du cordon et le courant induit à l'extérieur du cordon

Note 1 à l'article: En pratique, il est relevé entre des points définis par des connecteurs accouplés aux connecteurs du cordon

3.14
affaiblissement d'écran
rapport entre la puissance du signal à l'intérieur du cordon et la puissance totale qui est rayonnée à l'extérieur du cordon

3.15
puissance assignée
puissance à l'entrée qui peut être acceptée en continu par le cordon chargé sur son impédance caractéristique

Note 1 à l'article: Dans la pratique, la puissance maximale qui peut être acceptée dépend de l'affaiblissement de réflexion.

Note 2 à l'article: La puissance assignée dépend des détails de montage, de la température ambiante, de la pression et de la circulation d'air. Elle est normalement spécifiée à une température ambiante de 40 °C.

3.16
vieillissement artificiel
processus utilisé pour améliorer la stabilité de l'affaiblissement par déphasage et la dilatation avec la température

Note 1 à l'article: Ce processus consiste normalement à soumettre l'ensemble du cordon à un certain nombre de cycles de température. Sauf indication contraire dans la spécification particulière applicable, soumettre l'ensemble du cordon à un vieillissement artificiel est facultatif et est laissé à la discrétion du fournisseur.

4 Exigences de conception et de fabrication

4.1 Conception et construction des câbles

Il convient que les câbles conformes à des spécifications intermédiaires ou particulières de l'IEC 61196 soient spécifiés chaque fois que cela est possible. Lorsque des câbles dont la conception s'écarte de celle de spécifications intermédiaires ou particulières de l'IEC 61196 sont exigés, ces câbles doivent être conformes aux exigences de la spécification intermédiaire ou particulière applicable du fabricant.

Conformément aux réglementations locales, les matières premières constituant le câble ainsi que celles servant à la protection supplémentaire doivent être choisies pour satisfaire aux directives et réglementations régionales ou nationales telles que RoHS et REACH en Europe.

4.2 Conception et construction des connecteurs

Les types de connecteurs conformes à la partie applicable de l'IEC 61169 doivent être spécifiés chaque fois que cela est possible, mais lorsqu'un connecteur de conception spéciale est exigé, l'interface doit être conforme à la partie applicable de l'IEC 61169, le cas échéant, et la construction du connecteur doit satisfaire aux exigences de la spécification particulière applicable.

Conformément aux réglementations locales, les matières premières constituant le connecteur ainsi que celles servant à la protection supplémentaire doivent être choisies pour satisfaire au RoHS et à d'autres réglementations environnementales telles que le REACH en Europe.

4.3 Dimensions d'encombrement et dimensions de l'interface

Les dimensions d'encombrement doivent être conformes à la spécification particulière applicable relative au cordon.

Les dimensions de l'interface doivent être conformes à la spécification particulière applicable.

5 Qualité d'exécution, marquage et emballage

5.1 Qualité d'exécution

Le cordon ne doit pas avoir de défaut visible et doit être propre et en bon état.

5.2 Marquage

Le marquage doit être lisible et conforme à celui qui est indiqué dans la spécification particulière applicable. Il doit permettre d'identifier le fabricant du cordon.

5.3 Protections d'extrémités

Sauf indication contraire dans la spécification particulière applicable, les connecteurs doivent être munis de protections d'extrémités jetables faites d'un matériau approprié pour le transport et le stockage, afin de protéger au moins chaque interface des détériorations et de la poussière.

5.4 Emballage et étiquetage

Sauf indication contraire, l'emballage et l'étiquetage doivent être conformes à la spécification particulière applicable.

6 Gestion de la qualité

L'Annexe D fournit un guide relatif à la gestion de la qualité couvrant l'agrément de savoir-faire ainsi que l'homologation.

7 Méthodes d'essai – Généralités

7.1 Conditions atmosphériques normalisées pour les essais

Il est nécessaire de contrôler les conditions atmosphériques normalisées dans une certaine plage pour garantir une bonne corrélation des données obtenues à partir des mesurages et des essais réalisés dans différentes installations. Sauf spécification contraire, effectuer les mesurages et les essais dans les conditions atmosphériques suivantes. Dans certains cas, des conditions ambiantes spéciales peuvent être nécessaires et indiquées dans la spécification particulière.

Le Tableau 1 donne la plage normalisée de conditions atmosphériques pour effectuer des mesurages et des essais.

Tableau 1 – Plage normalisée de conditions atmosphériques

Conditions	Valeur normalisée
Température	23 °C ± 5 °C
Humidité relative	(45 ± 25) %
Pression atmosphérique (limites inclusives)	Pression atmosphérique ambiante du site

Maintenir les variations de température ambiante et d'humidité à leurs valeurs minimales pendant une série de mesurages.

Lorsqu'il est impossible d'effectuer les essais dans les conditions atmosphériques normalisées, une note à cet effet décrivant les conditions réelles d'essai doit être ajoutée au rapport d'essai.

7.2 Examen visuel

Le spécimen doit être examiné visuellement afin de s'assurer que:

a) l'état, la qualité d'exécution et la finition sont satisfaisants;

b) le marquage est conforme à 5.2 du présent document;

c) il n'y a pas de détérioration mécanique ni de mouvement ou déplacement non voulu de pièces;

d) il n'y a pas de corrosion ni d'écaillage sur les matériaux ou les surfaces.

L'examen peut généralement être effectué en utilisant un grossissement jusqu'à x 3.

7.3 Contrôle des dimensions

7.3.1 Dimensions d'interface

Les dimensions de l'interface doivent être soumises à des essais pour vérifier qu'elles sont conformes à la spécification particulière applicable en utilisant le matériel d'essai approprié.

Lorsque des connecteurs conformes à des spécifications intermédiaires et particulières de l'IEC 61169 sont utilisés, le contrôle des dimensions de l'interface peut être limité aux caractéristiques qui sont susceptibles de varier à la suite d'un mauvais assemblage, par exemple les dimensions axiales du plan de référence par rapport au diélectrique et aux caractéristiques des contacts intérieurs.

Lorsque d'autres connecteurs sont utilisés ou lorsque des exigences spéciales existent, les détails doivent être donnés dans la spécification particulière applicable.

7.3.2 Dimensions d'encombrement

Les dimensions d'encombrement doivent être mesurées conformément aux croquis de l'IEC 60966-2 (toutes les parties), de l'IEC 60966-3 (toutes les parties) ou de l'IEC 60966-4 (toutes les parties) selon le cas.

Toutes les exigences spéciales pour le mesurage des dimensions d'encombrement d'un cordon doivent être données dans la spécification particulière applicable.

8 Essais électriques

8.1 Propriétés de réflexion

8.1.1 Objet

Déterminer la quantité de signal réfléchie vers la source du signal par le cordon en essai dans un système adapté. Le comportement de la réflexion est de préférence exprimé en termes "d'affaiblissement de réflexion en dB".

8.1.2 Matériel d'essai

Un analyseur de réseau vectoriel (VNA: *Vector Network Analyzer*) capable de mesurer les paramètres S à l'aide d'étalons (circuit ouvert, court-circuit, charge) qui permet de caractériser les performances RF de dispositifs aux fréquences radioélectriques (RF) et hyperfréquences en termes de paramètres de diffusion de réseau, ou paramètres S.

L'affaiblissement de réflexion des cordons en essai doit être mesuré avec l'analyseur de réseau vectoriel (VNA) sur la plage de fréquences considérée spécifiée.

Une description détaillée de la procédure de correction d'erreur (étalonnage) est donnée dans le manuel de l'analyseur de réseau vectoriel.

Des raccords d'essai (ou fils d'essai) de précision avec de faibles réflexions intrinsèques doivent être montés aux deux extrémités du cordon en essai pour permettre une connexion directe à l'analyseur de réseau vectoriel et à la charge de sortie.

8.1.3 Procédure

Pour mesurer les caractéristiques de réflexion de cordons, une attention particulière doit être accordée aux éléments suivants:

- vérifier que la vitesse de balayage est suffisamment faible pour que le signal réfléchi reste au centre du filtre-IF du système de réception. Plus le câble est long, plus une vitesse de balayage réduite doit être choisie;
- les cordons peuvent comporter des transitoires d'affaiblissement de réflexion étroits. Dans le cas de systèmes d'analyse de réseau continus, la vitesse de balayage doit être suffisamment faible et, pour les systèmes d'analyse de réseau numériques, le nombre de points de mesurage doit être suffisamment élevé pour résoudre d'éventuels transitoires d'affaiblissement de réflexion.

Par exemple, pour les systèmes numériques, il convient que le nombre de points soit:

$$n \geq 3(f_2 - f_1)\ L\ /\ (120)$$

où

n est le nombre de points d'échantillonnage dans la plage de fréquences f_1 à f_2 formant la courbe de réponse;

f_1 est la plus basse fréquence de la plage, en MHz;

f_2 est la plus haute fréquence de la plage, en MHz;

L est la longueur physique du spécimen d'essai, en m.

Si ces critères ne sont pas respectés, la distance entre les points d'échantillonnage de fréquence peut être trop importante, et provoquer des défauts de mesurage importants.

L'affaiblissement de réflexion des cordons n'est pas nécessairement symétrique des deux côtés, et des mesurages peuvent être exigés des deux côtés. Sauf indication contraire dans

la spécification particulière applicable, le cas le plus défavorable doit être conforme à la spécification.

Le système doit être étalonné avec les types de connecteurs appropriés. S'ils ne sont pas disponibles, des raccords doivent être utilisés. Les raccords détériorent l'affaiblissement de réflexion mesuré, mais le résultat ne doit pas être corrigé pour les raccords. L'affaiblissement de réflexion combiné, raccords compris, doit être conforme à la spécification.

D'autres techniques pour mesurer les caractéristiques de réflexion d'un cordon peuvent être utilisées, après accord avec le client.

8.1.4 Exigences

Les valeurs de l'affaiblissement de réflexion mesurées doivent respecter les limites spécifiées.

8.1.5 Informations devant figurer dans la spécification particulière

a) affaiblissement de réflexion minimal, en fonction de la fréquence, le cas échéant;

b) plage de fréquences;

c) résolution de fréquence exigée;

Mesurages à effectuer à partir d'une extrémité ou des deux extrémités.

8.2 Uniformité d'impédance

8.2.1 Objet

Déterminer la variation de l'impédance caractéristique locale du cordon.

8.2.2 Procédure

Le mesurage est effectué en utilisant un réflectomètre dans le domaine temporel (TDR: *Time Domain Reflectometer*) avec un échelon d'entrée appliqué au cordon à travers une ligne à air agissant comme une impédance de référence (voir l'IEC 61196-1-112 et l'IEC 61169-1:2013, 9.2.1.2.2). La variation de l'impédance le long du cordon doit être observée.

En variante, un système utilisant la conversion du domaine fréquentiel en domaine temporel peut être utilisé.

8.2.3 Exigences

Conformes à celles indiquées dans la spécification particulière applicable.

8.2.4 Informations devant figurer dans la spécification particulière

a) temps de montée du système TDR;

b) limites de la variation d'impédance.

8.3 Pertes d'insertion

8.3.1 Procédure

Les pertes d'insertion doivent être contrôlées conformément à l'Annexe A.

8.3.2 Exigences

Les pertes d'insertion ne doivent pas dépasser les limites spécifiées à toutes les fréquences contenues dans la bande de fréquences indiquée dans la spécification particulière applicable.

8.3.3 Informations devant figurer dans la spécification particulière

a) pertes d'insertion maximales, le cas échéant, en fonction de la fréquence;

b) plage de fréquences.

8.4 Stabilité des pertes d'insertion

8.4.1 Objet

Déterminer les variations de l'affaiblissement à une fréquence donnée lorsque le cordon est soumis à une courbure dynamique.

8.4.2 Procédure

Pendant le mesurage des pertes d'insertion, effectuée conformément à 8.3, le câble est enroulé sur un mandrin de rayon égal au rayon de courbure dynamique et suivant le nombre de tours indiqué dans la spécification particulière applicable.

8.4.3 Exigences

Pendant et après l'essai, la variation spécifiée des pertes d'insertion indiquée dans la spécification particulière applicable ne doit pas être dépassée.

8.4.4 Informations devant figurer dans la spécification particulière

a) rayon de courbure dynamique du câble (rayon du mandrin);

b) nombre de tours et partie du cordon sur le mandrin;

c) fréquences d'essai;

d) variation maximale de pertes d'insertion.

8.5 Temps de propagation

8.5.1 Procédure

Le temps de propagation est contrôlé conformément à l'Annexe B.

8.5.2 Exigences

Le temps de propagation ne doit pas dépasser les limites indiquées dans la spécification particulière applicable.

8.5.3 Informations devant figurer dans la spécification particulière

a) bande de fréquences dans laquelle le mesurage est effectué (voir l'Article B.1) ou temps de montée du système (voir l'Article B.2);

b) temps de propagation et tolérance.

8.6 Stabilité de la longueur électrique

8.6.1 Objet

Déterminer la variation de phase provoquée par la variation de la longueur électrique lorsque le cordon est soumis à une courbure ou à une torsion.

8.6.2 Procédures

8.6.2.1 Courbure

Méthode 1

Un cordon en forme de U doit être raccordé à un analyseur de réseau approprié conformément à 8.1.2 (voir Figure 1). Durant l'enregistrement de la phase du signal d'émission, le câble est enroulé autour du mandrin sur 180° (voir Figure 1), déroulé jusqu'à la position de départ, enroulé dans le sens antihoraire sur 180° autour du mandrin (voir Figure 1), puis déroulé à nouveau jusqu'à la position initiale. La position initiale du mandrin doit être choisie de manière que seules les parties droites du U soient courbées durant l'essai.

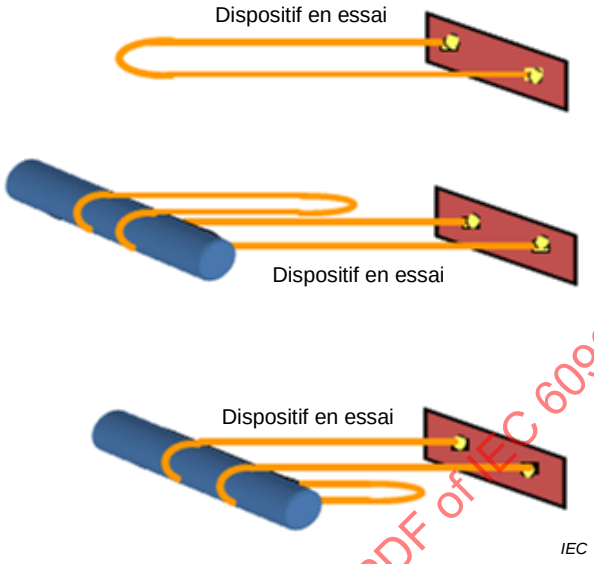


Figure 1 – Essai de courbure: cordon en forme de U

Méthode 2

Un cordon de forme droite doit se terminer par un court-circuit à une extrémité et doit être raccordé à un analyseur de réseau approprié, conformément à 8.1.2, à l'autre extrémité. Durant l'enregistrement de la phase du signal réfléchi, le câble est d'abord enroulé dans le sens horaire autour du mandrin sur un demi-tour, relâché jusqu'à la position de départ, enroulé dans le sens antihoraire autour du mandrin, puis relâché à nouveau pour regagner sa position de départ. Voir Figure 2.

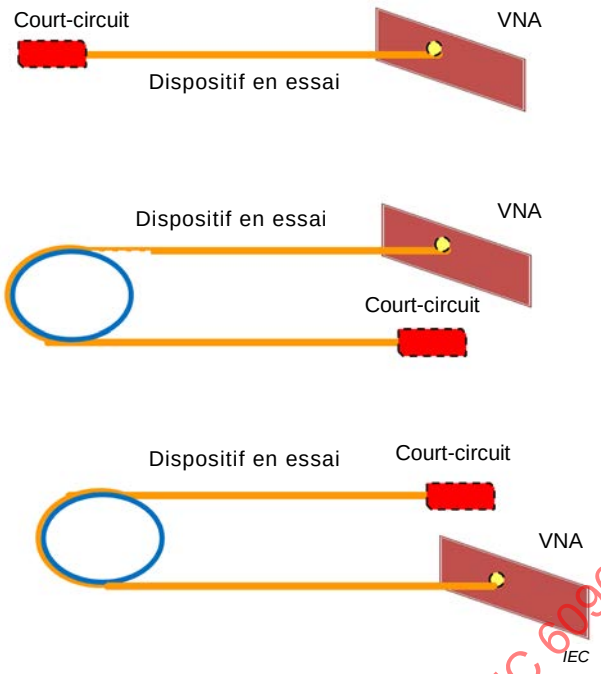
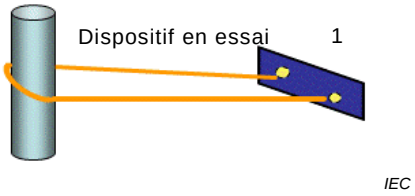


Figure 2 – Essai de courbure: cordon droit

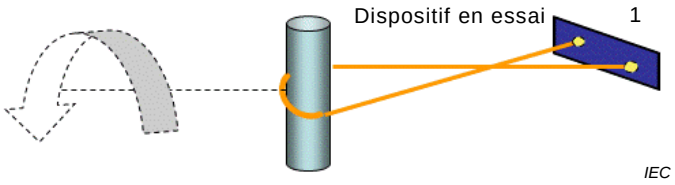
8.6.2.2 Torsion

Un cordon en forme de U doit être raccordé à un analyseur de réseau approprié conformément à 8.1.2 (voir Figure 3a). Durant l'enregistrement de la phase du signal d'émission, le mandrin au milieu du câble est d'abord tordu dans le sens horaire sur 180° (voir Figure 3b), puis relâché pour regagner la position de départ, tordu dans le sens antihoraire sur 180° (voir Figure 3c), puis relâché à nouveau pour regagner sa position de départ.

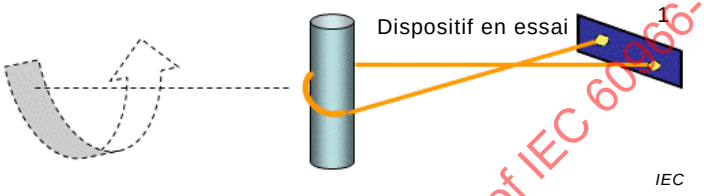
En fonction de la rigidité en torsion et du couple maximal admissible au niveau de l'interface des connecteurs de câble, l'angle de torsion maximal peut devoir être restreint.



a) Position de départ



b) Torsion dans le sens horaire



c) Torsion dans le sens anthoraire

Figure 3 – Essai de torsion: cordon en forme de U

8.6.3 Exigences

La différence de phase ne doit pas dépasser les limites indiquées dans la spécification particulière applicable.

8.6.4 Informations devant figurer dans la spécification particulière

a) rayon du mandrin (généralement le rayon de courbure dynamique du câble);

b) fréquence d'essai;

c) variation maximale de phase.

8.7 Différence de phase

8.7.1 Objet

Mesurer la différence de phase entre deux cordons ou plus.

8.7.2 Procédure

Les mesurages doivent être effectués en utilisant un analyseur de réseau approprié de résolution conforme à 8.1.2. En variante, une ligne à fente peut être utilisée lorsque les exigences relatives à la fréquence et à la précision le permettent.

8.7.3 Exigences

La différence de phase ne doit pas dépasser les limites indiquées dans la spécification particulière applicable.

8.7.4 Informations devant figurer dans la spécification particulière

a) différence de phase maximale ou différence de phase nominale avec les tolérances;

b) fréquence.

8.8 Variation de la phase avec la température

8.8.1 Objet

Déterminer les variations de phase dues à la variation de la longueur électrique lorsque le cordon est soumis à des variations de température dans sa plage de températures de fonctionnement.

Si cela est indiqué dans la spécification particulière applicable, cet essai peut être effectué sur un spécimen de cordon plutôt que sur un cordon fini. Le spécimen de cordon doit être identique au cordon fini excepté pour la longueur et la forme.

8.8.2 Procédure

Les mesurages doivent être effectués en utilisant un analyseur de réseau approprié conformément à 8.1.2, avec le cordon, y compris ses connecteurs, dans une enceinte dont la température est contrôlée. Les détails concernant chaque support de câble doivent être donnés dans la spécification particulière applicable.

Lorsque les essais sont effectués sur un spécimen de cordon, le câble doit former une ou plusieurs boucles sans support, d'un diamètre égal à au moins dix fois le rayon de courbure statique minimal.

Six cycles de température doivent être utilisés. En variante, une ligne à fente peut être utilisée lorsque les exigences relatives à la fréquence et à la précision le permettent.

8.8.3 Exigences

Pendant l'essai, la variation de phase ne doit pas dépasser les limites indiquées dans la spécification particulière applicable.

8.8.4 Informations devant figurer dans la spécification particulière

a) plage de températures et cycle de température en fonction du temps;

b) fréquence de mesurage;

c) méthode de présentation des résultats, par exemple $\Delta\varphi$/°C;

d) variation de phase admissible;

e) configuration du spécimen de cordon de remplacement, s'il est autorisé.

8.9 Efficacité d'écran

8.9.1 Impédance de transfert

L'impédance de transfert doit être soumise à essai.

Les essais applicables pour l'impédance de transfert sont présentés dans l'IEC 62153-4-6 ou l'IEC 62153-4-7.

La spécification particulière applicable doit indiquer l'essai applicable, la plage de fréquences et la valeur minimale d'impédance de transfert.

8.9.2 Affaiblissement d'écran

L'affaiblissement d'écran doit être soumis à essai conformément à l'IEC 62153-4-7.

La spécification particulière applicable doit indiquer la plage de fréquences et la valeur minimale d'affaiblissement d'écran.

8.10 Tenue en tension

8.10.1 Procédure

Chaque cordon doit pouvoir supporter la tension indiquée dans la spécification particulière applicable sans claquage ni contournement. La valeur minimale de la tension d'essai, déduite de la tension assignée de service U du cordon et de la tension d'essai E (toutes deux exprimées en tension continue ou en valeur de crête de la tension alternative), est donnée par:

E = 3 U pour les cordons ayant une tension assignée de service allant jusqu'à 1 kV compris,

ou

E = 1,5 U avec un minimum de 3 kV pour les cordons ayant une tension assignée de service supérieure à 1 kV.

La valeur de crête de la tension alternative indiquée dans la spécification particulière applicable, à une fréquence comprise entre 40 Hz et 60 Hz, doit être appliquée entre le conducteur intérieur et le conducteur extérieur du cordon en utilisant un connecteur accouplé comme interface.

En variante, une tension continue égale à la valeur de crête de la tension alternative peut être appliquée.

La tension doit être appliquée pendant 1 min, sauf indication contraire dans la spécification particulière applicable.

8.10.2 Exigences

Il ne doit pas se produire de claquage ni de contournement.

8.10.3 Informations devant figurer dans la spécification particulière

a) tension d'essai;

b) toutes les exigences spéciales.

8.11 Résistance d'isolement

8.11.1 Procédure

La résistance d'isolement doit être mesurée entre le conducteur intérieur et le conducteur extérieur du cordon sous une tension continue de 500 V ± 50 V ou sous la tension assignée du cordon si elle est inférieure.

La résistance d'isolement doit être mesurée après un temps de stabilisation de 60 s ± 5 s, sauf indication contraire dans la spécification particulière applicable.

8.11.2 Exigences

La valeur de la résistance d'isolement ne doit pas être inférieure à la valeur indiquée dans la spécification particulière.

8.11.3 Informations devant figurer dans la spécification particulière

a) tension d'essai;

b) temps de stabilisation;

c) valeur de résistance

8.12 Continuité des conducteurs intérieur et extérieur

8.12.1 Objet

Vérifier la continuité du conducteur intérieur et du conducteur extérieur en courant continu et à basse fréquence.

8.12.2 Procédure

Toute méthode appropriée peut être utilisée.

8.12.3 Exigences

Il ne doit pas y avoir de discontinuité indésirable du conducteur intérieur ou du conducteur extérieur en courant continu ou à basse fréquence.

8.12.4 Informations devant figurer dans la spécification particulière

a) tension d'essai;

b) courant d'essai;

c) fréquence.

8.13 Puissance assignée

8.13.1 Objet

La puissance assignée d'un cordon est définie comme la puissance d'entrée pour toutes fréquences, températures et pressions spécifiées, pouvant être supportée en continu lorsque le cordon est terminé sur une charge correspondant à l'impédance caractéristique.

La limite peut être la tension maximale de fonctionnement admissible ou la température maximale du conducteur intérieur du câble ou du connecteur.

L'essai de tenue en puissance se divise ainsi en deux catégories:

a) tenue en puissance continue;

b) tenue en puissance de crête ou pulsée.

8.13.2 Procédure

L'essai doit être réalisé conformément à l'IEC 61196-1-119 en relevant toute indication de formation d'un arc et de déplacement mécanique du joint de brasure ou mécanique.

8.13.3 Exigences

Il ne doit apparaître aucun signe de claquage dû à une surchauffe, un arc ou un contournement tout au long de l'application de la puissance spécifiée en relation avec les conditions d'environnement indiquées dans la spécification particulière applicable. Après l'essai, le cordon ne doit laisser apparaître aucune détérioration visible et les exigences électriques doivent être satisfaites.

Il convient que la température assignée des matériaux des composants ne soit pas dépassée.

8.13.4 Informations devant figurer dans la spécification particulière

a) température;

b) pression;

c) humidité relative.

Essai de puissance crête