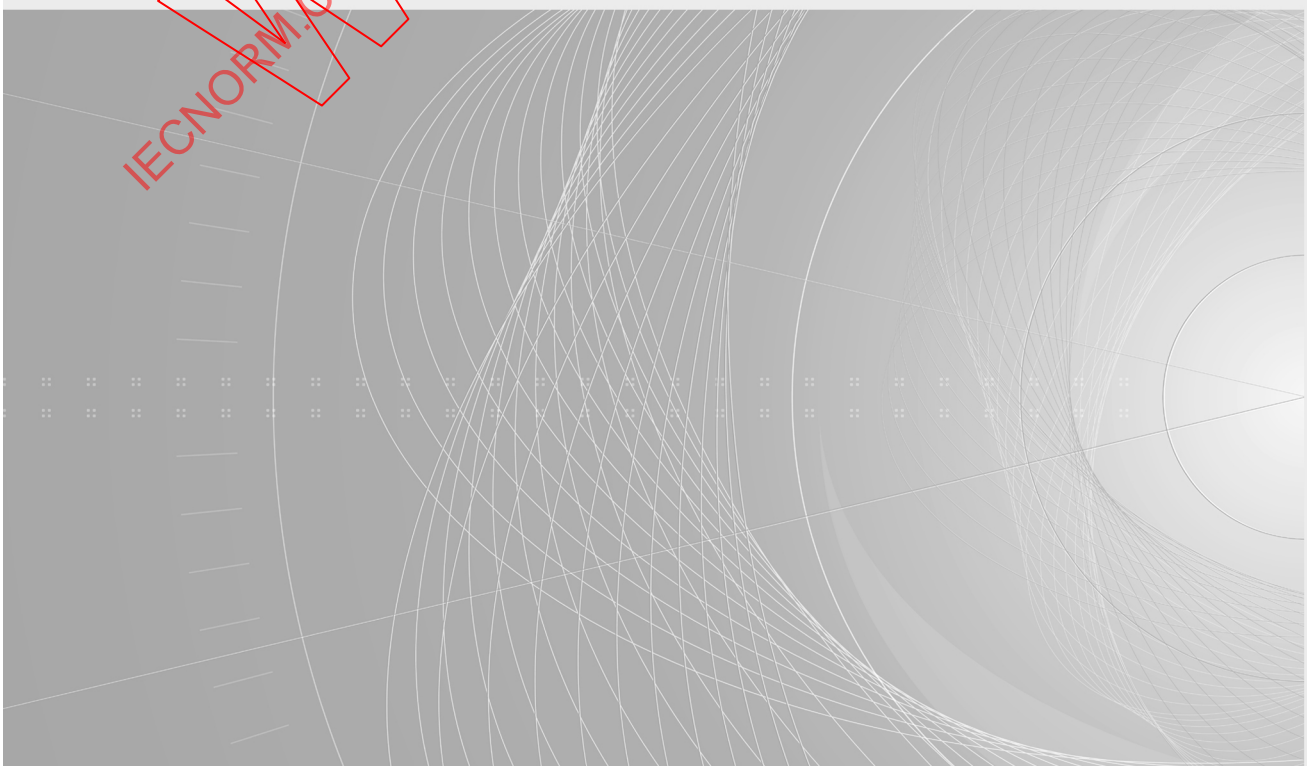
IEC/TR 60092-370

Edition 1.0 2009-07

TECHNICAL REPORT

Electrical installations in ships –
Part 370: Guidance on the selection of cables for telecommunication and data transfer including radio-frequency cables



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

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 corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC/TR 60092-370

Edition 1.0 2009-07

TECHNICAL REPORT

Electrical installations in ships – Part 370: Guidance on the selection of cables for telecommunication and data transfer including radio-frequency cables

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE R

ICS 29.060.20; 47.020.60

ISBN 978-2-88910-054-5

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 370: Guidance on the selection of cables for telecommunication and data transfer including radio-frequency cables

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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 60092-370, which is a technical report, has been prepared by subcommittee 18A: Electric cables for ships and mobile and fixed offshore units, of IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

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

Enquiry draft	Report on voting
18A/289/DTR	18A/302/RVC

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

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

A list of all parts of the IEC 60092 series can be found, under the general title *Electrical installations in ships*, on the IEC website.

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

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

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

INTRODUCTION

IEC 60092 series of International Standards concerns electrical installations in sea-going ships, and fixed and mobile offshore units, incorporating good practice and co-ordinating as far as possible existing rules.

These standards form a code of practical interpretation and amplification of the requirements of the International Convention on Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by shipowners, shipbuilders, mobile and fixed offshore units owners and builders and appropriate organisations.

This IEC/TR 60092-370 has been prepared by the maintenance team MT2 of the IEC subcommittee 18A.

Cables selected for installation onboard ships and on offshore installations are usually installed and are expected to operate in much harsher environments than equivalent land based types. The risk of mechanical abuse during installation, physical dislocation due to tension and bending allied with extremes of temperature are examples of the conditions to which these cables may be subject. If faults occur unlike onshore installations, trained experienced technicians may not always be readily available to affect a repair or replacement.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 370: Guidance on the selection of cables for telecommunication and data transfer including radio-frequency cables

1 Scope

This Technical Report gives guidance and lays down the basic recommendations for the selection and installation of shipboard and offshore unit cables intended for electrical systems used in both essential and non-essential analogue or digital signal communication, transmission and control networks, including types suitable for high-frequency signals (i.e. signals with a frequency of more than 10^5 Hz). These cables are not suitable for direct connection to low impedance supplies. Where such cables are required, attention is drawn to IEC 60092-353.

Cables intended to have limited circuit integrity (fire resistance) when affected by fire are not covered by this technical report.

Fibre optical cables are not included.

Sub-sea or umbilical cables are not included.

2 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60092-350 apply.

3 Selection of cables

Cables with physical and electrical characteristics in accordance with the IEC 60092 series of international standards are recommended for use in the marine environment.

Cables constructed in accordance with the following standards are acceptable provided that due consideration has been given to their use in a marine environment: IEC 60189-1, IEC 60189-2, IEC 60189-3, and IEC 60096-0-1.

4 Fundamental considerations

The choice of materials and cable construction should be suitable for the intended application and installation of the cable.

The high level of electrical performance associated with many modern cables is only achieved by the accurate, consistent positioning of the various components within the cable. Careless or excess tension, compression or bending can alter this relationship. This may then have significant detrimental effects upon the fundamental performance of the cable at high data rates.

Similarly these high levels of electrical performance can usually only be achieved by the use of polymers and insulation systems that may not have the same reaction to fire characteristics as the more traditional materials used in other marine cables. In recognition of this, careful consideration should be given to the method of installation to select that most appropriate to the particular application (see also Clause 8).

5 Constructional considerations

5.1 Selection of conductor

Only circular copper conductors, either plain or metal coated, or copper covered steel are recommended for use in a marine environment. Stranded conductors are recommended for general use. Where the applicable product standard specifies solid conductors, consideration should be given to the possible effects of vibration (due to the movement of the ship or installation) or movement (due to motion of the ship or installation).

The properties of copper conductors should be in accordance with IEC 60228. Joints in solid conductors or complete stranded conductors are not permitted, however joints in individual strands are allowed.

NOTE When cables are subject to continuous flexing the advice of the manufacture should be sought.

5.2 Selection of insulation

The range of materials for use as conductor insulation should, where possible, be selected from those listed in the IEC 60092-351 or as given in IEC 60096-0-1 and IEC 61156-5-1. For cables operating at the higher frequencies the insulation may be solid, cellular or a foam skin composite. The rated operating temperature of the insulating material should be at least 10 °C higher than the maximum ambient temperature likely to exist, or to be produced, in the space where the cable is installed.

The insulation should be continuous having a thickness as uniform as possible. The insulation should be applied to fit closely to the conductor.

NOTE The user should carefully select the insulation material regarding its electrical characteristics and intended use in the marine environment.

5.3 Cable elements

The cores within each pair, triple, or quad should be clearly identified by colour or number as given in the applicable cable standard. The identification used should be durable and legible.

The choice of the maximum average length of lay in the finished cable should be selected with respect to the specified crosstalk requirements, handling performance and the pair or quad integrity.

5.4 Selection of screen, core screen or shield

If a screen is required, it may consist of the following:

a) a metallic laminated tape bonded to polyester and a drain wire in direct contact with the metallic side of the tape,

b) plain or metal coated copper braid,

c) a metallic laminated tape bonded to polyester and a drain wire in direct contact with the metallic side of the tape with a plain or metal coated copper braid.

The construction of the screen, core screen or shield should be as listed in IEC 60092-350 or the applicable cable standard. Care should be taken when putting dissimilar metals in contact with each other. Coatings or other methods of protection may be necessary to prevent galvanic interaction often encountered in the saliferous marine environment.

NOTE The type of screening should be carefully selected by the user in respect of not only the type of disturbance, electrostatic or electro-magnetic, but also the mechanical hazards, and potential for corrosion, encountered in the marine environment.

5.5 Selection of outer protection

The range of materials for use as protective sheath should, where possible, be selected from those listed in IEC 60092-359 which have been proven by experience to be suitable for use in the marine environment. Materials listed in IEC 60096-0-1 and IEC 61156-1 may also be considered, the material chosen should meet the requirements of this technical report.

The material selected should be compatible with the cable components with which it is in contact and compatible with the intended environment and operating temperature of the cable.

In instances where the construction of a cable does not conform with a standard from the IEC 60092 series, it should be ensured that the material used as the protective sheath has adequate mechanical strength in respect of the mechanical hazards to which it may be subjected during installation and service. The potential for corrosion, of underlying layers, encountered in the marine environment should also be considered. Attention is drawn to the list of permitted protective coverings given in IEC 60092-350.

Due consideration should be given to fluid resistance for cables installed where water condensation or harmful vapours (including oil vapour) may be present. In this instance, the cables should meet the appropriate fluid resistance requirements of Annex D of IEC 61892-4.

NOTE Not all materials in IEC 60092-359 meet the fluid resistance requirement.

Also consideration should be given to the fire performance characteristics given in Clause 9.

The minimum thickness of sheath considered as being acceptable for cables for installation onboard a ship or offshore installation is 0,7 mm.

5.6 Selection of metallic sheath (covering), braid or armour

The construction of the metal braid armour should be in accordance with IEC 60092-350. The type of metal braid armour should be carefully selected by the user in respect of not only the mechanical hazards but also and potential for corrosion encountered in the marine environment. Care should be taken when putting dissimilar metals in contact with each other. Coatings or other methods of protection may be necessary to prevent galvanic interaction often encountered in the saliferous marine environment.

6 Marking

Cables should be provided with a continuous indication of origin (manufacturers name or trade mark), by one of the following methods:

a) printing, indenting or embossing on the outer sheath,

b) a printed tape within the cable,

c) the inclusion of identification threads within the cable,

d) printing on the insulation of at least one core.

The marking should be durable and legible.

The spacings and dimensions of the indication of origin should be as given in the applicable product standard.

7 Guidance on the selection of appropriate tests

Unless otherwise specified in the applicable product standard, tests should be made at an ambient temperature of (20 ± 15) °C.

This technical report defines, by the frequency range in the intended application, seven classes of cable (Table 1) and in Annex A gives guidance in the selection of the appropriate tests to be applied, related to each class.

Table 1 – Classification of cables by frequency range

Cable type	Frequency range
1	f max <100 kHz
2	100 kHz <f>1 MHz
3	1 MHz <f>16 MHz
4	16 MHz <f>125 MHz
5	125 MHz <f>250 MHz
6	250 MHz <f>600 MHz
7	250 Hz <f>1 000 MHz
NOTE All cables are backwards compatible.	

8 Guide to use

8.1 Introduction

The aim of this section is to inform users of characteristics and limitations of electric cables and thereby to minimise misuse.

It is assumed that the design of installation and the specification, purchase and installation of cables in accordance with this technical report is entrusted to suitable skilled and competent people.

In case of doubt as to the suitability of cables covered by this technical report for a particular use, further specific information should be obtained from the manufacturer.

8.2 General

All cables should be stored in a suitable place until required. Consideration should be given to security and environmental conditions.

Any protective packaging should not be removed until the cable is to be installed.

The ends of cables should always remain sealed during storage and installation to prevent the ingress of water and other contaminants.

8.3 Voltage rating

8.3.1 Data and telecommunication cables

All cables covered by this technical report should be subject to electrical tests applicable to their maximum rated voltage. Recommended maximum rated voltages for data and instrumentation cables are:

- 60 V a.c.
- 250 V a.c.

The rated voltage of any cable should not be lower than the nominal voltage of the circuit for which it is used.

NOTE These cables are not intended to be used for power supply.

8.3.2 High-frequency radio communications cables

The voltage rating of the cable should not be lower than the nominal voltage of the radio communication system in which it will be used.

8.4 Current ratings

The cables covered by this technical report are only recommended for use in circuits carrying analogue and digital signals.

Where high power co-axial feeder cables are to be used, advice from the cable manufacturer should be sought.

NOTE These cables are not intended to be used for power supply.

8.5 Thermal considerations

It is recommended that the rated operating temperature of the cable selected shall be at least 10 °C higher than the maximum ambient temperature likely to exist, or to be produced, in the space where the cable is installed.

These cables should not normally be run in groups or bundles containing power cables operating at or near their maximum operating temperature. Where this is unavoidable then the operating temperature should be based upon the lowest maximum operating temperature of any cable in the group or bundle.

All insulation and sheathing materials used for cables become progressively stiffer as their temperature is lowered below the normal ambient temperature to the point where they become brittle. This should be carefully considered when comparing the minimum operating temperature of the cable with the intended environment and application.

The cable should be acclimatised at the recommended environmental conditions before installation.

8.6 Size of conductors

The selection of the size of each conductor should not be based upon the attenuation or the electrical characteristics of the circuit alone. Account should be taken of the mechanical strength, the method, as well as the route, upon which the cable is to be installed. The cable should be of sufficient size as to mitigate mechanical damage, and impairment of its electrical integrity and characteristics, during installation and subsequent operation in the conditions encountered in the marine environment.

8.7 Radius of bend

The internal radius of bend for the installation of all cables should be chosen according to the type of cable as recommended by the manufacturer such that the electrical integrity and characteristics of the cable are not impaired due to disassociation of components within the cable.

The minimum bending radius used should never be less than what is recommended by the manufacturer.

Particular care should be taken when dressing cable, inserting cable into conduit, bending around corners in conduit or at the transition from vertical to horizontal tray to ensure that the cable is never bent below the recommended minimum bending radius.

NOTE Cable runs should be selected to keep the number of bends to a minimum.

Cables with class 5 conductors are not intended for flexible applications.

8.8 Tensile stress

In assessing the risk of mechanical damage to cables, account should be taken of any mechanical strains likely to be imposed during the normal process of installation of cables.

Cables should be so installed that the tensile stress applied to them either by reason of their own weight or for any other reason, is minimised. Excessive tension can cause disassociation of components within the cable resulting in the impairment of the electrical integrity and characteristics of the cable. These precautions are particularly important for cables of small cross-section and for cables on vertical runs or in vertical conduit or ducting.

The distances between supports should be as recommended by the cable manufacturer and chosen to avoid excessive tension due to sagging in the cable. Careful consideration should be given to cable runs along weather decks, when the cable run is arranged so that the cables can be subjected to forces by water washing over the deck.

The mechanical strength of conductors should be sufficient for the method of installation and working conditions.

8.9 Compression

Fixings and supports used should have a surface area sufficiently large and be shaped that the cables remain tight without their coverings being damaged. Care should be exercised to ensure that the forces applied by these fixings do not cause impairment of the electrical integrity and characteristics of the cable due to disassociation of components within the cable. Installations should be such that tensions in cables and cinching of bundles shall be minimized. The cable sheath should not be deformed.

Where individual stuffing glands or boxes containing several cables are used to penetrate bulkheads or decks, care needs to be taken to avoid excessive clamping or compressive forces causing impairment of the electrical integrity and characteristics of the cable due to disassociation of components within the cable. Installations shall be such that tensions in cables and cinching of bundles are minimized. The cable sheath should not be deformed.

8.10 Mechanical damage

To avoid the risk of mechanical damage, data, telecommunication and high-frequency radio communications cables should not normally be installed within the same conduit or trunking as cables of other services. Where this is impractical they should be separated by a strong, rigid and continuous partition.

8.11 Electromagnetic interference

In order to avoid as much as possible the effects of unwanted electromagnetic interference, attention should be given to IEC 60533. This might be of particular importance for the installation of cables in vicinity of radio equipment and for the installation of cables belonging to sensitive electronic control and monitoring systems.

Careful consideration shall be given to the earthing of metal coverings of cables to ensure that safety of personnel and equipment is achieved as well as meeting the requirements of the electrical characteristics of the circuit.

As general guidance, earthing of the metal covering at one end only will be effective against static electricity, spikes and discharges. However, the cable may then act as an antenna. Earthing of the metal covering at both ends will be effective against magnetic fields. However, ground loops or circulating currents may be set up in the cable.

The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The electrical continuity of all metal coverings throughout the length of the cables, particularly at joints and tappings, should be ensured.

Metal casings, pipes and conduits or trunking should be effectively earthed.

8.12 Terminations

Only approved proprietary terminations should be used when terminating essential, and non-essential, analogue or digital signal, communication, transmission and control cables. The length of sheath and protection removed should be minimised to prevent disassociation of the components within the cable.

8.13 Joints

Cable runs should not normally include joints. Where the use of joints is unavoidable, the advice of the cable manufacturer should be sought.

9 Performance in a fire

The high-level signal transmission characteristics achieved by some types of cables rely upon the use of polymers and insulation systems with reaction to fire properties that may not match those of the more traditional materials listed in IEC 60092-351 and IEC 60092-359, especially where cables are installed in large bunches. This problem has been recognised and there are now several possible solutions to it. Careful consideration should be given to each installation to select the most appropriate method. Examples of these solutions relate to the installation methods employed as well as material types. Typical methods are:

a) Installation techniques:
   - the use of additional fire stops,
   - additional segregation,

b) General housekeeping
   - removal of redundant obsolete cables,

c) Materials and related matters,
   - the use of intumescent coatings.

NOTE 1 The above examples are neither exhaustive, nor show any particular order of preference.

NOTE 2 Care should be taken with the use of methods in c) as some materials, if they burn, release significant quantities of dense smoke, which may obscure an escape route, and/or gases than may be corrosive to equipment or harmful to personnel.

NOTE 3 For the use of fire stops see Annex C of IEC 60092-352.

Not withstanding the foregoing, all cables should meet the requirements for flame as given in:

– IEC 60332-1-1 and IEC 60332-1-2,

– and IEC 60332-3-25. Unless otherwise specified in the individual product standard, the cables should be tested in a touching configuration.

NOTE 4 If a cable or an insulated wire meets the requirements of IEC 60332-12, it cannot be assumed that a bunch of similar cables or insulated wires will behave in a similar manner. The flame spread performance of bunched cables is assessed by the requirements of IEC 60332-3-25. This performance requirement (i.e. for cables mounted vertically in a touching formation) has been chosen to best reflect the installation conditions generally observed on board ships. Experience has shown that the test for the flame spread of cables installed vertically is adequate for horizontal installations, all other parameters being generally the same.

NOTE 5 Further information is given in IEC 60332-3-25.

For systems intended to maintain electrical circuit integrity under fire conditions, the selection of cable should only be made after consultation with the appropriate approval and regulatory authority.

Requirements for smoke emission and acid gas evolution should be considered where applicable and the cables evaluated in accordance with the following test methods and should meet the requirements specified in the individual product standard: IEC 61034-2, IEC 60754-1 and IEC 60754-2.

Annex A
(informative)

Table of tests

Test	Test basis	Requirements	Applicable to cable classification	T	S	R
		General properties				
Visual Inspection		Material free of cracks, splits, irregularities, foreign material, colour code and marking	1,2,3,4,5,6	X	X	X
Dimensions		Outer sheath thickness	1,2,3,4,5,6	X		X
		Electrical properties, low-frequency and d.c.				
Conductor loop resistance	IEC 61156-1, 6.2.1	The maximum value shall be ≤ 19 Ω/100 m	1,2,3,4,5,6	X	X	X
Conductor resistance unbalance	IEC 61156-1, 6.2.2	≤ 2 %	3,4,5,6	X	X	X
Dielectric strength conductor/conductor and conductor/screen	IEC 61156-1, 6.2.3	1,0 kV d.c. or 0,7 kV a.c. for 1 min or 2,5 kV d.c. or 1,7 kV a.c. for 2 s	1,2,3,4,5,6	X	X	X
Insulation resistance	IEC 61156-1, 6.2.4	≥ 500 MΩ.km using 100-500 V test voltage	1,2,3,4,5,6	X	X	X
Mutual capacitance	IEC 61156-1, 6.2.5	Measure and record in the test report	1			
Capacitance unbalance to earth	IEC 61156-1, 6.2.6	≤ 1 600 pF/km	2,3,4,5,6	X	X	X
		Electrical properties, high frequency				
Velocity of propagation	IEC 61156-1, 6.3.1	Phase delay ≤ 534 +36 /√f ns/100m, 1 MHz≤f≤600 MHz	2,3,4,5,6	X	X	
Propagation delay difference (skew)	IEC 61156-1	≤ 45 ns/100 m at 100 MHz ≤ 25 ns/100 m at 100 MHz	3,4,5 6	X X	X X	
Longitudinal attenuation	IEC 61156-1, 6.3.3	– α ≤ 1,910 8 √f+0,022 2 f+0,2/√f, 1 MHz ≤ f ≤ 100 MHz – α ≤ 1,82 √f+0,016 9 f+0,25 /√f, 1 MHz ≤ f ≤ 250 MHz – α ≤1,75 √f+0,01 f+0,2 /√f, 1 MHz ≤ f ≤ 600 MHz	2,3,4 5 6	X X X	X X X	X X X
Longitudinal attenuation	IEC 61156-1, 6.3.3	α ≤ 1,5(1,910 8 √f+0,022 2 f+0,2 /√f,) 1 MHz ≤ f ≤ 100 MHz α ≤ 1,5(1,82 √f+0,016 9 f+0,25 /√f), 1 MHz ≤ f ≤ 250 MHz α≤1,5(1,75 √f+0,01 f+0,2 /√f), 100 MHz ≤ f ≤ 600 MHz	2,3,4 5 6	X X X	X X X	X X X
Near-end crosstalk (NEXT)	IEC 61156-1, 6.3.5	≥4,0 MHz ≥ f < 125,0 MHz, 65,3 -15logf ≥4,0 MHz ≥ f < 250,0 MHz, 75,3 -15logf ≥80,01 MHz ≥ f < 31,25 MHz, 80 -15logf /31,25 31,25 MHz ≤ f ≤ 600 MHz	2,3,4 5 6	X X X	X X X	X X X

Test	Test basis	Requirements	Applicable to cable classification	T	S	R
Power sum near-end Crosstalk (PSNEXT)	IEC 61156-1	≥4,0 MHz ≥ f < 125,0 MHz, 62,3 -15logf ≥4,0 MHz ≥ f < 250,0 MHz, 72,3 -15logf ≥77,01 MHz ≤ f < 31,25 MHz 77,0-15logf /31,25 31,25 MHz ≤ f ≤ 600 MHz	2,3,4 5 6	X X X	X X X	X X X
Equal level far-end Crosstalk (ELFEXT)	IEC 61156-1	≥4,0 MHz ≥ f < 125,0 MHz, 62,3 -20logf ≥4,0 MHz ≥ f < 250,0 MHz, 72,3 -20logf ≥80,01 MHz ≤ f ≥ 4 MHz 94-20 logf, 4 MHzf ≤ 600 MHz, Values ref. to 100 m	4 5 6	X X X	X X X	
Power sum equal level far-end crosstalk (PSELFEXT)	IEC 61156-1	≥4,0 MHz ≥ f < 100 MHz, 61,0 -20logf ≥4,0 MHz ≥ f < 250,0 MHz, 65,0 -20logf ≥ 91-20 log(f), 4 MHz < f ≤ 600 MHz (77 dB max.) Values ref. to 100 m	4 5 6	X X X	X X X	
Mean characteristic impedance	IEC 61156-1, 6.3.10	100 ± 5 Ω, 120 ± 5 Ω, at 100 MHz; f.f.s	2,3,4,5,6	X	X	X
Return loss	IEC 61156-1	≥ 20+5 log (f), 4 MHz ≤ f ≤ 10 MHz; 25 dB, 10 MHz ≤ f < 20 MHz; 25-7 log (f/20), 20 MHz < f ≤ 100 ≥ 20+5 log (f), 4 MHz ≤ f ≤ 10 MHz; 25 dB, 10 MHz ≤ f < 20 MHz; 25-7 log (f/20), 20 MHz < f ≤ 250 ≥ 20+5 log (f), 4 MHz≤ f ≤ 10 MHz; 25 dB, 10 MHz ≤ f <20 MHz; 25-7 log (f/20), 20 MHz < f ≤ 250 MHz;17,3 dB, 250 MHz < f ≤ 600 MHz; f.f.s	3,4 5 6	X X X	X X X	X X X
Near end unbalance attenuation	IEC 61156-1	≥40-10 log(f) dB, 1 MHz ≤ f ≤ 600 MHz; f.f.s	2,3,4	X	X	
Coupling attenuation	IEC 61156-1	≥ 80 dB, 30 MHz ≤ f ≤ 100 MHz; f.f.s ≥ 80 - 20 log (f/100) dB, 100 MHz<f≤1 000 MHz; f.f.s	4,5,6	X	X	
Transfer impedance	IEC 61156-1, 6.2.7	≤ 15 mΩ/m at 1 MHz; ≤ 10 mΩ/m at 10 MHz; ≤ 30 mΩ/m at 30 MHz	1,2,3,4,5,6	X	X	
Screening attenuation	IEC 61156-1	≥ 55 dB, 30 MHz ≤ f ≤ 600 MHz; f.f.s Note - measured to 1 GHz	1,2,3,4,5,6	X	X	
		Tests to assess installation characteristics				
Crush resistance of the cable	IEC 61156-1, 6.4.8	1 000 N/1 min/100 mm Near end crosstalk, return loss and characteristic impedance shall remain within the specified limits	3,4,5,6	X	X	
Impact resistance of the cable	IEC 61156-1, 6.4.9	12,5 mm radius/1 J/3 impacts at 1m from the measured end Near end crosstalk, return loss and characteristic impedance shall remain within the specified limits	3,4,5,6	X	X	
Simulated installation testing of the cable	IEC 61156-1, 6.4.10.3.2	Single bend 4 × dia/10 turns/2 cycles Near end crosstalk, return loss and characteristic impedance and coupling attenuation (u/c) shall remain within the specified limits	3,4,5,6	X	X	
Simulated installation testing of the cable	IEC 61156-1, 6.4.3	"S" bend 8 × dia/100 m/1 cycle/120 °/1 m/s Near end crosstalk, return loss and characteristic impedance and coupling attenuation (u/c) shall remain within the specified limits	3,4,5,6	X	X	