INTERNATIONAL STANDARD

ISO 19642-11

First edition
2023-05

Road vehicles — Automotive cables —

Part 11: Dimensions and requirements for coaxial RF cables with a specified analogue bandwidth up to 6 GHz (20 GHz)

Véhicules routiers — Câbles automobiles —

Partie 11: Dimensions et exigences des câbles RF coaxiaux de bande passante analogique spécifiée jusqu'à 6 GHz (20 GHz)

Reference number
ISO 19642-11:2023(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

A list of all parts in the ISO 19642 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document has been added to existing standards in the ISO 19642 series. It was prepared following a joint resolution to improve the general structure of the ISO automotive electric cable standards. This new structure adds more clarity and, by defining a new standard family, opens up the standard for future amendments.

Many other standards currently refer to ISO 6722-1, ISO 6722-2 and ISO 14572. Therefore, these standards will stay valid at least until the next scheduled systematic review and will be replaced later on by the ISO 19642 series.

For new automotive cable projects customers and suppliers are advised on using the ISO 19642 series.

Road vehicles — Automotive cables —

Part 11: Dimensions and requirements for coaxial RF cables with a specified analogue bandwidth up to 6 GHz (20 GHz)

WARNING — The use of this document may involve hazardous materials, operations, and equipment. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This document specifies the dimensions and requirements for coaxial radio frequency (RF) cables with a specified analogue bandwidth up to 6 GHz (for special cases up to 20 GHz) intended for use in road vehicle applications where the nominal system voltage is 30 V a.c. or 60 V d.c.

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.

ISO 19642-1, *Road vehicles — Automotive cables — Terminology and design guidelines*

ISO 19642-2:—[1)], *Road vehicles — Automotive cables — Test methods*

IEC 62153-4-3, *Metallic communication cable test methods — Part 4-3: Electromagnetic compatibility (EMC) - Surface transfer impedance — Triaxial method*

IEC 62153-4-4, *Metallic communication cable test methods — Part 4-4: Electromagnetic compatibility (EMC) — Test method for measuring of the screening attenuation as up to and above 3 GHz, triaxial method*

ASTM B452, *Standard Specification for Copper-Clad Steel Wire for Electronic Application*

ASTM B105, *Standard Specification for Hard-Drawn Copper Alloy Wires for Electric Conductors*

CEN/TS 13388,*Copper and copper alloys — Compendium of compositions and products*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19642-1 apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

1) Second edition under preparation. Stage at the time of publication: ISO/PRF 19642-2:2023.

4 Specifications

4.1 General test conditions

The test conditions given in ISO 19642-2:—[2], 4.1 shall apply. The descriptions of the tests are found in ISO 19642-2. This document only contains requirements and specific remarks. The cables shall be submitted to the tests as specified in Clause 7.

If the supplier and the customer agree upon modifications or changes to the methods and requirements, it is required that all the changes and modifications are clearly documented.

NOTE The clause numbers in this document are aligned with the clause numbers in ISO 19642-2. Test clause numbers not needed in this document are identified as “Test is not required” or “Test is not possible”.

4.2 Voltage rating

The voltage rating is established by the rating of the cores 30 V a.c. or 60 V d.c.

4.3 Temperature classes

The temperature class rating is established by the rating(s) of the core and sheath. The rating of the cable shall be equal to the lowest rating of the core and sheath. For details on temperature classes, see ISO 19642-1.

4.4 Cable construction

For detailed information on preferred constructions, see Tables 12 to 15.

Other constructions and materials are permissible when agreed between customer and supplier.

4.5 Safety concerns

See the “Warning" at the beginning of this document.

4.5.1 Core

4.5.1.1 Conductor

4.5.1.1.1 Conductor material

For preferred conductor materials see ISO 19642-3:2019, Table 1. Additional materials such as copper clad steel (CCS) shall be according to ASTM B452 and copper alloys shall be according to ASTM B105 or CEN/TS 13888.

4.5.1.1.2 Conductor construction

For preferred conductors of the core, see ISO 19642-3. Conductor materials as well as other conductors may be used as agreed between the customer and the supplier.

4.5.1.1.3 Conductor diameter

For construction requirements of preferred cable types please refer to Tables 12 to 15.

2) Second edition under preparation. Stage at the time of publication: ISO/DIS 19642-2:2023.

4.5.2 Dielectric core

4.5.2.1 Insulation material

The insulation material shall be documented.

4.5.2.2 Dielectric core outside diameter

Please refer to Tables 12 to 15.

4.5.3 Screen

4.5.3.1 Screen construction

The screen shall consist of at least one metallic braid. Additionally, the use of metal foils, single or double-sided metal layered polymer foils is allowed. The metal foil shall be between the dielectric and the braid. A metallic side of the foil shall be in electrical contact to the braid. For construction requirements of cable types please refer to Tables 12 to 15.

4.5.3.2 Diameter under sheath

For construction requirements of cable types please refer to Tables 12 to 15.

4.5.4 Sheath

4.5.4.1 Sheath material

The sheath material shall be documented.

4.5.4.2 Sheath thickness

For construction requirements of preferred cable types please refer to Tables 12 to 15.

4.5.4.3 Outside cable diameter

For construction requirements of preferred cable types please refer to Tables 12 to 15

4.6 Cable designation

The cable designation is established or determined using the fields according to Table 1. The entries follow the example.

EXAMPLE CX174a.

Table 1 — Cable designator fields

CX	for coaxial cable
174	an up to 3-digit reference number to identify similar cable types
a	a lower-case version designator to differentiate between similar constructions

For cable designators of preferred cable types refer to Tables 12 to 15.

4.7 Testing of representative cable constructions

When a test is required in Clause 7, all cable constructions shall meet the requirements. However, if testing of representative cable constructions is permitted by agreement between customer and supplier, conformity for a cable family may be demonstrated by testing samples of selected cable types only.

Conformity of a cable family made of the same insulation and sheath compound may be demonstrated by testing the sample of the cable family with the smallest sheath wall thickness only. Resistance to flame propagation 6.5.14 shall be performed on all sheathed finished cables. RF testing according to Table 10 is required for all members of the cable family.

4.8 Reference and requirements for the tests according ISO 19642-2

All tests are defined in ISO 19642-2. This document only contains requirements and specific remarks.

4.9 General remark on requirements

Requirements are specified in Tables 12 to 15 for the preferred coaxial RF cable types. The requirements for other coaxial RF cable types shall be as agreed between customer and supplier.

5 Requirements for the conductor and dielectric

5.1 General

The conductor and dielectric shall fulfil the requirements per the tests as specified in Table 8 according to its temperature class rating.

The details of the usage of "If required" tests shall be as agreed between customer and supplier. Both have to define:

1) if the test has to be performed;

2) if the test has to be performed for gathering data without a limit;

3) a mandatory limit.

Numbers and titles in this clause are aligned with the tests defined in ISO 19642-2 giving an implicit reference. Tests not required for this document are identified as "Test is not required" or "Test is not possible".

5.2 Dimensional tests

5.2.1 Dielectric core outside diameter

No single value shall be outside the specified values in Tables 12 to 15.

5.2.2 Insulation thickness

Test is not required.

5.2.3 Conductor diameter

No single value shall be outside the specified values Tables 12 to 15.

5.2.4 Cross sectional area

Test is not required.

5.2.5 In-process dielectric outside diameter

In-process dielectric outside diameter monitoring is mandatory. No single value shall be outside the specified values in Tables 12 to 15.

5.3 Electrical tests

5.3.1 Conductor resistance

No single value shall be outside the specified values in Tables 12 to 15.

5.3.2 Determination of temperature coefficients

Test is not required.

5.3.3 Withstand voltage

Test is not required.

5.3.4 Withstand voltage after environmental testing

5.3.4.1 Test voltage

The test voltage is 1 kV a.c., hold for 1 min.

5.3.4.2 Requirement

Breakdown shall not occur.

5.3.5 Insulation faults

5.3.5.1 Test voltage

The test voltage is 1 kV a.c.

5.3.5.2 Requirement

Breakdown shall not occur.

5.3.6 Insulation volume resistivity

The usage of this test shall be as agreed between customer and supplier. In this case the value shall be $\geq 1 \times 10^9\ \Omega \times \text{mm}$.

5.4 Mechanical tests

5.4.1 Strip force (A) of dielectric

The usage of this test shall be as agreed between customer and supplier. In this case measure the strip force between inner conductor and dielectric cable insulation. The measured force shall be within the values as agreed between customer and supplier.

5.4.2 Abrasion test

Test is not required.

5.4.3 Breaking force of the finished cable

Test is not required.

5.4.4 Cyclic bending test

Test is not required.

5.4.5 Flexibility test

Test is not required.

5.5 Environmental tests

5.5.1 Test specimen preparation and winding tests

Test does not apply.

5.5.2 Long term heat ageing, 3 000 h, at temperature class rating

Test is not required.

5.5.3 Short term heat ageing, 240 h at temperature class rating + 25 °C

Test is not required.

5.5.4 Thermal overload, 6 h at temperature class rating + 50 °C

Test is not required.

5.5.5 Pressure test at high temperature

Test is not required.

5.5.6 Shrinkage by heat

The maximum shrinkage shall not exceed 2 mm from either end.

5.5.7 Low temperature winding

Test is not required.

5.5.8 Cold impact

Test is not required.

5.5.9 Temperature and humidity cycling

Test is not required.

5.5.10 Resistance to hot water

Test is not required.

5.5.11 Resistance to liquid chemicals

Test is not required.

5.5.12 Durability of cable marking

Test is not required.

5.5.13 Stress cracking resistance

This test is to be performed for cables with insulation materials that are prone to environmental stress cracking problems (e.g. FEP and ETFE) by agreement between customer and supplier. After the test no conductor shall be visible. During 5.3.4 breakdown shall not occur.

5.5.14 Resistance to ozone

Test is not required.

5.5.15 Resistance to flame propagation

Test is not required.

6 Requirements for the screened and sheathed coaxial RF cable

6.1 General

The finished cable shall be submitted to the tests as specified in Table 9 and Table 10.

Numbers and titles in this clause are aligned with the tests defined in ISO 19642-2 giving an implicit reference. Tests not required for this part are intentionally omitted in this document.

The details of the usage of "If required" tests shall be as agreed between customer and supplier. Both shall define:

1) if the test shall be performed;

2) if the test shall be performed for gathering data without a limit;

3) a mandatory limit.

6.2 Dimensional tests

6.2.1 Cable outside and inner layer diameters

Measure the following parameters:

— dielectric core outside diameter;

— diameter under sheath;

— outside cable diameter.

No single value shall be outside the specified values in Tables 12 to 15.

6.2.2 Ovality of sheath

The usage of this test shall be as agreed between customer and supplier. In this case the value of ovality shall be < 10 % measured immediately after extrusion.

NOTE Sheath ovality can be different after handling due to mechanical deformation.

6.2.3 Thickness of sheath

No single value shall be outside the specified values in Tables 12 to 15.

6.2.4 In-process cable outside diameter

In-process cable outside diameter monitoring is mandatory. No single value shall be outside the specified values in Tables 12 to 15.

6.2.5 Lay length

Test is not possible.

6.3 Electrical tests

6.3.1 Electrical continuity

The indicator shall show continuity.

6.3.2 Withstand voltage at final inspection

6.3.2.1 Test voltage

The test voltage is 1 kV a.c. between the conductor and the screen for a minimum of 3 s.

6.3.2.2 Requirement

Breakdown shall not occur.

6.3.3 Screening effectiveness

6.3.3.1 General

The usage of these tests shall be as agreed between customer and supplier.

6.3.3.2 DC resistance of the screen

The requirement for this test shall be as agreed between customer and supplier.

6.3.3.3 Surface transfer impedance — Triaxial method

The test shall be performed according to IEC 62153-4-3, method C: (mismatched)-short-short without damping resistor:

— coupling length: 400 mm;

— length of DUT: length of triaxial tube + 500 mm;

— frequency range: 10 kHz – 30 MHz.

The test report shall contain:

— length of test tube;

— coupling length;

— inner diameter of test tube;

— impedance of outer system;

— cut off frequency of electrically short system;

— graphical representation of test result over the specified frequency range.

The requirement for this test shall be as agreed between customer and supplier.

6.3.3.4 Screening attenuation — Absorbing clamp method

Test is not required.

6.3.3.5 Screening attenuation — Triaxial method

The test shall be performed according to IEC 62153-4-4:

— coupling length > 2 500 mm;

— length of DUT: length of triaxial tube + 500 mm;

— frequency range: 30 MHz – 6 GHz.

The test report shall contain:

— length of test tube;

— coupling length;

— inner diameter of test tube;

— impedance of outer system;

— cut off frequency of electrically long system;

— graphical representation of screening attenuation over the specified frequency range;

— additional graphical representation of 150 Ω normalized screening attenuation over the specified frequency range.

The requirement for this test shall be as agreed between customer and supplier.

6.3.3.6 Coupling attenuation — Triaxial method

Test is not possible.

6.3.4 Sheath fault on screened cables

6.3.4.1 Test voltage

The test voltage is 3 kV a.c.

6.3.4.2 Requirement

Breakdown shall not occur.

6.3.5 General information on electrical test setups of unscreened cables

Test is not possible.

6.3.6 General information on low frequency electrical tests

The measurement is performed at room temperature either on a new cable which was not subjected to any prior environmental stress or to a cable after applied stress according to the requirement in Table 11 and subsequent environmental test descriptions. At least three test specimens shall be measured.

6.3.7 Resistance unbalance

Test is not possible.

6.3.8 Capacitance

6.3.8.1 Mutual capacitance

This test to be performed as agreed between customer and supplier. Measured capacitance shall be documented.

6.3.8.2 Bus capacitance

Test is not possible.

6.3.8.3 Capacitance unbalance to earth

Test is not possible.

6.3.9 Inductance

Test is not required.

6.3.10 General information on radio frequency (RF) electrical tests

The measurement is performed at room temperature either on a new cable which was not subjected to any prior environmental stress or to a cable after applied stress according to the requirement in Table 11 and in subsequent environmental test descriptions.

Gating and de-embedding techniques may be used to eliminate the influence of connectors on the test results.

6.3.11 Velocity of propagation

6.3.11.1 Phase velocity $v_p(f)$ of propagation

No single value shall be outside the specified values in Tables 12 to 15.

6.3.11.2 Test of group velocity $v_a(f)$ of propagation

Test is not required.

6.3.12 Characteristic impedance in frequency domain (CIF)

6.3.12.1 Test specimens

The test is performed on a minimum of three test specimens. The length of the test specimens shall be ≥ 10 m and shall be documented in the test report. The test shall start at 10 MHz and proceed up to 6 GHz.

6.3.12.2 Unbalanced cables (CICMF)

This is the preferred method. No single value shall be outside the specified values in Tables 12 to 15.

6.3.12.3 Balanced cables for symmetrical data transmission

Test is not possible.

6.3.12.4 Calculation

Information is not provided in this edition.

6.3.13 Characteristic impedance in time domain (CIT)

6.3.13.1 Unbalanced cables (CICMT)

This test is only performed after 6.4.4. The difference of the results on the new cable and on the cable after stress shall not be greater than agreed between customer and supplier.

6.3.14 Insertion loss, IL

6.3.14.1 Unbalanced cables for asymmetrical data transmission

The maximum insertion (attenuation) loss requirement is defined in this document by defining the three parameters according to Table 2:

Table 2 — Three parameter IL definition

a	Constant factor	The attenuation $\alpha[\mathrm{dB/m}]$ at each frequency point f [MHz] is derived using the following formula: $\alpha = a + b \cdot f^{0,5} + c \cdot f$
b	$\sim f^{0,5}$	
c	$\sim f$	

By use of this formula, the maximum attenuation at each frequency point within the specified range from 50 MHz to 6 GHz (20 GHz) can be calculated not only at some discrete frequency values. As the temperature is a big contributor to the diagrams of the attenuation losses, parameters and diagrams of the attenuation over frequency are provided for room temperature and for the upper value of the temperature class rating for the preferred cable types. No single measured attenuation value at RT shall be larger than the calculated value using the parameters a, b and c in 8.2.

For cables with IL limits up to 20 GHz a formula with six parameters according to Table 3 shall be used.

Table 3 — Six parameter IL definition

a	Constant factor	The attenuation $\alpha[\mathrm{dB/m}]$ at each frequency point f [MHz] is derived using the following formula: $\alpha = a + b \cdot f^{0,5} + c \cdot f + d \cdot f^{1,5} + e \cdot f^{2} + g \cdot f^{2,5}$
b	$\sim f^{0,5}$	
c	$\sim f$	
d	$\sim f^{1,5}$	
e	$\sim f^{2}$	
g	$\sim f^{2,5}$	

No single measured attenuation value at RT and the temperature class rating shall be larger than the calculated values using the parameters in 8.2.

6.3.14.2 Balanced cables for symmetrical data transmission

Test is not possible.

6.3.14.3 Report

Information is not provided in this edition.

6.3.15 Return loss, RL

6.3.15.1 Unbalanced cables for unsymmetrical data transmission

No single value shall be outside the specified values in Tables 12 to 15.

6.3.15.2 Balanced cables for symmetrical data transmission

Test is not possible.

6.3.15.3 Report

Information is not provided in this edition.

6.3.16 Unbalance attenuations

Test is not possible.

6.3.17 Near end crosstalk, NEXT

Test is not possible.

6.3.18 Far end crosstalk, FEXT

Test is not possible.

6.3.19 PS alien near end crosstalk, PS ANEXT – exogenous crosstalk

Test is not required.

6.3.20 PS attenuation to alien far-end crosstalk ratio, PS AACR-F - exogenous crosstalk

Test is not required.

6.4 Mechanical tests

6.4.1 Strip force (C) of sheath

The undisturbed section of the sheath shall be able to be removed without damage to the screen and the interior cores. The requirement for this test shall be as agreed between customer and supplier.

6.4.2 Cyclic bending

Test is not required.

6.4.3 Flexibility

The requirement for this test shall be as agreed between customer and supplier.

6.4.4 Cyclic bending test for RF cables

Only cables for flex (FX) and high flex (HX) applications need to be tested.

Perform the test sequence as defined in 8.2 for the addressed cable type.

Test is only required for cables addressed in 8.2.

For changes in RF properties after this test see Table 4.

Table 4 — Allowable deviations after performing the 6.4.4 test

Acronym	Test description	According to	Changes after performing the test
STI	Surface transfer impedance — Triaxial method	6.3.3.3	to be documented
SA	Screening attenuation — Triaxial method	6.3.3.5	to be documented
CIT	Characteristic impedance in time domain (CIT)	6.3.13	to be documented
IL	Insertion loss, IL	6.3.14	to be documented

6.4.5 Dynamic bending tests for RF cables

6.4.5.1 General

Only cables for flex (FX) and high flex (HX) applications need to be tested.

Test is only required for cables addressed in 8.2.

6.4.5.2 Sample preparation

6.4.5.3 RF tests after dynamic bending tests

6.4.5.4 Test A, torsion test

6.4.5.5 Test B, combined torsion and bending test

Perform the test sequence as defined in 8.2 for the addressed cable type.

Document the change of the properties defined in Table 5 in the test report.

Table 5 — RF tests after performing the 6.4.5.5 test

Acronym	Test description	According to
VP	Phase velocity $v_p(f)$ of propagation	6.3.11.1
CIF	Characteristic impedance in frequency domain (CIF)	6.3.12
IL	Insertion loss, IL	6.3.14

6.4.6 Test for assessment of minimum bending radius

The requirement for this test shall be as agreed between customer and supplier. For test parameters see Table 6.

Table 6 — Test parameters

Coax type	Mandrel diameter, D	Mass, maximum cable outside diameter (OD), D_0			Minimum number of turns
		$D_0 \leq 3$ mm	$3 < D_0 \leq 4$ mm	$D_0 > 4$ mm	
High flex HX	$D \leq 3 \times D_0$	0,5 kg	1 kg	1,5 kg	5
Flex FX	$D \leq 5 \times D_0$				
Standard	$D \leq 10 \times D_0$				

Tests to be performed after the test: insertion loss IL, return loss RL, characteristic impedance CI.

6.4.7 Strip force (B) of screen

The requirement for this test shall be as agreed between customer and supplier.

6.4.8 Abrasion test on sheath

The requirement for this test shall be as agreed between customer and supplier.

6.5 Environmental tests

6.5.1 Test specimen preparation and winding tests

ISO 19642-2:—, 6.5.1 describes the mandrel sizes used for preparation of specimens in different subsequent environmental tests. It also describes the winding tests used to detect defects caused by environmental stresses.

6.5.2 Long term heat ageing, 3 000 h at temperature class rating

6.5.2.1 Test specimens

Prepare a 10 m test specimen for RF tests and two 600 mm test specimen for the winding test.

Wind the 10 m test specimen into a coil to enable it to fit into an oven. The diameter of the coil shall be larger than 20 times the cable outside diameter (OD).

Before performing the ageing test, perform the tests specified in Table 11 on the 10 m test specimen.

6.5.2.2 Preparation for the 10 m test specimen:

Method 1: Crimp the coax cable to the SMA terminal/connector and place the 10 m test specimen with the connectors into the oven.

Method 2: Place test the 10 m test specimen into the oven. The cable ends are then fed through the pass-through hole of the oven to the outside. A maximum of 500 mm of cable length on each end shall be outside the oven.

6.5.2.3 Performing the ageing test

Hang the two 600 mm test specimens in the oven and place the coiled 10 m on top of a screen inside the oven.

6.5.2.4 Tests after the ageing test

After ageing exposure, condition the samples at room temperature for a minimum of 16 h. Then repeat the tests specified in Table 11 on the 10 m aged test specimen still in the coiled state. For allowable changes in RF properties after this test see Table 7.

Perform the winding test according to 6.5.1 on the two 600 mm test specimens.

6.5.2.5 Requirement

Table 7 — Allowable change after performing the 6.5.2 test

Acronym	Test description	According to	Allowable change
VP	Phase velocity $v_p(f)$ of propagation	6.3.11.1	0
CIF	Characteristic impedance in frequency domain (CIF)	6.3.12	increase tolerance by ±1 Ω
IL	Insertion loss, IL (cables with metallic foil and braid)	6.3.14	+ 5 % [a]
RL	Return loss, RL	6.3.15	- 2 dB

[a] IL change after testing of cables can be deviated and are to be documented as agreed between customer and supplier.

After the winding test according to 6.5.1 the test specimen shall show no signs of cracks. During withstand voltage at final inspection according to 6.3.2 breakdown shall not occur.

6.5.3 Short term heat ageing, 240 h at temperature class rating + 25 °C

After the winding test according to 6.5.1 the test specimen shall show no signs of cracks. During withstand voltage at final inspection according to 6.3.2 breakdown shall not occur.

6.5.4 Thermal overload, 6 h at temperature class rating + 50 °C

Test is not required.

6.5.5 Pressure test at high temperature

The thickness within the area of the indentation shall not be less than 40 % of the mean of the other two values.

6.5.6 Shrinkage of sheath by heat

The requirement for this test shall be as agreed between customer and supplier.

6.5.7 Low temperature winding

The test specimen shall show no signs of cracks. During withstand voltage at final inspection 6.3.2 breakdown shall not occur.

6.5.8 Cold impact

The usage of this text shall be as agreed between customer and supplier. In this case perform the test with a mass of the hammer of 100 g. The test specimen shall show no signs of cracks. During 6.3.2 breakdown shall not occur.

6.5.9 Temperature and humidity cycling

The usage of this text shall be as agreed between customer and supplier. In this case the test specimen shall show no signs of cracks.

6.5.10 Resistance to liquid chemicals

The test specimen shall show no signs of cracks. Other requirements shall be as agreed between customer and supplier.

6.5.11 Durability of sheath marking

The requirement for this test shall be as agreed between customer and supplier.

6.5.12 Resistance to ozone

The requirement for this test shall be as agreed between customer and supplier.

6.5.12.1 Requirement

The visual examination of the sheath shall show no cracks.

6.5.13 Artificial weathering

The requirement for this test shall be as agreed between customer and supplier.

6.5.13.1 Requirement

After exposure to the artificial weathering, the elongation of the conditioned test specimen shall not be less than 50 % of the unconditioned specimen measured value.

6.5.14 Resistance to flame propagation

Any combustion flame of the cable shall extinguish within 70 s from the end of ignition and a minimum of 50 mm of insulation and sheath at the top of the test specimen shall remain unburnt. All five specimens shall pass the test.

7 Test overview tables

Table 8 — Tests on the dielectric core

Test description		Mandatory			If required[c]	
		In process[a]	Initial certification	Periodic[b]	Initial certification	Periodic[b]
5.2.1	Dielectric core outside diameter	–	X	X	–	–
5.2.3	Conductor diameter	–	X	X	–	–
5.2.5	In-process dielectric outside diameter	X	–	–	–	–
5.3.1	Conductor resistance	–	X	X	–	–
5.3.5	Insulation faults	X	–	–	–	–
5.3.6	Insulation volume resistivity	–	–	–	X	X
5.4.1	Strip force (A) of dielectric	–	–	–	X	X
5.5.6	Shrinkage by heat	–	X	X	–	–
5.5.13	Stress cracking resistance [d]	–	–	–	X	–

Key

X test shall be performed according to ISO 19642-2

– test is not required

[a] A test made on the entire cable lot during or after manufacture.

[b] The frequency of periodic testing shall be as agreed between customer and supplier.

[c] The usage of "If required" tests shall be as agreed between customer and supplier.

[d] Conformity of a cable family made of the same insulation and sheath compound may be demonstrated by testing the sample of the cable family with the smallest sheath wall thickness only.

Table 9 — Tests on the screened and sheathed cable

Test description		Mandatory			If required[c]	
		In process[a]	Initial certification	Periodic[b]	Initial certification	Periodic[b]
6.2	Dimensional tests					
6.2.1	Cable outside and inner layer diameters	–	X	X	–	–
6.2.2	Ovality of sheath	–	–	–	X	X
6.2.3	Thickness of sheath	–	X	X	–	–

Key

X test shall be performed according to ISO 19642-2

– test is not required

[a] A test made on the entire cable lot during or after manufacture.

[b] The frequency of periodic testing shall be as agreed between customer and supplier.

[c] The usage of "If required" tests shall be as agreed between customer and supplier.

[d] Conformity of a cable family made of the same insulation and sheath compound may be demonstrated by testing the sample of the cable family with the smallest sheath wall thickness only.

[e] It is mandatory for FX and HX cables.

Table 9 *(continued)*

Test description		Mandatory			If required[c]	
		In process[a]	Initial certification	Periodic[b]	Initial certification	Periodic[b]
6.2.4	In-process cable outside diameter	X	–	–	–	–
6.3.2	Withstand voltage at final inspection	X	–	–	–	–
6.3.4	Sheath fault on screened cables	X	–	–	–	–
6.4	Mechanical tests					
6.4.1	Strip force (C) of sheath	–	–	–	X	X
6.4.3	Flexibility	–	–	–	X	–
6.4.4	Cyclic bending test for RF cables[e]	–	X	–	–	–
6.4.5	Dynamic bending tests for RF cables [e]	–	X	–	–	–
6.4.6	Test for assessment of minimum bending radius	–	–	–	X	–
6.4.7	Strip force (B) of screen	–	–	–	X	X
6.4.8	Abrasion test on sheath	–	–	–	X	–
6.5	Environmental tests					
6.5.1	Test specimen preparation and winding tests					
6.5.2	Long term heat ageing, 3 000 h at temperature class rating [d]	–	X	–	–	–
6.5.3	Short term heat ageing, 240 h at temperature class rating + 25 °C	–	X	X	–	–
6.5.5	Pressure test at high temperature	–	X	X	–	–
6.5.6	Shrinkage of sheath by heat	–	X	X	–	–
6.5.7	Low temperature winding	–	X	X	–	–
6.5.8	Cold impact	–	–	–	X	X
6.5.9	Temperature and humidity cycling [d]	–	–	–	X	–
6.5.10	Resistance to liquid chemicals [d]	–	X	X	–	–
6.5.11	Durability of sheath marking [d]	–	–	–	X	X
6.5.12	Resistance to ozone [d]	–	–	–	X	–
6.5.13	Artificial weathering [d]	–	–	–	X	–
6.5.14	Resistance to flame propagation	–	X	X	–	–

Key

X test shall be performed according to ISO 19642-2

– test is not required

[a] A test made on the entire cable lot during or after manufacture.

[b] The frequency of periodic testing shall be as agreed between customer and supplier.

[c] The usage of "If required" tests shall be as agreed between customer and supplier.

[d] Conformity of a cable family made of the same insulation and sheath compound may be demonstrated by testing the sample of the cable family with the smallest sheath wall thickness only.

[e] It is mandatory for FX and HX cables.

Table 10 — RF tests

Test description		Mandatory			If required [b]	
		Final inspection test [d]	Initial certification	Periodic [a]	Initial certification	Periodic [a]
6.3	Electrical tests					
6.3.1	Electrical continuity	–	X	X	–	–
6.3.2	Withstand voltage at final inspection					
6.3.3.2	DC resistance of screen	–	–	–	X	X
6.3.3.3	Surface transfer impedance — Triaxial method	–	–	–	X	X
6.3.3.5	Screening attenuation — Triaxial method	–	–	–	X	X
6.3.8.1	Mutual capacitance	X	X	–	–	–
6.3.11.1	Phase velocity $v_p(f)$ of propagation	X	X	–	–	–
6.3.12.2	Characteristic impedance in frequency domain (CICMFD)	X	X	–	–	–
6.3.13.1	Characteristic impedance in time domain (CICMTD) [c]	–	–	–	X	–
6.3.14.1	Insertion loss, (IL)	X	X	–	–	–
6.3.15.1	Return loss, (RL)	X	X	–	–	–

Key

X test shall be performed according to ISO 19642-2

– test is not required

[a] The frequency of periodic testing shall be as agreed between customer and supplier.

[b] The usage of "If required" tests shall be as agreed between customer and supplier.

[c] Only used after cyclic bending test for RF cables.

[d] Performed on a test specimen with a length of 10 m on each batch.

Table 11 — RF tests to be performed after the tests defined below

RF test to be performed, acronym according to key		STI	SA	VP	CICMFD	CICMTD	IL	RL
6.4.4	Cyclic bending test for RF cables	X	X	–	–	X	–	–
6.4.5.5	Test B, combined torsion and bending test	–	–	X	X	–	X	–
6.5.2	Long term heat ageing, 3 000 h, at temperature class rating	–	–	X	X	–	X	X

	Key	**Test description**	**according to**
	STI	Surface transfer impedance — Triaxial method	6.3.3.3
	SA	Screening attenuation — Triaxial method	6.3.3.5
	VP	Phase velocity $v_p(f)$ of propagation	6.3.11.1
	CICMFD	Characteristic impedance in frequency domain (CIF)	6.3.12
	CICMTD	Characteristic impedance in time domain (CIT)	6.3.13
	IL	Insertion loss, IL	6.3.14
	RL	Return loss, RL	6.3.15

8 Preferred cable types

8.1 Parameter tables

Table 12 — Parameters of preferred cable types (part 1 of 4)

Cable designator short		CX174a	CX174b	CX174c	CX174d CX174e
Temperature class		B – T100	A – T85	B – T100	B – T100 C – T125
Dynamic bending class		FX HX	–	–	FX HX
Conductor					
Material		CCS	CCS	bare copper	CCS
Number of single strands		7	1	1	7
Diameter of strands	max., mm	0,16	0,47	0,57	0,16
Conductor diameter	max. mm	0,5	0,47	0,57	0,5
Conductor resistance at 20 °C	max., mΩ/m	317	285	79	317
Dielectric					
Material		to be documented	to be documented	to be documented	to be documented
Dielectric core outside diameter	max., mm	1,57	1,57	1,65	1,57
Metalized foil below braid		no	Al foil	Al foil	Al foil
Braid		single	single	single	single
Material		tin plated copper	tin plated copper	tin plated copper	tin plated copper
Diameter of strands	nom	0,1	0,1	0,1	0,1
Diameter under sheath	max., mm	2,1	2,15	2,15	2,15
Optical coverage	min., %	85	85	85	80
Resistance at 20 °C	max., mΩ/m	44	33	33	38
Surf. transf. impedance					
@ 100 kHz	max., mΩ/m	60	35	35	45
@ 1 MHz	max., mΩ/m	60	35	35	45
@ 10 MHz	max., mΩ/m	125	35	35	45
@ 30 MHz	max., mΩ/m	220	35	35	45
Screening attenuation	min., dB	45	< 3 GHz ..70 3 – 6 GHz ..60	< 3 GHz ..70 3 – 6 GHz ..60	75
Sheath					
Material		to be documented	to be documented	to be documented	to be documented
Wall thickness	min., mm	0,27	0,25	0,25	0,25
Outside cable diameter	max., mm	2,9	2,9	2,9	2,9
RF parameters					
Capacitance	nom, pF/m	to be documented	to be documented	to be documented	to be documented
Characteristic impedance	nom, Ω	50	50	50	50

Table 12 *(continued)*

Characteristic Impedance	Tol., ± Ω	3	3	3	3
Return loss, up to 1 GHz	min., dB	20	20	20	20
Return loss, up to 6 GHz	min., dB	14	15	15	15
Return loss, up to f_{max}	min., dB	–	–	–	–
Attenuation at 20 °C,	max., dB/m	see 8.2.1.1	see 8.2.2.1	see 8.2.3.1	see 8.2.4.1 see 8.2.5.1
Attenuation at temperature class rating (TCR)	max., dB/m				
Velocity of propagation, % of velocity of light	min., %	66	66	78	66

Table 13 — Parameters of preferred cable types (part 2 of 4)

Cable designator short		**CX58a**	**CX58b CX58c**	**CX31a**	**CX44a CX44b**	**CX44c**
Temperature class		B – T100	B – T100 C – T125	B – T100	B - T100	B - T100
Dynamic bending class		–	FX HX	-	-	-
Conductor						
Material		bare copper	bare copper	bare copper	bare copper	bare copper
Number of single strands		1	7	7	1	1
Diameter of strands	max., mm	1,05	0,37	0,27	0,87	0,87
Conductor diameter	max. mm	1,05	1,12	0,9	0,87	0,87
Conductor resistance at 20 °C	max., mΩ/m	25,5	25,5	52	33,9	33,9
Dielectric						
Material		to be documented	to be documented	to be documented	to be documented	to be documented
Dielectric core outside diameter	max., mm	3,0	3,0	2,15	2,5	2,5
Metalized foil below braid		Al foil	Al foil	Al foil	Al foil (Type a) Cu foil (Type b)	Al foil
Braid		single	single	single	single	single
Material		tin plated copper	tin plated copper	tin plated copper	tin plated copper	tin plated copper
Diameter of strands	nom	0,13	0,13	0,1	0,1	0,1
Diameter under sheath	max., mm	3,72	3,72	2,85	3	3
Optical coverage	min., %	80	80	85	85	85
Resistance at 20 °C	max., mΩ/m	18	18	30	25	25
Surf. transf. impedance						
@ 100 kHz	max., mΩ/m	25	25	40	40	40
@ 1 MHz	max., mΩ/m	25	25	40	40	40
@10 MHz	max., mΩ/m	25	25	40	40	40

Table 13 *(continued)*

Cable designator short		CX58a	CX58b CX58c	CX31a	CX44a CX44b	CX44c
@30 MHz	max., mΩ/m	25	25	40	40	40
Screening attenuation	min., dB	< 3 GHz ..70 3 - 6 GHz ..65	70	65	70	70
Sheath						
Material		to be documented	to be documented	to be documented	to be documented	to be documented
Wall thickness	min., mm	0,45	0,45	0,16	0,16	0,16
Outside cable diameter	max., mm	5,0	5,0	3,4	3,6	3,6
RF parameters						
Capacitance	nom, pF/m	to be documented	to be documented	to be documented	to be documented	to be documented
Characteristic impedance	nom, Ω	50	50	50	50	50
Characteristic impedance	Tol., ± Ω	3	3	3	2	3
Return loss, up to 1 GHz	min., dB	20	20	20	25	25
Return loss, up to 6 GHz	min., dB	15	15	14	20	20
Return loss, up to f_{max}	min., dB	–	–	–	18 up to 20 GHz	18 up to 9 GHz
Attenuation at 20 °C,	max., dB/m	see 8.2.6.1	see 8.2.7.1 see 8.2.8.1	see 8.2.9.1	see 8.2.10.1 IL defined up to 20 GHz	see 8.2.11.1 IL defined up to 9 GHz
Attenuation at temperature class rating (TCR)	max., dB/m					
Velocity of propagation, % of velocity of light	min., %	75	75	75	78	75

Table 14 — Parameters of preferred cable types (part 3 of 4)

Cable designator short		CX501a	CX501b	CX501c	CX502a	CX502b
Temperature class		B – T100	B – T100	B – T100	B – T100	B – T100
Dynamic bending class		-	-	-	-	-
Conductor						
Material		bare copper tin plated copper	bare copper tin plated copper	bare copper tin plated copper	bare copper tin plated copper	bare copper
Number of single strands		7	7	7	7	1
Diameter of strands	max., mm	0,19	0,19	0,21	0,335	1,07
Conductor diameter	max. mm	0,57	0,57	0,63	1,01	1,07
Conductor resistance at 20 °C	max., mΩ/m	120	120	90	34	23
Dielectric						
Material		to be documented	to be documented	to be documented	to be documented	to be documented
Dielectric core outside diameter	max., mm	1,7	1,7	1,7	2,8	2,8
Metalized foil below braid		Al foil	no	Cu foil	Cu foil	Al foil Cu foil

Table 14 *(continued)*

Cable designator short		CX501a	CX501b	CX501c	CX502a	CX502b
Braid		single	single	single	single	single
Material		tin plated copper	tin plated copper	tin plated copper	tin plated copper	tin plated copper
Diameter of strands	nom	0,1	0,1	0,1	0,08	0,08
Diameter under sheath	max., mm	2,35	2,35	2,35	3,3	3,3
Optical coverage	min., %	85	85	85	85	85
Resistance at 20 °C	max., mΩ/m	35	35	35	25	25
Surf. transf. impedance						
@ 100 kHz	max., mΩ/m	45	50	45	40	40
@ 1 MHz	max., mΩ/m	45	50	45	40	40
@10 MHz	max., mΩ/m	45	135	45	40	40
@30 MHz	max., mΩ/m	45	330	45	40	40
Screening attenuation	min., dB	< 1 GHz ..55 1 – 6 GHz ..75	35	< 1 GHz ..55 1 – 6 GHz ..75	< 1 GHz ..55 1 – 6 GHz ..75	< 1 GHz ..55 1 – 6 GHz ..75
Sheath						
Material		to be documented	to be documented	to be documented	to be documented	to be documented
Wall thickness	min., mm	0,32	0,36	0,32	0,24	0,24
Outside cable diameter	max., mm	3,2	3,3	3,2	4	4
RF parameters						
Capacitance	nom, pF/m	to be documented	to be documented	to be documented	to be documented	to be documented
Characteristic impedance	nom, Ω	50	50	50	50	50
Characteristic impedance	Tol., ± Ω	3	3	3	3	3
Return loss, up to 1 GHz	min., dB	20	20	20	20	20
Return loss, up to 6 GHz	min., dB	15	15	15	15	15
Return loss, up to f_{max}	min., dB	–	–	–	–	–
Attenuation at 20 °C,	max., dB/m	see 8.2.12.1	see 8.2.13.1	see 8.2.14.1	see 8.2.15.1	see 8.2.16.1
Attenuation at temperature class rating (TCR)	max., dB/m					
Velocity of propagation, % of velocity of light	min., %	66	66	78	74	83

Table 15 — Parameters of preferred cable types (part 4 of 4)

Cable designator short		**CX502c**	**CX502d**	**CX751a**	**CX751b**	**CX751c**
Temperature class		B – T100	B – T100	B – T100	B – T100	B – T100
Dynamic bending class		-	-	-	-	-
Conductor						
Material		bare copper	bare copper	CCS tinned CCS	CCS tinned CCS	CCS tinned CCS
Number of single strands		1	7	1	1	1
Diameter of strands	max., mm	0,97	0,325	0,27	0,27	0,27
Conductor diameter	max. mm	0,97	0,975	0,27	0,27	0,27
Conductor resistance at 20 °C	max., mΩ/m	27	36	1 200	1 200	1 200
Dielectric						
Material		to be documented	to be documented	to be documented	to be documented	to be documented
Dielectric core outside diameter	max., mm	2,5	2,5	1,7	1,7	1,7
Metalized foil below braid		Al foil Cu foil	Al foil Cu foil	no	Al foil	no
Braid		single	single	single	single	double
Material		tin plated copper	tin plated copper	tin plated copper	tin plated copper	tin plated copper
Diameter of strands	nom	0,08	0,08	0,1	0,1	0,08~0,1
Diameter under sheath	max., mm	3,05	3,05	2,35	2,35	2,75
Optical coverage	min., %	85	85	85	85	60×60
Resistance at 20 °C	max., mΩ/m	29	29	35	35	38
Surf. transf. impedance						
@ 100 kHz	max., mΩ/m	42	42	not required	not required	not required
@ 1 MHz	max., mΩ/m	42	42	not required	not required	not required
@10 MHz	max., mΩ/m	42	42	not required	not required	not required
@30 MHz	max., mΩ/m	42	42	not required	not required	not required
Screening attenuation	min., dB	< 1 GHz ..55 1 – 6 GHz ..75	< 1 GHz ..55 1 – 6 GHz ..75	not required	not required	not required
Cable designator short		CX502c	CX502d	CX751a	CX751b	CX751c
Sheath						
Material		to be documented	to be documented	to be documented	to be documented	to be documented
Wall thickness	min., mm	0,24	0,24	0,32	0,32	0,32
Outside cable diameter	max., mm	3,6	3,6	3,2	3,2	3,6
RF parameters						
Capacitance	nom, pF/m	to be documented	to be documented	to be documented	to be documented	to be documented

Table 15 *(continued)*

Cable designator short		CX502c	CX502d	CX751a	CX751b	CX751c
Characteristic impedance	nom, Ω	50	50	75	75	75
Characteristic impedance	Tol., ± Ω	3	3	3	3	3
Return loss, up to 1 GHz	min., dB	20	20	20	20	20
Return loss, up to 6 GHz	min., dB	15	15	not required	not required	not required
Return loss, up to f_{max}	min., dB	–	–	–	–	–
Attenuation at 20 °C,	max., dB/m	see 8.2.17.1	see 8.2.18.1	see 8.2.19.1	see 8.2.20.1	see 8.2.21.1
Attenuation at temperature class rating (TCR)	max., dB/m					
Velocity of propagation, % of velocity of light	min., %	83	83	66	66	66

8.2 Insertion loss IL (tables and diagrams), bending test sequences

To eliminate the influence of connectors on the RF test results gating and de-embedding techniques according to 6.3.10 may be applied.

Flex (FX) and High flex (HX) cables shall be tested additionally according to 6.4.4 Cyclic bending test for RF cables and dynamic bending tests for RF cables, 6.4.5.5 Test B, combined torsion and bending test.

8.2.1 CX174a

8.2.1.1 Insertion loss IL

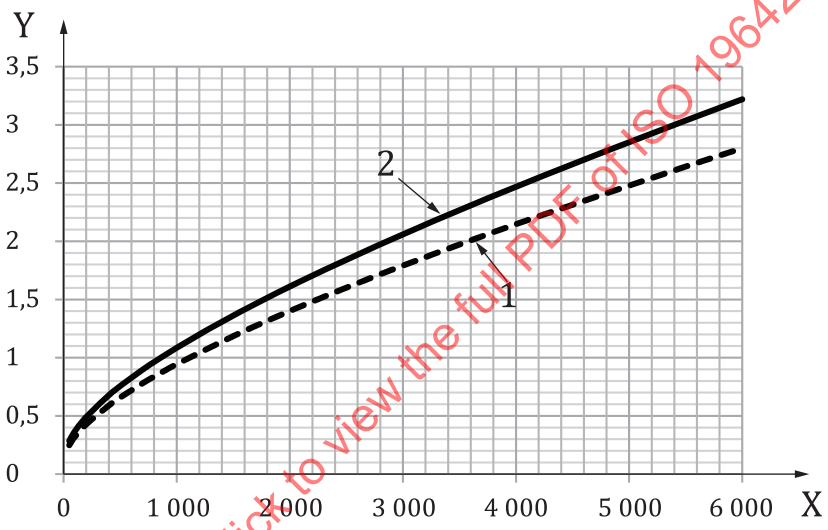
Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 16. For a graphic representation please refer to Figure 1.

Table 16 — CX174a, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 100 °C [dB/m] max.
50	0,248	0,286
100	0,321	0,369
200	0,428	0,492
400	0,589	0,677
500	0,658	0,756
700	0,781	0,898
800	0,838	0,963
900	0,892	1,03
1 000	0,945	1,09
1 500	1,18	1,36
1 800	1,32	1,51
1 900	1,36	1,56
2 000	1,40	1,61
2 100	1,44	1,66
2 400	1,56	1,80
2 500	1,60	1,84

Table 16 *(continued)*

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
3 000	1,79	2,06
4 000	2,15	2,47
5 500	2,64	3,04
5 600	2,67	3,07
5 900	2,77	3,18
6 000	2,80	3,22
a	8,630E-02	+15 %
b .. $f^{0,5}$	2,170E-02	
c .. f	1,720E-04	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 1 — CX174a, insertion loss limit

8.2.1.2 Bending tests

Perform the bending test according to 6.4.4 using the test sequences in Table 17.

Table 17 — Cyclic bending tests for RF cables - test sequences

Number of repetitions of test sequences L1, L2 and L3		Bending type FX	Bending type HX
		3	5
test sequence	temperature, °C	number of cycles in test sequence	sum of cycles at end of test sequence
L1	RT	5 000	5 000
L2	100	600	5 600
L3	-25	400	6 000

Perform the bending test according to 6.4.5.5 using the test sequence in Table 18.

Table 18 — Test B, combined torsion and bending test - test sequence

Group	Temperature / humidity	Number of cycles in group	Sum of cycles at end of group
CG1	+40 °C / 30 % r.h.	60 000 ± 200	60 000 ± 200
CG2	-20 °C r.h. undefined	20 000 ± 70	80 000 ± 270
CG3	+85 °C / 20 % r.h.	20 000 ± 70	100 000 ± 340
CG4	RT r.h	5 000 ± 20	105 000 ± 360

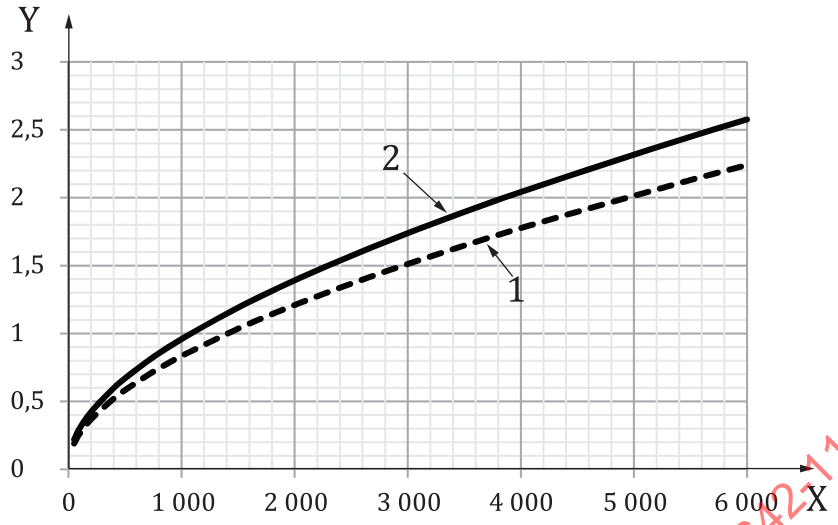
8.2.2 CX174b

8.2.2.1 Insertion loss IL

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 19. For a graphic representation please refer to Figure 2.

Table 19 — CX174b, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 100 °C [dB/m] max.
50	0,190	0,219
100	0,263	0,303
200	0,368	0,423
400	0,520	0,598
500	0,583	0,670
700	0,693	0,797
800	0,743	0,854
900	0,790	0,909
1 000	0,835	0,960
1 500	1,04	1,19
1 800	1,14	1,31
1 900	1,18	1,35
2 000	1,21	1,39
2 100	1,24	1,43
2 400	1,34	1,54
2 500	1,37	1,57
3 000	1,51	1,74
4 000	1,78	2,04
5 500	2,13	2,45
5 600	2,15	2,48
5 900	2,22	2,55
6 000	2,24	2,58
a	1,837E-02	+15 %
b .. $f^{0,5}$	2,385E-02	
c .. f	6,240E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 2 — CX174b, insertion loss limit

8.2.2.2 Bending tests

Tests are not required.

8.2.3 CX174c

8.2.3.1 Insertion loss IL

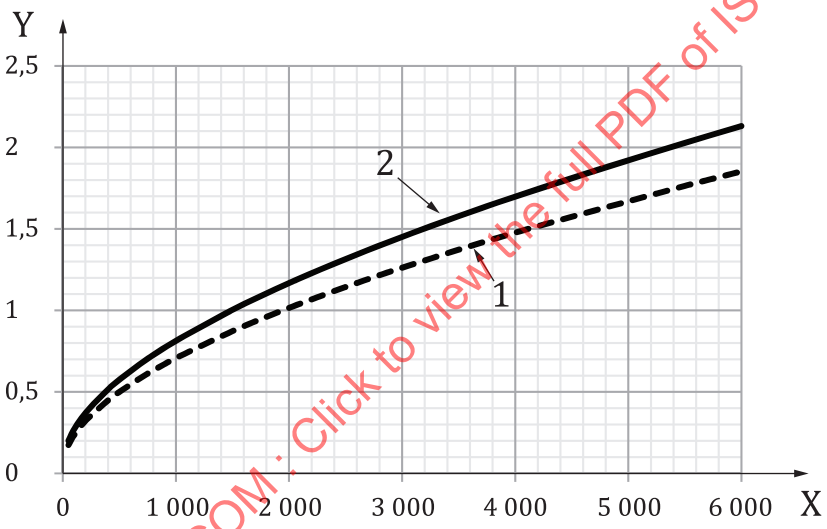
Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 20. For a graphic representation please refer to Figure 3.

Table 20 — CX174c, insertion loss limit

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
50	0,174	0,200
100	0,235	0,270
200	0,322	0,370
400	0,448	0,515
500	0,500	0,575
700	0,591	0,679
800	0,632	0,727
900	0,671	0,771
1 000	0,708	0,814
1 500	0,873	1,00
1 800	0,960	1,10
1 900	0,988	1,14
2 000	1,02	1,17

Table 20 *(continued)*

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
2 100	1,04	1,20
2 400	1,12	1,29
2 500	1,14	1,32
3 000	1,26	1,45
4 000	1,48	1,70
5 500	1,76	2,03
5 600	1,78	2,05
5 900	1,84	2,11
6 000	1,85	2,13
a	3,052E-02	+15 %
b .. $f^{0,5}$	1,996E-02	
c .. f	4,602E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 3 — CX174c, insertion loss limit

8.2.3.2 Bending tests

Tests are not required.

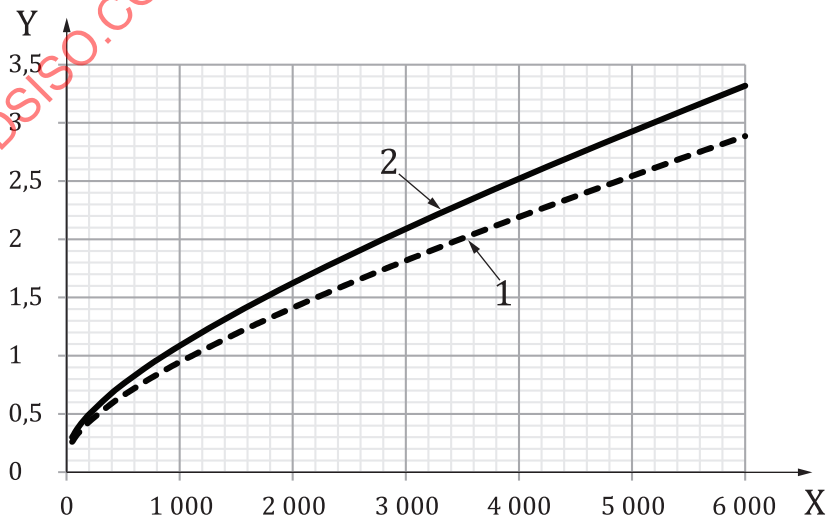
8.2.4 CX174d

8.2.4.1 Insertion loss IL

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 21. For a graphic representation please refer to Figure 4.

Table 21 — CX174d, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 100 °C [dB/m] max.
50	0,261	0,300
100	0,330	0,379
200	0,433	0,498
400	0,590	0,679
500	0,658	0,757
700	0,781	0,898
800	0,838	0,963
900	0,892	1,03
1 000	0,945	1,09
1 500	1,19	1,37
1 800	1,32	1,52
1 900	1,37	1,57
2 000	1,41	1,62
2 100	1,45	1,67
2 400	1,58	1,82
2 500	1,62	1,86
3 000	1,82	2,09
4 000	2,19	2,52
5 500	2,72	3,12
5 600	2,75	3,16
5 900	2,85	3,28
6 000	2,89	3,32
a	1,098E-01	+15 %
b .. $f^{0,5}$	1,992E-02	
c .. f	2,055E-04	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 4 — CX174d, insertion loss limit

8.2.4.2 Bending tests

Perform the bending test according to 6.4.4 using the test sequences in Table 22.

Table 22 — Cyclic bending tests for RF cables - test sequences

Number of repetitions of test sequences L1, L2 and L3		Bending type FX	Bending type HX
		3	5
test sequence	temperature, °C	number of cycles in test sequence	sum of cycles at end of test sequence
L1	RT	5 000	5 000
L2	85	600	5 600
L3	-25	400	6 000

Perform the bending test according to 6.4.5.5 using the test sequence in Table 23.

Table 23 — Test B, combined torsion and bending test - test sequence

Group	Temperature / humidity	Number of cycles in group	Sum of cycles at end of group
CG1	+40 °C / 30 % r.h.	60 000 ± 200	60 000 ± 200
CG2	-20 °C r.h. undefined	20 000 ± 70	80 000 ± 270
CG3	+85 °C / 20 % r.h.	20 000 ± 70	100 000 ± 340
CG4	RT r.h	5 000 ± 20	105 000 ± 360

8.2.5 CX174e

8.2.5.1 Insertion loss IL

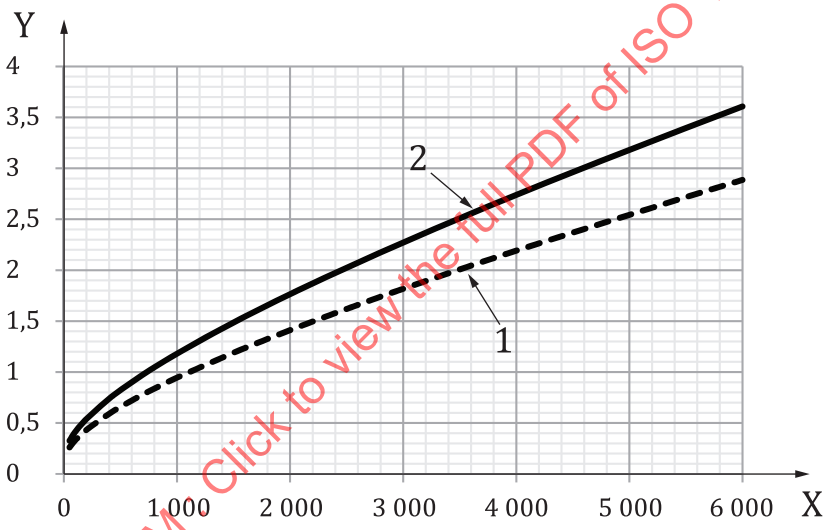
Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 24. For a graphic representation please refer to Figure 5.

Table 24 — CX174e, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 125 °C [dB/m] max.
50	0,261	0,326
100	0,330	0,412
200	0,433	0,541
400	0,590	0,738
500	0,658	0,822
700	0,781	0,976
800	0,838	1,05
900	0,892	1,12
1 000	0,95	1,18
1 500	1,19	1,49
1 800	1,32	1,66
1 900	1,37	1,71
2 000	1,41	1,76
2 100	1,45	1,82

Table 24 *(continued)*

f	IL at 20 °C	IL at 125 °C
[MHz]	[dB/m] max.	[dB/m] max.
2 400	1,58	1,97
2 500	1,62	2,02
3 000	1,82	2,27
4 000	2,19	2,74
5 500	2,72	3,40
5 600	2,75	3,44
5 900	2,85	3,57
6 000	2,89	3,61
a	1,098E-01	+25 %
b .. $f^{0,5}$	1,992E-02	
c .. f	2,055E-04	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 125 °C

Figure 5 — CX174e, insertion loss limit

8.2.5.2 Bending tests

Perform the bending test according to 6.4.4 using the test sequences in Table 25.

Table 25 — Cyclic bending tests for RF cables - test sequences

Number of repetitions of test sequences L1, L2 and L3		**Bending type FX**	**Bending type HX**
		3	5
test sequence	**temperature, °C**	**number of cycles in test sequence**	**sum of cycles at end of test sequence**
L1	RT	5 000	5 000
L2	85	600	5 600
L3	-25	400	6 000

Perform the bending test according to 6.4.5.5 using the test sequence in Table 26.

Table 26 — Test B, combined torsion and bending test - test sequence

Group	Temperature / humidity	Number of cycles in group	Sum of cycles at end of group
CG1	+40 °C / 30 % r.h.	60 000 ± 200	60 000 ± 200
CG2	-20 °C r.h. undefined	20 000 ± 70	80 000 ± 270
CG3	+85 °C / 20 % r.h.	20 000 ± 70	100 000 ± 340
CG4	RT r.h	5 000 ± 20	105 000 ± 360

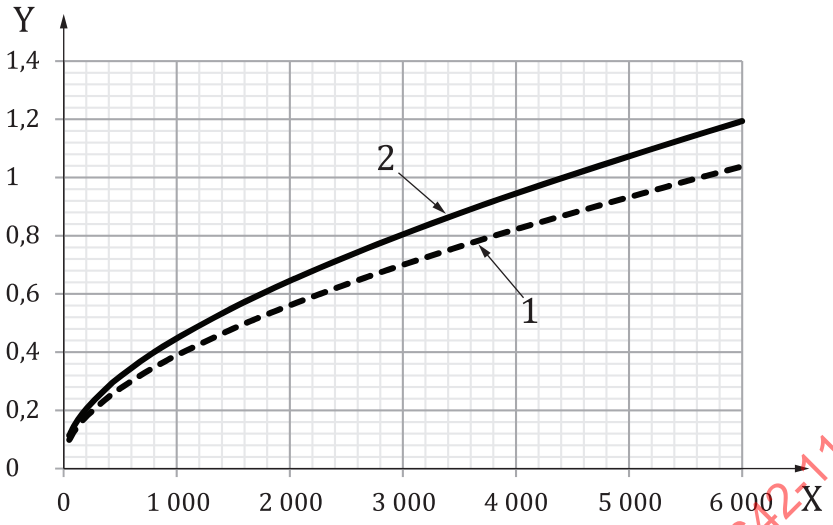
8.2.6 CX58a

8.2.6.1 Insertion loss

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 27. For a graphic representation please refer to Figure 6.

Table 27 — CX58a, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 100 °C [dB/m] max.
50	0,099	0,113
100	0,131	0,151
200	0,178	0,205
400	0,247	0,284
500	0,275	0,316
700	0,325	0,37
800	0,348	0,400
900	0,369	0,424
1 000	0,389	0,448
1 500	0,481	0,553
1 800	0,530	0,609
1 900	0,545	0,627
2 000	0,561	0,645
2 100	0,576	0,662
2 400	0,619	0,712
2 500	0,633	0,728
3 000	0,700	0,805
4 000	0,822	0,945
5 500	0,987	1,13
5 600	1,00	1,15
5 900	1,03	1,18
6 000	1,04	1,19
a	2,210E-02	+15 %
b .. $f^{0,5}$	1,058E-02	
c .. f	3,273E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 6 — CX58a, insertion loss limit

8.2.6.2 Bending tests

Tests are not required.

8.2.7 CX58b

8.2.7.1 Insertion loss

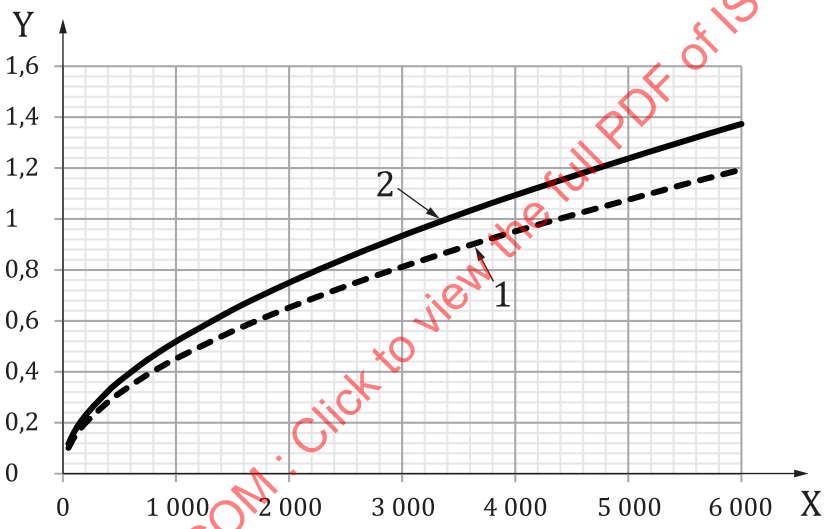
Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 28. For a graphic representation please refer to Figure 7.

Table 28 — CX58b, insertion loss limit

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
50	0,102	0,117
100	0,142	0,163
200	0,199	0,229
400	0,282	0,324
500	0,316	0,363
700	0,375	0,432
800	0,402	0,463
900	0,428	0,492
1 000	0,452	0,520
1 500	0,559	0,643
1 800	0,616	0,709
1 900	0,634	0,730
2 000	0,652	0,750

Table 28 *(continued)*

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
2 100	0,669	0,770
2 400	0,719	0,827
2 500	0,736	0,846
3 000	0,812	0,934
4 000	0,952	1,09
5 500	1,14	1,31
5 600	1,15	1,32
5 900	1,18	1,36
6 000	1,19	1,37
a	7,159E-03	+15 %
b .. $f^{0,5}$	1,319E-02	
c .. f	2,754E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 7 — CX58b, insertion loss limit

8.2.7.2 Bending tests

Tests are not required.

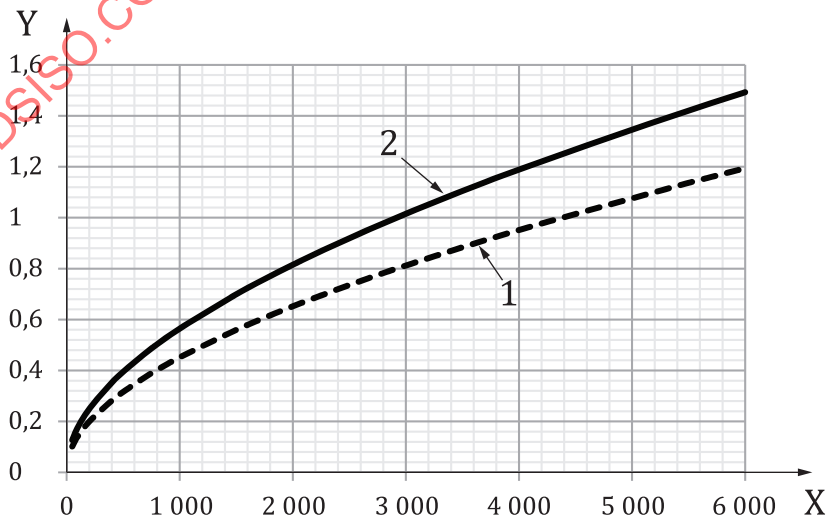
8.2.8 CX58c

8.2.8.1 Insertion loss

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 29. For a graphic representation please refer to Figure 8.

Table 29 — CX58c, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 125 °C [dB/m] max.
50	0,102	0,127
100	0,142	0,177
200	0,199	0,249
400	0,282	0,352
500	0,316	0,395
700	0,375	0,469
800	0,402	0,503
900	0,428	0,535
1 000	0,452	0,565
1 500	0,559	0,699
1 800	0,616	0,770
1 900	0,634	0,793
2 000	0,652	0,815
2 100	0,669	0,837
2 400	0,719	0,899
2 500	0,736	0,919
3 000	0,812	1,02
4 000	0,952	1,19
5 500	1,14	1,42
5 600	1,15	1,44
5 900	1,18	1,48
6 000	1,19	1,49
a	7,159E-03	+25 %
b .. $f^{0,5}$	1,319E-02	
c .. f	2,754E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 125 °C

Figure 8 — CX58c, insertion loss limit

8.2.8.2 Bending tests

Tests are not required.

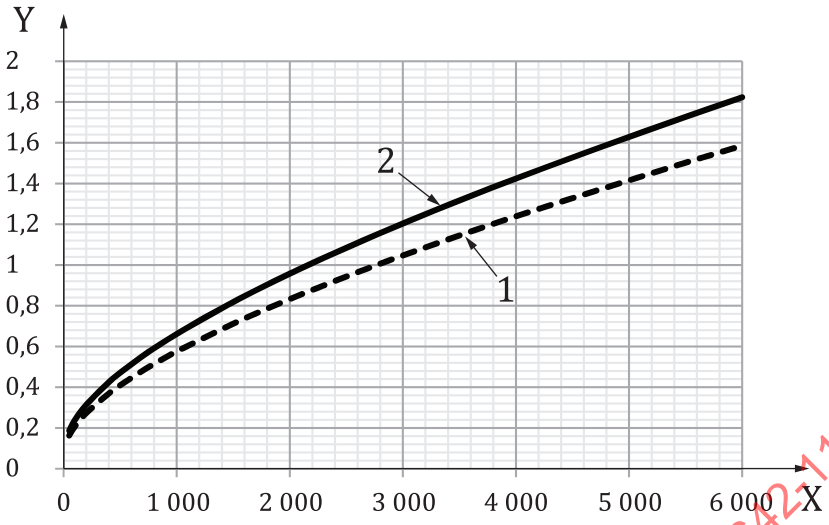
8.2.9 CX31a

8.2.9.1 Insertion loss

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 30. For a graphic representation please refer to Figure 9.

Table 30 — CX31a, insertion loss limit

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
50	0,163	0,187
100	0,207	0,239
200	0,273	0,314
400	0,369	0,424
500	0,409	0,471
700	0,481	0,554
800	0,514	0,591
900	0,546	0,627
1 000	0,576	0,662
1 500	0,712	0,819
1 800	0,786	0,903
1 900	0,809	0,931
2 000	0,832	0,957
2 100	0,855	0,983
2 400	0,922	1,06
2 500	0,943	1,08
3 000	1,05	1,20
4 000	1,24	1,42
5 500	1,50	1,73
5 600	1,52	1,75
5 900	1,57	1,80
6 000	1,59	1,82
a	6,065E-02	+15 %
b .. $f^{0,5}$	1,394E-02	
c .. f	7,416E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 9 — CX31a, insertion loss limit

8.2.9.2 Bending tests

Tests are not required.

8.2.10 CX44a, CX44b

8.2.10.1 Insertion loss

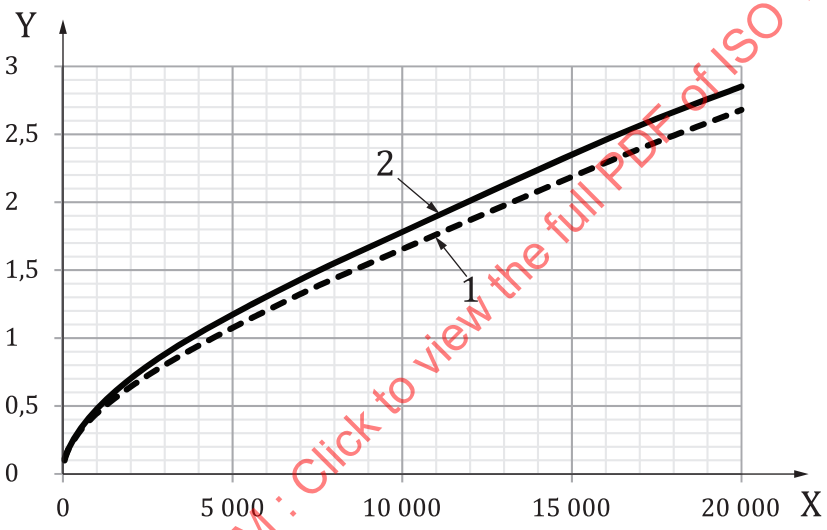
Insertion loss limits are calculated according to the formula in Table 3. For a table of some selected frequency points and the calculation parameters (a, b, c, d, e and g) see Table 31. For a graphic representation please refer to Figure 10.

Table 31 — CX44a and CX44b, insertion loss limit

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
50	0,099	0,113
100	0,140	0,148
200	0,197	0,203
500	0,313	0,326
800	0,397	0,422
1 000	0,446	0,477
1 500	0,551	0,599
2 000	0,642	0,703
2 500	0,725	0,796
3 000	0,802	0,881
4 000	0,944	1,03
5 500	1,14	1,24
5 600	1,15	1,25

Table 31 *(continued)*

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
5 800	1,18	1,28
6 000	1,20	1,30
8 000	1,44	1,55
16 000	2,29	2,46
20 000	2,68	2,85
a	9,536E-04	4,306E-02
b .. $f^{0,5}$	1,388E-02	7,977E-03
c .. f	-4,636E-06	2,969E-04
d .. $f^{1,5}$	3,119E-07	-4,693E-06
e .. f^{2}	7,279E-10	3,677E-08
g .. $f^{2,5}$	-6,441E-12	-1,006E-10



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 10 — CX44a and CX44b, insertion loss limit

8.2.10.2 Bending tests

Tests are not required.

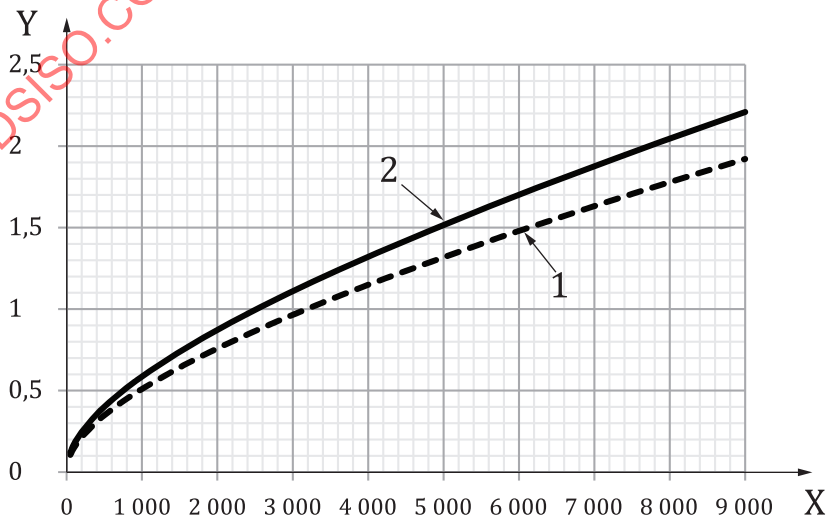
8.2.11 CX44c

8.2.11.1 Insertion loss

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 32. For a graphic representation please refer to Figure 11.

Table 32 — CX44c, insertion loss limit

f [MHz]	IL at 20 °C [dB/m] max.	IL at 100 °C [dB/m] max.
50	0,106	0,121
100	0,150	0,172
200	0,214	0,246
400	0,309	0,355
500	0,348	0,400
700	0,418	0,481
800	0,450	0,518
900	0,481	0,553
1 000	0,510	0,587
1 500	0,642	0,738
1 800	0,713	0,820
1 900	0,736	0,847
2 000	0,759	0,872
2 100	0,781	0,898
2 400	0,845	0,971
2 500	0,865	1,00
3 000	0,965	1,11
4 000	1,15	1,32
5 600	1,42	1,63
6 000	1,48	1,70
7 500	1,71	1,96
9 000	1,92	2,21
a	3,970E-03	+15 %
b .. $f^{0,5}$	1,390E-02	
c .. f	6,650E-05	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 11 — CX44c, insertion loss limit

8.2.11.2 Bending tests

Tests are not required.

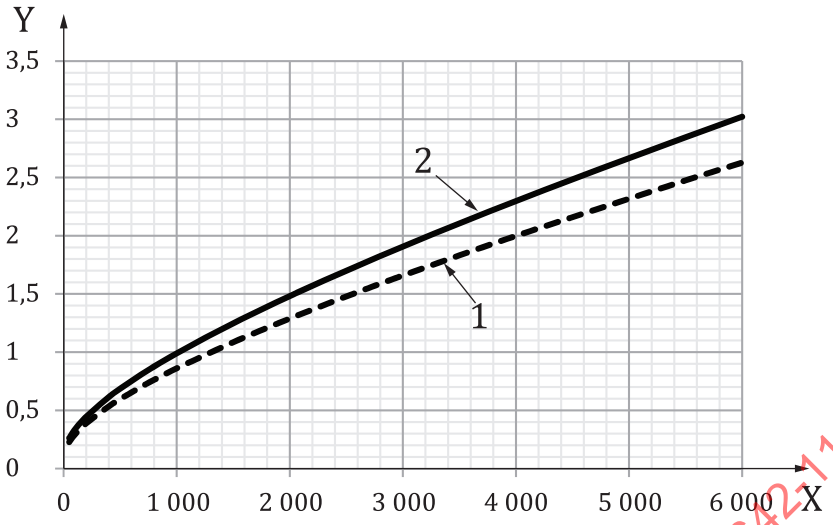
8.2.12 CX501a

8.2.12.1 Insertion loss

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 33. For a graphic representation please refer to Figure 12.

Table 33 — CX501a, insertion loss limit

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
50	0,228	0,262
100	0,292	0,335
200	0,388	0,446
400	0,534	0,614
500	0,596	0,686
700	0,710	0,816
800	0,762	0,876
900	0,813	0,934
1 000	0,861	0,990
1 500	1,09	1,25
1 800	1,21	1,39
1 900	1,25	1,44
2 000	1,29	1,48
2 100	1,33	1,53
2 400	1,44	1,66
2 500	1,48	1,70
3 000	1,66	1,91
4 000	2,00	2,30
5 500	2,48	2,85
5 600	2,51	2,88
5 900	2,60	2,99
6 000	2,63	3,02
a	8,560E-02	+15 %
b .. $f^{0,5}$	1,880E-02	
c .. f	1,810E-04	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 12 — CX501a, insertion loss limit

8.2.12.2 Bending tests

Tests are not required.

8.2.13 CX501b

8.2.13.1 Insertion loss

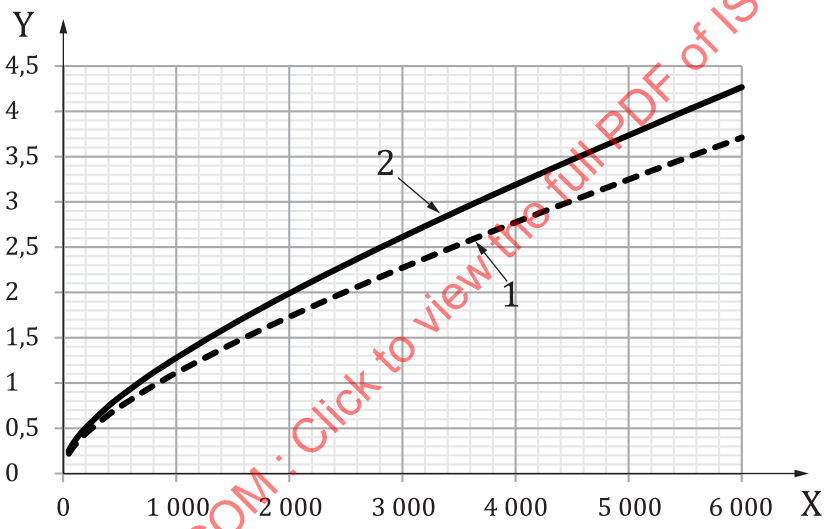
Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 34. For a graphic representation please refer to Figure 13.

Table 34 — CX501b, insertion loss limit

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
50	0,220	0,253
100	0,308	0,354
200	0,441	0,507
400	0,646	0,743
500	0,735	0,845
700	0,895	1,03
800	0,970	1,12
900	1,04	1,20
1 000	1,11	1,28
1 500	1,44	1,65
1 800	1,61	1,86
1 900	1,67	1,92
2 000	1,73	1,99

Table 34 *(continued)*

f	IL at 20 °C	IL at 100 °C
[MHz]	[dB/m] max.	[dB/m] max.
2 100	1,79	2,06
2 400	1,95	2,25
2 500	2,01	2,31
3 000	2,27	2,61
4 000	2,77	3,19
5 500	3,48	4,00
5 600	3,53	4,06
5 900	3,66	4,21
6 000	3,71	4,27
a	2,782E-02	+15 %
b .. $f^{0,5}$	2,515E-02	
c .. f	2,889E-04	



Key

X frequency, *f*, [MHz]
Y insertion loss, IL, [dB/m] max.
1 IL at 20 °C
2 IL at 100 °C

Figure 13 — CX501b, insertion loss limit

8.2.13.2 Bending tests

Tests are not required..

8.2.14 CX501c

8.2.14.1 Insertion loss

Insertion loss limits are calculated according to the formula in Table 2. For a table of some selected frequency points and the calculation parameters (a, b and c) see Table 35. For a graphic representation please refer to Figure 14.