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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



11/315/CD

COMMITTEE DRAFT (CD)

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IEC TC 11 : OVERHEAD LINES

SECRETARIAT:

South Africa

SECRETARY:

Mr John Dlamini

OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 7, TC 36, TC 42, TC 78, TC 99, TC 115, TC 122

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

Safety

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TITLE:

Overhead lines - Requirements and tests for fittings

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**OVERHEAD LINES –
REQUIREMENTS AND TESTS FOR FITTINGS****FOREWORD**

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International Standard IEC 61284 has been prepared by IEC technical committee 11: Overhead lines.

This third edition cancels and replaces the second edition published in 1997 and constitutes a technical revision.

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

FDIS	Report on voting

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

Annexes A, C, F, G, H, I and J form an integral part of this standard.

Annexes B, D, E, K, L, M, N, O and P are for information only.

The contents of the corrigenda of September 1998 have been included in this copy.

OVERHEAD LINES – REQUIREMENTS AND TESTS FOR FITTINGS

1 Scope

This International Standard applies to fittings for overhead lines of nominal voltage above 45 kV. Fittings concerned particularly are all fittings except those that have a specific standard dedicated like spacers (IEC 61854), dampers (IEC 61897) and end fittings for insulators (IEC 61466-1). It may also be applied to fittings for overhead lines of lower nominal voltage and to similar fittings for substations. Moreover, fittings designed for use with High Temperature (HT) conductors are included.

In some cases, test procedures and test values are left to agreement between purchaser and supplier and are stated in the procurement contract. The purchaser is best able to evaluate the intended service conditions, which should be the basis for establishing the test severity.

In Annex A, the minimum technical details to be agreed between purchaser and supplier are listed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050, *International Electrotechnical Vocabulary (IEV) – Chapter 466: Overhead lines* (available at www.electropedia.org)

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60120, *Dimensions of ball and socket couplings of string insulator units - Dimensions*

IEC 60372, *Locking devices for ball and socket couplings of string insulator units – Dimensions and tests*

IEC 60437, *Radio interference test on high-voltage insulators*

IEC 60471, *Clevis and tongue couplings of string insulator units - Dimensions*

IEC 60794-1-2, *Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures - General guidance*

IEC 60794-4, *Optical fibre cables - Part 4: Sectional specification - Aerial optical cables along electrical power lines*

IEC 60826, *Loading and strength of overhead transmission lines*

IEC 61089, *Round wire concentric lay overhead electrical stranded conductors*

IEC 61466-1, *Composite string insulator units for overhead lines with a nominal voltage greater than 1000 V - Part 1: Standard strength and end fittings*

IEC 61467, *Insulators for overhead lines - Insulator strings and sets for lines with a nominal voltage greater than 1000 V - AC power arc tests*

IEC 61854, *Overhead lines – Requirements and tests for spacers*

IEC 61897, *Overhead lines – Requirements and tests for Aeolian vibration dampers*

IEC 62641:2022, *Conductors for overhead lines - Aluminium and aluminium alloy wires for concentric lay stranded conductors*

- 43 IEC 63248, *Conductors for overhead lines - Coated or clad metallic wire for concentric lay*
44 *stranded conductors*
- 45 CISPR 16-1, *Specification for radio disturbance and immunity measuring apparatus and methods*
46 *– Part 1: Radio disturbance and immunity measuring apparatus*
- 47 CISPR TR 18-2, *Radio interference characteristics of overhead power lines and high-voltage*
48 *equipment – Part 2: Methods of measurement and procedure for determining limits*
- 49 ISO 1461:2022, *Hot dip galvanized coatings on fabricated ferrous products – Specifications*
- 50 ISO 9000, *Quality management systems – Fundamentals and vocabularies*
- 51 ISO 9001, *Quality management systems – Requirements*
- 52 ISO 9004, *Managing for the sustained success of an organization – A quality management*
53 *approach*
- 54 ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes*
55 *indexed by acceptable quality limit (AQL) for lot-by-lot inspection*
- 56 ISO 2859-2, *Sampling procedures for inspection by attributes – Part 2: Sampling plans indexed*
57 *by limiting quality (LQ) for isolated lot inspection*
- 58 ISO 3951-1, *Sampling procedures for inspection by variables – Part 1: Specification for single*
59 *sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single*
60 *quality characteristic and a single AQL*
- 61 ISO 3951-2, *Sampling procedures for inspection by variables – Part 2: General specification for*
62 *single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection of*
63 *independent quality characteristics*

64 **3 Definitions**

65 For the purpose of this document, the following terms and definitions apply. The term and the
66 definitions listed here are those which differ or do not appear in IEC 60050-466.

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

- 69 • IEC Electropedia: available at <http://www.electropedia.org>
70 • ISO Online browsing platform: available at <http://www.iso.org/obp>

71 **3.1**

72 **characteristic dimension**

73 Dimension of a component of the test circuit or of a fitting which characterizes its effect on the
74 electric field. In the case of a bundle, this dimension is approximately the diameter of an
75 enclosing circle; in the case of a corona ring or sphere, it is its largest dimension, etc.

76 **3.2**

77 **conductor classification**

78 The following last four types are generally called High Temperature (HT) conductors, being able
79 to withstand operating temperatures above the limits of conventional aluminium alloy or hard-
80 drawn aluminium wires without significant reduction of mechanical strength during its expected
81 lifetime. These conductors are usually designed to achieve an higher ampacity than conventional
82 conductors (Type 0) of the same size or to reduce size keeping the same ampacity.

83 **Type 0**

84 Conductors made up of hard-drawn aluminium or aluminium alloy wires (Ax or ALx as per IEC
85 62641, except A0 or AL0) with or without an inner core made up of steel wires (as per IEC 63248);
86 conductors made up of only steel wires (as per IEC 63248).

87 NOTE – In case of optical fibre conductors, the maximum operating temperature shall be agreed between purchaser
88 and supplier.

89 **Type 1**

90 Conductors made up of thermal resistant aluminium alloy wires (ATx as per IEC 62641) with
91 or without an inner core made up of steel wires (as per IEC 63248).

92 **Type 2**

93 Conductors made up of annealed aluminium wires (A0 or AL0 as per IEC 62641) supported
94 by an inner core made up of steel wires (as per IEC 63248).

95 **Type 3**

96 Conductors made up of thermal resistant aluminium alloy wires (ATx as per IEC 62641)
97 supported by an inner core made up of metal-matrix composite (MMC).

98 **Type 4**

99 Conductors made up of annealed aluminium wires (A0 or AL0 as per IEC 62641) or thermal
100 resistant aluminium alloy wires (ATx as per IEC 62641) supported by an inner core made up
101 of polymer-matrix composite (PMC).

102 **3.3**

103 **corona discharge**

104 Electric discharge that only partially breaks down the gas insulation around the fittings under
105 test.

106 **3.4**

107 **corona extinction**

108 Voltage or conductor voltage gradient at which corona discharges cease during a decreasing
109 test voltage sequence.

110 **3.5**

111 **corona inception**

112 Voltage or conductor voltage gradient at which corona discharges initiate during an increasing
113 test voltage sequence.

114 **3.6**

115 **earth wire fitting**

116 Any component of an assembly for attaching an earth wire to a supporting structure other than
117 a suspension clamp, a tension fitting or a mechanical protective fitting.

118 **3.7**

119 **factory-formed helical conductor fitting**

120 Fitting consisting of helically formed rods which provide the force necessary to grip the conductor
121 by self-tightening.

122 **3.8**

123 **insulator set fitting**

124 Any component of a suspension or tension insulator set other than a string insulator unit, a
125 suspension clamp, a conductor tension fitting, an insulator protective fitting or a mechanical
126 protective fitting.

127 **3.9**

128 **non-tension joint / partial tension fitting**

129 A fitting for the connection of two consecutive pieces of conductor which are to be held, but not
130 at the full line tension. Typical non-tension joints are the T joint [IEV 461-11-06], the lug

terminal [IEV 442-06-16], the branch-joint [IEV 461-11-17] and the fittings installed on slack spans.

NOTE – In branch joints, the connection is not subjected to line tension although the conductor to which the fitting is applied on its length may be at the line tension.

3.10

tension joint

A fitting for the connection of two consecutive pieces of conductor which are to be held at the full line tension. Typical tension joints are the dead-end tension joint [IEV 466-11-04] and the mid-span tension joint [IEV 466-11-03].

3.11

mechanical damage load

Maximum load which can be applied to a fitting without an unacceptable permanent deformation when the fitting is tested under specified test conditions.

NOTE – The unacceptable permanent deformation should be agreed upon between purchaser and supplier.

3.12

mechanical failure load

Maximum load which can be applied to a fitting under specified test conditions.

3.13

mechanical protective fitting

Any device attached to a conductor or to an earth wire for their mechanical protection.

3.14

operating temperatures

The operating temperatures are the temperatures, as below detailed, at which the conductor can be operated satisfying the conditions agreed between purchaser and conductor manufacturer.

NOTE - The following definitions will be in accordance with the similar ones introduced in the relevant IEC standards and which take precedence over this standard. In fact, these temperatures (as well as the RTS below defined) are peculiar characteristics of conductors and it is not the task of this standard to verify them; instead, they must be seen as parameters required to make the test protocols described here applicable.

maximum conductor continuous operating temperature (T_c)

Maximum continuous temperature at which the conductor can be operated without significant reduction of its rated tensile strength during its expected lifetime.

maximum conductor peak load (emergency operating) temperature (T_p)

Maximum temperature at which the conductor can be exposed without significant reduction of its rated tensile strength during a cumulative period of time (peak loads).

3.15

radio-interference voltage (RIV)

Voltage in the radio frequency range produced by an electromagnetic disturbance and which can be measured in accordance with CISPR 16 on the test circuit equipped with the fitting.

3.16

rated tensile strength (RTS)

Using the specified tensile properties of its elementary components, the calculated maximum load value at which a conductor or earth wire may be subjected before one or more of its elementary components break.

NOTE – The value is indicated in the manufacturer's datasheet and/or calculated according to the applicable IEC standard (e.g. IEC 61089, IEC 62420, IEC 60794-4-10, etc.).

3.17

specified maximum radio-interference voltage

Maximum acceptable radio-interference voltage at a specified test voltage or conductor voltage gradient. This is specified by the purchaser or declared by the supplier.

3.18**specified minimum corona extinction**

Minimum acceptable voltage or conductor voltage gradient at which corona discharges cease. This is specified by the purchaser or declared by the supplier.

3.19**specified minimum mechanical damage load (SMDL)**

Minimum load specified by the purchaser or declared by the supplier at which unacceptable permanent deformation will not take place.

NOTE – The unacceptable permanent deformation should be agreed upon between purchaser and supplier.

3.20**specified minimum failure load (SMFL)**

Minimum load at which mechanical failure will not take place. This is specified by the purchaser or declared by the supplier.

NOTE – From the probabilistic point of view, the specified minimum failure load corresponds to the value having the probability of e % in the distribution function of the strength of the fitting. The exclusion limit e % is usually taken within 2 % to 5 % with 10 % being the upper limit (see IEC 60826).

3.21**specified minimum failure load in coupling with the conductor (SMFLc)**

Minimum load at which, when in coupling with the conductor, mechanical failure will not take place. This is specified by the purchaser or declared by the supplier.

3.22**specified maximum slip load**

Maximum load specified by the purchaser or declared by the supplier at which slippage will take place.

3.23**specified minimum slip load**

Minimum load specified by the purchaser or declared by the supplier at which slippage will not take place.

3.24**highest voltage for equipment (U_m)**

Highest voltage for which the equipment is designed in respect of its insulation (representative highest continuous voltage). For AC, highest rms value of phase-to-phase voltage, for DC, highest mean or average pole DC voltage to earth, excluding harmonics, commutation and dynamic overshoots [IEV 421-09-01, modified].

4 Requirements**4.1 General requirements****4.1.1 Design**

The fittings shall be designed so as to

- avoid damaging the conductor under service conditions;
- withstand the mechanical loads relevant to installation, maintenance and service, the designed service current, including short-circuit current, the service temperatures and environmental circumstances;
- ensure that individual components are secured against becoming loose in service.

- 223 – have limited corona effects;
- 224 – allow the conductor to be used at its operating temperatures.
- 225 NOTE - However the purchaser is free to require limitations in fittings design (i.e. shape, mass, dimensions, etc.)
- 226 or handling during installation and maintenance fittings and/or conductor; this matter could lead to the limitation of
- 227 conductor temperatures and, so, to the conductor ampacity itself. These updated values (referred to the conductor
- 228 and also to the fittings, if any) shall be agreed between purchaser and fittings manufacturer and they shall be
- 229 indicated on contract drawings. In any case, the operating conductor temperatures shall be clearly indicated as
- 230 required by Annex A. In case operating temperatures on fitting are agreed, the heat dissipation test / thermal profile
- 231 shall be a mandatory test.
- 232 Fittings for live line maintenance shall be suitably designed for safe and easy handling.
- 233 Surfaces of compression fittings in contact with the conductor or earth wire shall be protected
- 234 from becoming contaminated before installation.
- 235 Brittleness of finished parts shall be avoided by adopting suitable materials and manufacturing
- 236 process.
- 237 **4.1.2 Materials**
- 238 Fittings shall be made of any material suitable for the purpose.
- 239 **4.1.2.1 Metallic materials**
- 240 The materials shall meet service life requirements and shall not be liable to intergranular or
- 241 stress corrosion. They shall not cause corrosion of any other parts of the conductor or earth wire.
- 242 The materials of compression fittings shall be capable of withstanding the cold working due to
- 243 compression. Furthermore, the steel compression components shall also have a sufficient impact
- 244 strength after the compression.
- 245 Examples of suitable materials are the following:
- 246 – aluminium or aluminium alloy;
- 247 – galvanized steel;
- 248 – galvanized malleable or ductile iron;
- 249 – stainless steel;
- 250 – copper and copper alloys.
- 251 It is recommended that ISO standards for materials be used where they exist. Examples of ISO
- 252 standards for fitting materials are listed in Annex L.
- 253 **4.1.2.2 Non-metallic materials**
- 254 Non-metallic materials employed shall have good resistance to ageing and be capable of
- 255 withstanding service temperatures without detrimental change of properties. Materials shall have
- 256 adequate resistance to the effects of ozone, ultra-violet radiation and air pollution over the whole
- 257 range of the service temperature.
- 258 The conductivity of the various non-metallic components shall be such that when properly
- 259 installed
- 260 – potential differences between metallic components do not cause damage due to discharge;
- 261 – line current including short circuit current and any current flow through the fitting do not
- 262 degrade the components.
- 263 They shall not induce corrosion in materials which are in contact with them.
- 264 **4.1.3 Dimensions and tolerances**
- 265 The dimensions shall be shown on contract drawings.
- 266 Particular regard shall be paid to those dimensions which involve interchangeability, correct
- 267 assembly, and those for which gauges are specified. Reference shall be made to relevant
- 268 standards, for example IEC 60120, IEC 60372, IEC 61466-1, etc.

269 Tolerances applied to dimensions shall ensure that the fittings meet their specified mechanical
270 and electrical requirements.

271 **4.1.4 Protection against corrosion**

272 All parts of insulator, conductor and earth wire fittings shall be either inherently resistant to
273 atmospheric corrosion or be suitably protected against corrosion, such as can occur during
274 transport, storage and in service. All ferrous parts which will be exposed to the atmosphere in
275 service, except those made of appropriate stainless steel, shall be protected by galvanizing in
276 accordance, for example, with ISO 1461 or other means giving equivalent protection.

277 Moreover, unless special measures are taken, there shall never be contact between metals for
278 which the difference in electrochemical potential can give rise to galvanic corrosion capable of
279 impairing the efficiency of the whole equipment. This applies especially to those parts of the
280 fittings that are in direct contact with the conductor.

281 All external threads shall be cut or rolled before galvanizing. Internal threads can be cut before
282 or after galvanizing. If cut after galvanizing they shall be oiled or greased.

283 NOTE - In case of hot dip galvanizing, ISO 965/4 and ISO 965/5 specify deviations and limits of sizes for hot-dip
284 galvanized external and internal screw threads.

285 **4.1.5 Marking**

286 Marking shall ensure the system of traceability for each of the component parts of the fittings.

287 When practicable, and unless otherwise agreed between purchaser and manufacturer, fittings
288 shall be clearly and indelibly marked as follows:

289 **Fittings used as individual components**

290 **Castings**

- 291 a) identification of fittings (reference number/SMFL);
- 292 b) manufacturer's identification;
- 293 c) date of manufacture (month and year);
- 294 d) cast code.

295 **Forgings**

- 296 a) identification of fittings (reference number/SMFL);
- 297 b) manufacturer's identification;
- 298 c) date of manufacture (month and year).

299 **Links and plates**

- 300 a) identification of fittings (reference number/SMFL);
- 301 b) manufacturer's identification;
- 302 c) date of manufacture (month and year).

303 **Assemblies of fittings**

- 304 a) identification (reference number/SMFL);
- 305 b) manufacturer's identification;
- 306 c) date of manufacture of individual items (month and year);
- 307 d) conductor diameter range or conductor code(s), as agreed between purchaser and
308 supplier;
- 309 e) fitting bolt installation torque (unless breakaway torque bolts are used).

310 **Conductor compression fittings**

- 311 a) identification (reference number);
- 312 b) manufacturer's identification;
- 313 c) date of manufacture (month and year);

d) conductor size or code name;

e) compression die sizes;

f) length to be compressed.

4.1.6 Instructions for assembly

The manufacturers shall provide the assembly instructions of the fittings as far as necessary.

4.2 Requirements for specific fittings

4.2.1 Insulator set fittings and earth wire fittings

For parts made of forged steel, the holes subjected to mechanical stress can be made by hot punching (cold punching is not allowed) providing that they have a cylindrical central part long not less than 70 % of the nominal length L of the hole in which the tolerances are respected (see Figure 1).

For parts made of forged steel, holes which are not under mechanical stress can be made by cold or hot punching without the aforementioned limits.

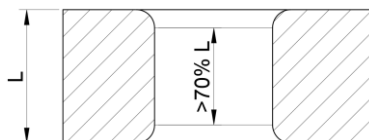


Figure 1 – Tolerance on holes subjected to mechanical stress

4.2.2 Suspension clamps

The suspension clamps shall be so designed that the effects of vibration, both on the conductor or on the earth wire and on the clamps themselves, are minimized. The clamps shall be designed to avoid localized pressure or damage to the conductor or the earth wire.

The suspension clamps shall have sufficient contact surface to avoid damage by fault currents.

The wear resistance of the articulation assembly shall be sufficient to prevent deterioration in service.

Magnetic losses shall not exceed the defined value, if specified.

The body of a suspension clamp shall permit oscillation around a horizontal axis perpendicular to the conductor. Regarding the position of the articulation, they are:

- clamps with articulation above the conductor; the pivot is above the horizontal plane passing through the conductor axis at the suspension point (see Figure 2a);
- clamps with articulation in the plane of the axis of the conductor (twin or triple articulation) (see Figure 2b); one of the three articulations is in the horizontal plane of the conductor axis;
- clamps with articulation under the axis of the conductor (see Figure 2c).

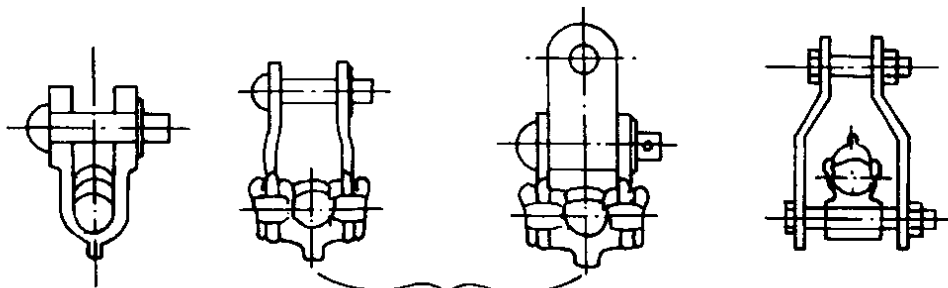


Figure 2a

Figure 2b

Figure 2c

IEC 692/95

Figure 2 – Different articulation of suspension clamps

The conductor or the earth wire installed in the suspension clamps can be used bare or equipped with factory-formed helical armour rods (later only armour rods). The clamps shall be tested with or without armour rods depending on customer use case.

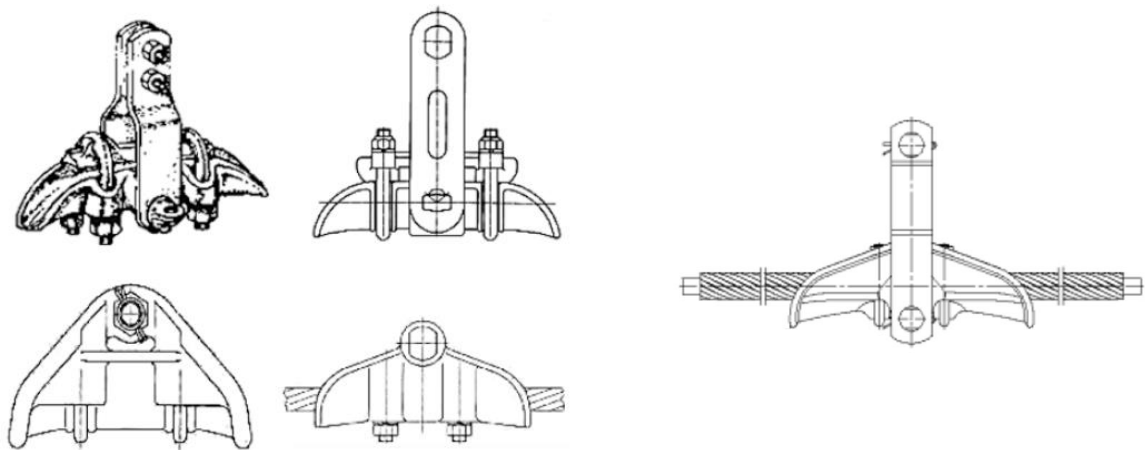
The clamping system can be:

- metal to metal; the suspension body and the keeper are tightened together around the conductor or the earth wire (see Figure 3);
- Elastomer Suspension (ES); a elastomeric liner is placed between the metal part of the suspension and the conductor or the earth wire (see Figure 4);
- Helically Attached Elastomeric Suspension (HAES); the clamp is composed by two elastomeric inserts, in contact with the conductor or earth wire and a set of factory-formed helical attachment rods (later only attachment rods) wrapped around them, a metallic housing provides the connection with the rest of the hardware (see Figure 5).

The manufacturer shall provide the purchaser with the performances of the suspension clamps, including, at least, the maximum admissible turning angle (see Figure 9) and the specified minimum failure load (SMFL).

NOTE – For each type of clamp, the purchaser can choose between

- standard clamps: the slip load of the conductor or earth wire is not lower than a specified minimum slip load and, if defined, no greater than a specified maximum slip load;
- controlled slippage clamps: the slip load of the conductor remains between two values defined by mutual agreement between the purchaser and the supplier.



With armour rods

Figure 3 – Different types of metal-to-metal suspension clamps

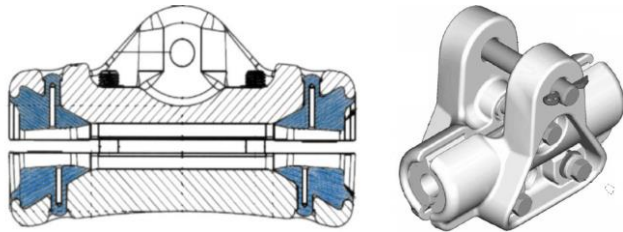


Figure 4 – Different types of rubber/elastomer-lined (ES) clamps

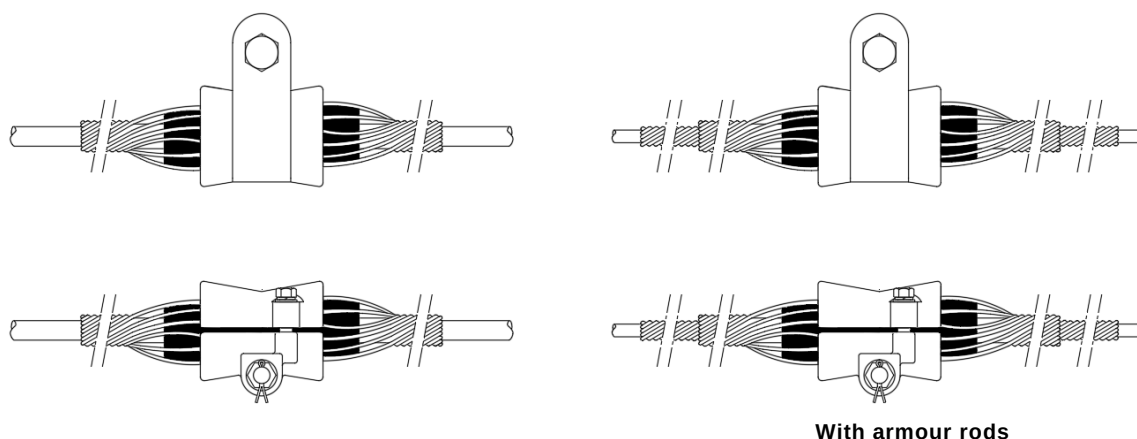


Figure 5 – Different types of HAES clamps

4.2.3 Fittings for jointing, terminating and repairing conductor and earth wire

Fittings for the purpose of jointing, terminating and repairing conductor and earth wire include, but are not limited to, the following:

- clamps mechanically compressed during installation;
- clamps installed using explosive charges;
- cone or wedge type clamps;
- bolted type clamps;
- factory-formed helical fittings.

The above fitting types may be used for tension and non-tension joints, and T joints. When the fittings are designed so as not to provide electrical continuity of the conductor (e.g. a tension clamp) the fittings shall not reduce the electrical capability of the conductor or earth wire.

Fittings used for electrical continuity connections shall meet the requirements of clause 13.

NOTE – The long-term thermal performances of the material used for the conductive parts of full tensions joints designed for type 1, 3 and 4 conductors (this last one only when the envelope is made up of thermal resistant aluminium alloy) shall be carefully considered because their degradation, due to the annealing, is critical. In fact, for the conductors mentioned above, the conductive part (and therefore the related joint) contributes significantly to their RTS.

Those fittings with auxiliary eyes intended for use during construction or maintenance shall be marked with a SMFL stated by the manufacturer.

All fittings shall be designed to minimize internal voids and to prevent the ingress or entrapment of moisture during service.

Fittings may be provided with an oxide-inhibiting compound intended to reduce metal oxidation at metal-to-metal electrical contact points. These compounds are commonly used in compression fittings to fill internal voids and to prevent ingress of water during service. They shall have chemical-physical characteristics suitable for use at the temperatures reachable by the fittings and durable over time.

NOTE – If requested by customer for specific configurations such as long spans and very inclined with risk of water ingress, joint can be greased entirely to avoid any void where water could accumulate (see dead-end joints where crimping cannot be done all along it specially at the place of pads).

Fittings and joints shall be designed in such a way that after installation, the initial contact area between the fitting and the conductor does not raise stresses which can lead to failure under aeolian vibration or other conductor oscillation conditions.

Fittings and joints intended to connect conductors of two dissimilar materials shall be designed to avoid bimetallic corrosion.

408 Fittings and joints shall be designed to avoid localized pressures which may cause excessive
409 cold flow of the conductor or earth wire material.

410 Fittings and joints intended for the restoration of electrical and mechanical properties of a
411 conductor shall have clearly defined manufacturer's instructions as to the extent of damage which
412 they are intended to repair.

413 **4.2.4 Insulator protective fittings**

414 Should steel tubes be used for insulator protective fittings, both the internal and external surfaces
415 of the tubes shall be hot dip galvanized.

416 When the tube is sealed after galvanizing, the quality of the internal surface shall be agreed
417 between purchaser and supplier.

418 For insulator protective fittings designed to protect insulator sets against damage caused by
419 power arcs (arcing horns, arcing rings, rings), the short-circuit current conditions shall be stated
420 by the customer in the order.

421 The protective fittings shall be designed in such a way as not to be subject to breakage through
422 fatigue due to vibration caused by the wind. The insulator protective fittings shall withstand a
423 static mechanical load agreed upon between supplier and purchaser.

424 **5 Quality assurance**

425 A quality assurance programme taking into account the requirements of this standard can be
426 used by agreement between the purchaser and the supplier to verify the quality of the fittings
427 during the manufacturing process.

428 Detailed information on the use of quality assurance is given in a system as per ISO 9001 or
429 similar.

430 The test and measuring equipment used to verify compliance to this standard shall be maintained
431 and calibrated in accordance with a relevant quality standard.

432 **6 Classification of tests – type tests, sample tests, routine tests**

433 **6.1 Type tests**

434 **6.1.1 General**

435 Type tests are intended to establish design characteristics. They are normally made once and
436 repeated only when the design or the material of the fitting is changed. The results of type tests
437 are recorded as evidence of compliance with design requirements.

438 **6.1.2 Application**

439 Fittings shall be subject to type tests in accordance with Table 1. Unless otherwise specified,
440 each type test shall be performed on three test samples which are identical in all essential
441 respects with fittings to be supplied under contract to the purchaser. Only Corona and RIV tests
442 on complete insulator sets shall be carried out on one sample assembly.

443 All units shall pass the tests.

444 In addition other tests may be agreed between purchaser and supplier, for example corrosion
445 tests, ageing tests, fatigue tests, short-circuit tests and power arc tests.

446 **6.2 Sample tests**

447 **6.2.1 General**

448 Sample tests are intended to verify that the fittings meet the performance specifications of the
449 type test samples. In addition, they are intended to verify the quality of materials and
450 workmanship.

6.2.2 Application

Overhead line fittings shall be subjected to sample tests as listed in Table 1. The samples to be tested shall be selected at random from the lot offered for acceptance. The purchaser has the right to make the selection.

The fittings used for tests during which no damage occurs to the units or their components may be used in subsequent tests.

6.2.3 Sampling and acceptance criteria

Unless otherwise agreed between purchaser and supplier, the sampling plan procedures according to ISO 2859-1 and ISO 2859-2 (inspection by attributes) and to ISO 3951-1 and ISO 3951-2 (inspection by variables) shall be applied.

For each sample test, the type of inspection (by attributes or by variables) and the detailed procedures (inspection level, acceptable quality level, single, double or multiple sampling, etc.) shall be agreed between purchaser and supplier (see example in Annex N for inspection by attributes, Annex O for inspection by variables. Annex P proposes a practical inspection method by attributes already widely adopted.

NOTE – Sampling inspection by variables is an acceptance sampling procedure to be used in place of inspection by attributes when it is more appropriate to measure on some continuous scale the characteristic(s) under consideration. In the case of failure load tests and similar expensive tests, better discrimination between acceptable quality and objective quality is available with acceptance sampling by variables than by attributes for the same sample size.

The purpose of the sampling process may also be important in the choice between a variables or attributes plan. For example, a purchaser may choose to use an attributes acceptance sampling plan to ensure that parts in a shipment lot are within a required dimensional tolerance; the manufacturer may make measurements under a variables sampling plan of the same dimensions because he is concerned with gradual trends or changes which may affect his ability to provide shipment lots which meet the AQL.

6.3 Routine tests

6.3.1 General

Routine tests are intended to prove conformance of fittings to specific requirements and are made on every fitting. The tests shall not damage the fitting.

6.3.2 Application and acceptance criteria

Whole lots of fittings may be subjected to routine tests as listed in Table 1. Fittings which do not conform to the requirements shall be discarded.

6.4 Table of tests to be applied

Table 1 indicates the tests which shall be performed.

These are marked with an "X" in the table. However, the purchaser may specify additional tests which are included in the table and marked with an "O".

Units or components damaged during the tests shall be excluded from the delivery to the customer.

Table 1 – Tests on fittings**Table 1a**

Insulator set fittings and earth wire fittings				
Clause	Test	Type tests	Sample tests	Routine tests
7	Visual examination	X	X ¹⁾	O
8	Dimensional and material verification	X	X	O
9	Corrosion protection tests	X	X	-
10	Non-destructive testing	O	O	O
11.3.1	Mechanical damage and failure load test	X	X	O ²⁾
11.3.2	Mechanical damage and failure load test of the attachment point used during erection	O	O	O ²⁾
14	Corona and radio interference voltage (RIV) tests	O ³⁾	-	-
1) Inspection by attributes only 2) Only as regards damage load test 3) Applicable only to insulator set fittings and only in connection with the complete set				

Table 1b

Suspension clamps						
Clause		Test	Conductor type	Type tests	Sample tests	Routine tests
7		Visual examination	All	X	X ¹⁾	O
8		Dimensional and material verification	All	X	X	O
9		Corrosion protection tests	All	X	X	-
10		Non-destructive testing	All	O	O	O
11.4.1		Vertical damage load and failure load test	All	X	X	O ²⁾
Alternative subsets as per suspension type and defined slip loads	11.4.2	Slip test on standard clamps with a specified minimum and maximum slip load	All	X	X	-
	11.4.2.1	Slip test after thermal cycles preconditioning	1, 2, 3, 4	X	-	-
	11.4.3	Slip test on standard clamps with only specified minimum slip load	All	X	X	-
	11.4.3.1	Slip test after thermal cycles preconditioning	1, 2, 3, 4	X	-	-
	11.4.4	Slip test on controlled slippage clamps	All	X	X	-
	11.4.4.1	Slip test after thermal cycles preconditioning	1, 2, 3, 4	X	-	-
11.4.5		Clamp bolt tightening test	All	X ³⁾	X ¹⁾³⁾	-
11.4.5.1		Clamp bolt tightening test after thermal cycles preconditioning	1, 2, 3, 4	X ³⁾	-	-
11.4.6		Turning angle test	3, 4	X	-	-
12		Magnetic losses test	All	O ⁴⁾	-	-
14		Corona and radio interference voltage (RIV) tests	All	O ⁵⁾	-	-
15		Fittings' thermal profile	1, 2, 3, 4	O ⁶⁾	-	-
16		Characterization of elastomers	All	O	-	-
1) Inspection by attributes only						
2) Only as regards damage load test						
3) Only on bolts which need to be tightened or for which a tightening torque is defined						
4) Only if clamps contain ferromagnetic material which forms a ring around the conductor						
5) Applicable only to suspension clamp for insulator set and only in connection with the complete set						
6) Mandatory in case operating temperatures on fittings are agreed as per Annex A						
If conical washers are used on bolted clamps, embrittlement tests shall be performed in accordance with clause 7.5.2.3 of IEC 61854:2020.						

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Table 1c

Tension clamps, dead-end tension joints and mid-span tension joints					
Clause	Test	Conductor type	Type tests	Sample tests	Routine tests
7	Visual examination	All	X	X ¹⁾	O
8	Dimensional and material verification	All	X	X	O
9	Corrosion protection tests	All	X	X	-
10	Non-destructive testing	All	O	O	O
11.5.1	Tensile test	All	X	X	-
11.5.1.1	Tensile test after thermal cycles preconditioning	1, 2, 3, 4	X	-	-
11.5.2	Mechanical damage and failure load test (except compressed clamps)	All	X ²⁾	O ²⁾	O ²⁾³⁾
11.5.3	Mechanical damage and failure load test of the attachment point used during erection	All	O	O	O ³⁾
11.5.4	Clamp bolt tightening test	All	X ⁴⁾	X ¹⁾⁴⁾	-
11.5.4.1	Clamp bolt tightening test after thermal cycles preconditioning	1, 2, 3, 4	X ⁴⁾	-	-
12	Magnetic losses test	All	O ⁵⁾	-	-
13	Heat cycle tests	All	X ⁶⁾	-	-
14	Corona and radio interference voltage (RIV) tests	All	O ⁷⁾	-	-
15	Fittings' thermal profile	1, 2, 3, 4	O ⁸⁾	-	-
1) Inspection by attributes only 2) Except compressed clamp 3) Only as regards damage load test 4) Only on bolts which need to be tightened or for which a tightening torque is defined 5) Only if clamps contain ferromagnetic material which forms a ring around the conductor 6) Only for current-carrying joints 7) Applicable only to tension clamps and dead-end tension joints for insulator set and only in connection with the complete set. Applicable only to mid-span tension joint for conductor 8) Mandatory in case operating temperatures on fittings are agreed as per Annex A					
If conical washers are used on bolted clamps, embrittlement tests shall be performed in accordance with clause 7.5.2.3 of IEC 61854:2020.					

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Table 1d

Repair sleeves					
Clause	Test	Conductor type	Type tests	Sample tests	Routine tests
7	Visual examination	All	X	X ¹⁾	O
8	Dimensional and material verification	All	X	X	O
9	Corrosion protection tests	All	X	X	-
11.7.1	Tensile test	All	X	X	-
11.7.1.1	Tensile test after thermal cycles preconditioning	1, 2, 3, 4	X	-	-
13	Heat cycle tests	All	O ²⁾		
14	Corona and radio interference voltage (RIV) tests	All	O ²⁾	-	-
15	Fittings' thermal profile	1, 2, 3, 4	O ³⁾	-	-
1) Inspection by attributes only 2) Applicable only to repair sleeves for conductor 3) Mandatory if the operating temperatures of fittings are agreed in accordance with Annex A					

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Table 1e

Partial tension fittings					
Clause	Test	Conductor type	Type tests	Sample tests	Routine tests
7	Visual examination	All	X	X ¹⁾	O
8	Dimensional and material verification	All	X	X	O
9	Corrosion protection tests	All	X	X	-
10	Non-destructive testing	All	O	O	-
Other than T joints	11.6.1.1	Tensile test	All	X	-
	11.6.1.1.1	Tensile test after thermal cycles preconditioning	1, 2, 3, 4	X	-
T joints	11.6.2.1	Tensile test with mechanical tension between main conductor and branch conductor	All	X	-
	11.6.2.1.1	Tensile test after thermal cycles preconditioning	1, 2, 3, 4	X	-
	11.6.2.2	Tensile test with mechanical tension on the main conductor	All	X	-
	11.6.2.2.1	Tensile test after thermal cycles preconditioning	1, 2, 3, 4	X	-
11.6.3	Clamp bolt tightening test	All	X ²⁾	O ¹⁾²⁾	-
11.6.3.1	Clamp bolt tightening test after thermal cycles preconditioning	1, 2, 3, 4	X ²⁾	-	-
13	Heat cycle tests	All	X ³⁾	-	-
14	Corona and radio interference voltage (RIV) tests	All	O	-	-
15	Fittings' thermal profile	1, 2, 3, 4	O ⁴⁾	-	-
1) Inspection by attributes only 2) Only on bolts which need to be tightened or for which a tightening torque is defined 3) Only for current-carrying joints 4) Mandatory in case operating temperatures on fittings are agreed as per Annex A					
If conical washers are used on bolted clamps, embrittlement tests shall be performed in accordance with clause 7.5.2.3 of IEC 61854:2020.					

500

501

Table 1f

Insulator protective fittings ¹⁾				
Clause	Test	Type tests	Sample tests	Routine tests
7	Visual examination	X	X ²⁾	O
8	Dimensional and material verification	X	X	O
9	Corrosion protection tests	X	X	-
10	Non-destructive testing	O	O	O
11.8	Mechanical damage and failure load test for insulator protective fittings	O	O	O
14	Corona and radio interference voltage (RIV) tests	O ³⁾	-	-
1) Includes electrical gradient devices 2) Inspection by attributes only 3) Applicable only to insulator set fittings and only in connection with the complete set				

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7 Visual examination

Type tests shall include visual examination to ascertain conformity of the fittings, in all essential respects, with the contract drawings. Deviations from the drawings shall be subject to agreement between supplier and purchaser and shall be appropriately documented as an agreed concession.

NOTE – The good execution of casting (if any) on suspension clamps can be verified by the checking of some sections (longitudinal, transversal) of the samples. The acceptance criteria shall be agreed upon between supplier and purchaser.

Sample tests include visual examination in accordance with 6.2.3. Visual examination shall ensure conformity of manufacturing process, shape, coating and surface finish of the fitting with the contract drawings. Particular attention shall be given to markings required and to the finish of surfaces which come into contact with the conductor.

NOTE – Verification of marking may include marking required by the purchaser in order to verify inspection or testing (e.g. hardness tests, indent marks, inspectors' stamps, etc.).

For fittings subject to corona type tests, the sample test shall include a comparison of shape and surface finish with one of the corona type test samples when agreed between purchaser and supplier.

Routine tests do not include visual examination unless otherwise agreed between supplier and purchaser or unless included in the quality assurance system of the supplier.

8 Dimensional and material verification

Type and sample tests shall include verification of dimensions, in accordance with clause 6, to ensure that fittings are within the dimensional tolerances stated on contract drawings. The purchaser may choose to witness the measurement of selected dimensions or may inspect the supplier's documentation when this is available. Measuring devices/gauges shall be selected with regard to the required precision and accuracy. Documentary evidence of calibration of such devices shall be provided on request.

Routine tests shall include a specified level of dimensional checking when required by the contract quality plan.

NOTE – Particular attention should be given to those dimensions potentially affecting fitting interchangeability (for example ball and socket couplings (IEC 60120); clevis and tongue couplings (IEC 60471); other end fittings for insulators couplings (IEC 61466-1)) or mechanical and/or electrical performance.

Type and sample tests shall also include verification of materials to ensure that they are in accordance with contract documents. This verification shall normally be carried out by the purchaser inspecting the supplier's documentation relative to material purchasing specifications, certificates of conformity or other quality documentation. When agreed between purchaser and supplier, material verification shall include tests appropriate to the material specification.

Routine tests shall include a specified level of material verification (including tests) when required by the contract quality plan.

9 Corrosion protection tests

9.1 Hot dip galvanized components

Type and sample tests shall include galvanizing tests in accordance with clause 6 to ensure that galvanized coatings comply with the requirements as specified in ISO 1461.

The coating thicknesses shall conform to Tables 3 and 4 unless otherwise agreed between purchaser and supplier. However, for the purpose of this document, Tables 3 and 4 of ISO 1461:2022 shall apply to the following categories of items (and not to the categories specified in ISO 1461):

Table 3: Coating thickness on all samples except

- washers;
- threaded components;
- small parts which are centrifuged (significant surface area $\leq 1000 \text{ mm}^2$).

Table 4: Coating thickness on

- washers;
- threaded components;
- small parts which are centrifuged (significant surface area $\leq 1000 \text{ mm}^2$).

9.2 Ferrous components protected from corrosion by methods other than hot dip galvanizing

Ferrous components protected from corrosion by methods other than hot dip galvanizing shall be tested in accordance with the requirement of the relevant IEC/ISO standards, as agreed between purchaser and supplier.

9.3 Corrosion caused by non-metallic components

By agreement between purchaser and supplier, evidence of non-corrosion compatibility between the elastomer and the conductor or fitting's components, as appropriate, shall be demonstrated by a corrosion test or by suitable service experience.

NOTE – Some constituents of the non-metallic components, such as carbon, chlorides, free sulphur, etc. may have corrosion effects. The combination of the nature of the material, the pollution and the electrolyte are responsible for a corrosion process.

10 Non-destructive testing

The purchaser shall specify or agree to relevant test methods, classification (type, sample, routine tests) and acceptance criteria.

Examples of non-destructive tests are as follows:

- magnetic test;
- eddy current test;
- radiograph test;
- ultrasonic test;
- proof load test;
- dye penetrant test;
- hardness test.

11 Mechanical tests

11.1 Fittings' thermal preconditioning for HT conductors

The purpose of this procedure is to expose the fittings to high temperatures for a reference time period before the execution of the mechanical test at ambient temperature. Such high temperatures are that ones that the fittings reach when the conductor is at its maximum admissible temperature (T_p).

NOTE - Considering that this exposition at high temperatures leads the ageing of both the fittings and the conductor and the acceptance criteria are the same for unconditioned fittings, the duration shall be not so long to have a significant loss of conductor strength.

The following conditioning shall be applied before the test when required. A suitable length of conductor shall be used in order to have a free length of reference conductor as described in 13.4.2 and to install the fittings at the following relative distances:

- For tension clamps, dead-end tension joints, mid-span tension joints, repair sleeves and partial tension fittings the length of conductor between the fittings under test and any other clamp or joint in the test assembly shall be at least equal to than 100 times the overall diameter of the conductor or 2,5 m, whichever is greater.

- For suspension clamps between a test sample and an adjacent fitting at least equal to than 50 times the overall diameter of the conductor or 1,25 m, whichever is greater, if no sensor to measure conductor temperature is applied in between.

The test conditions shall be as defined by 13.4.1. The fittings shall be installed on the conductor in accordance with the supplier's instructions.

The temperature measurements shall be according to 13.4.5.2. During and after the conditioning, no modification (e.g. removing, changing the tightening torque, reapplying the compression, etc.) are permitted on tested specimens. The preconditioning shall be carried out employing conductors in an "as new" condition (i.e. free of any deterioration or damage), and a mechanical constant tension not exceeding 20 ± 2 % of conductor RTS of the main conductor may be applied to the assembly.

Alternatively, the main conductor may be tensioned to 20 ± 2 % of conductor RTS at room temperature, then this tension is allowed to fluctuate during the continuation of the test.

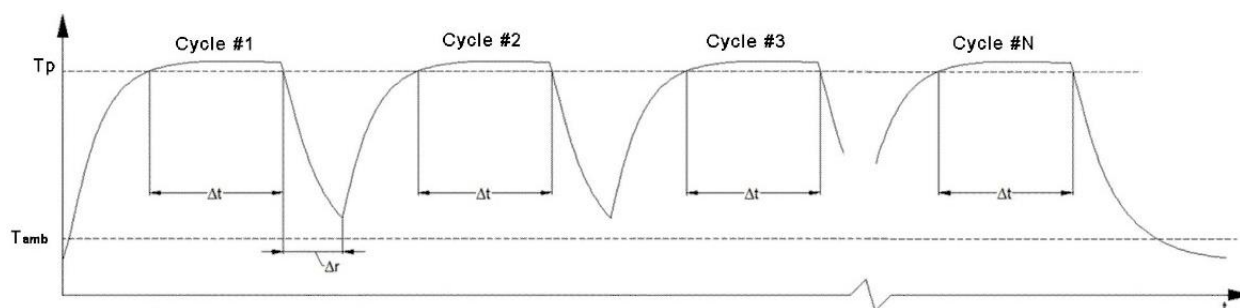
NOTE – In this case, at the end of each cooling period the tension shall be checked. In case the tension drops below 15 % of conductor RTS, the test shall be stopped, and fittings reviewed for slip. Then a constant tension (does not vary with changes in temperature) will be applied as above defined for the remaining cycles.

The conductor shall be ohmic heated to the temperature at maximum peak load temperature to $T_p + 5$ °C. The use of an initial current of value not greater than 150 % of the test current, to provide accelerated heating so as to reduce the time to raise the conductor to $T_p + 5$ °C above ambient, is permitted.

The thermal cycles shall be composed by a steady state period Δt with a duration of at least 2 hours. The total duration of all heating periods summarized shall be at least 168 hours¹. The cooling period Δr shall be at least 2 hours (see Figure 6). Forced cooling, to reduce the time cycle, is permitted providing that this shall affect the whole assembly uniformly. The new heating period can start only when the temperature of all components is less than the ambient one plus 5 °C.

At the end, all the tests where the fittings are preconditioned using the procedure here described, shall be executed at room temperature.

NOTE – An alternative to the above preconditioning procedure is presented in Annex B.



$$\Delta t \geq 2h \quad \Delta r \geq 2h \quad \sum \Delta t \geq 168h$$

Figure 6 – Thermal cycles preconditioning

11.2 Test specimen and attachments for mechanical damage and failure load tests, conductors used in the mechanical tests

A fitting under test shall be complete with all components and shall be tested in a manner as near as possible to the arrangement used in service. In order to avoid their unacceptable deformation, it is permissible to strengthen the attachments required to transmit the mechanical loads to the test fitting.

¹ This duration is equivalent to an exposition of one week at the maximum peak load temperature T_p . Considering that no upper limit to Δt is defined, the whole preconditioning can be even executed in a single cycle.