



INDEPENDENT POWER TRANSMISSION OPERATOR S.A.

TRANSMISSION NEW PROJECTS DEPARTMENT

**OVERHEAD TRANSMISSION LINES TOWER DESIGN
AND SPECIFICATIONS SECTION**

SPECIFICATION TR - 20

**SPECIAL TYPE CONDUCTORS
(THERMAL RESISTANT CONDUCTORS)**

Revision March 2016

ATHENS - GREECE



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SPECIAL TYPE CONDUCTORS (THERMAL RESISTANT CONDUCTORS)

1. SCOPE

This specification covers the design, manufacturing and testing of concentric lay stranded phase thermo-resistant conductors, which are used as overhead electrical conductors at 150kV T.L.

2. GENERAL REQUIREMENTS

These conductors are designated for the replacement of ACSR phase conductors at existing 150kV T.L. in order to increase the ampacity of the T.L. without exceeding in ruling span the maximum allowable sag and the maximum allowable tension as they appear in Annex A and taking into consideration the conditions in Annex B.

2.1 Technical characteristics

2.1.1. The manufacturing, industrialization, testing and the characteristics of these conductors shall be in accordance with the requirements of the International Standards IEC 61089 and its Amendment IEC 61089-am1/97 or ASTM B 232/B 232M, ASTM B 856/857, where they are applicable, as well as with the requirements of the British Standard EN 50540/2010 “Conductors for overhead lines – Aluminium Conductors Steel Supported (ACSS)”, and don’t confront with the requirements of the present specification.

2.1.2. The specified direction of lay of the external layer shall be “right – hand”. The manufacture of standard conductor length shall be continuous.

2.1.3. The mechanical characteristics of the conductor shall be similar to those of the conductor which will be replaced and are given in Annex A. The study for the conductor will be done according to the conditions of Annex B.

2.1.4. The conductor must have the required ampacity without exceeding in ruling span (350m and 500m) the maximum allowable sag of the conductor which will be replaced.

2.2 Material

2.2.1. If the conductor comprises from thermal resistant aluminium wires made from aluminium-zirconium alloy their conductivity shall be in accordance with the corresponding values of Table 4, of par.6.6 of International Standard IEC 62004. All aluminium–zirconium wires should have, before stranding, characteristics that meet the requirements of par.6 of International Standard IEC 62004.

2.2.2. If the conductor comprises from aluminium alloy wires fully annealed (type 1350-O), their conductivity shall be in accordance with the corresponding value of Table 4 of ASTM B/609. All aluminium alloy fully annealed wires should have before annealing characteristics which shall comply with the requirements of par.10 of International Standard IEC 889.

2.2.3. For the core wires of the conductor the geometrical and mechanical characteristics shall be subjected and be confirmed with tests, similar with those of par.10,11 of International Standard IEC 888(zinc coated) or IEC 61232(Aluminium clad steel), depending on the core material of the conductor which will be replaced. Alternatively par.8, 9, 10 of ASTM B 498 (zinc coated) or par.7,8,9 of ASTM B 606-02 (HS zinc coated), ASTM B341/B 341M-02, ASTM B 803-02 or par.8,9,10 of ASTM B 802/B 802M-02 can be used, whichever is applicable. In case that the material of the core has no applicable standard, tests shall be carried out similar



of those described above and subjected to the purchaser for approval.

2.3 Stranding – Joints

Stranding and joints of aluminum and core wires shall meet the requirements of par.5.4 and 5.5 of International Standard IEC 61089 and its Amendment (IEC 61089–am1/97), which overrules. No joints shall be made to the core wires.

2.4 Length of each section

Unless specified otherwise by the contract, the specified “standard reel length” is approximate. The accepted tolerance is $\pm 5\%$. No more than 5% of the total weight of conductor may be furnished in random lengths, none of which shall be less than 65% of the standard reel length. It is not allowed a random length to be wound on the same reel with a standard length.

The specified standard reel length may be increased by approval or commission of the Company.

2.5 Reels

2.5.1 The conductor will be packed in wooden reels, designed in such a way so the conductor is properly protected from damages during transportation (sea, rail, road, and air), moving or storing it outdoors.

2.5.2 Reels shall be made from dry pine or fir wood. The wood humidity before reels manufacturing has to vary between 15-25%. Wood quality and its humidity will be proved either by measurements using special electronic devices or by the relevant reports and wood Supplier's shipping invoices. The reels will be brand-new, they must not be used and their surfaces have to be frictionless, without any flakes or holes or generally any inkling of insects presence.

2.5.3 Reel heads shall be firmly bolted to the drum and shall be equipped with a cast iron hub bushing with a hole at the center of the head. Reels shall be lagged with wood lagging, so that the outer layer of the conductor to be protected. In addition the reels shall have a layer of water proof paper around the drum and around the conductor lies inside the lagging and also on the inner surface of the reel heads. Special attention shall be taken during the winding of the conductor to the reel, so that the conductor is properly placed in order to avoid friction between the lays of the conductor during transportation.

The connection of the wooden parts of the reel shall be done in such a manner so that the conductor won't be scratched or afflicted, such as staples, while the use of nails shall be avoided. The outer surface of the reels shall be properly painted in order to protect the reel from humidity and to characterize each type of conductor.

2.5.4 The winding of the conductor on the reel has to be uniform and in accordance with the rules of art, the conductor layers have to be distinguished, the layer level must keep order and the phenomenon of “straddled” conductors must not appear. For this reason Manufacturer has to pay high attention to the winding during conductor fabrication from the very first layer, which is of highest importance, so that the conductor spires are strictly the one beside the other, without leaving any spaces for all along the reel length and continue in the same way for all layers.

2.5.5 The correspondence between drum's colour and conductor's type is:

Type of conductor	Colour
- Equivalent ACSR Linnet	Green – White
- Equivalent ACSR/AW Linnet	Red – White
- Equivalent ACSR Grosbeak	Blue – White

The drawing of the reel shall meet the requirements of drawing TR–2/1A of IPTO S.A. in Annex C.

2.6 Marking

2.6.1 On a tablet or label properly attached at the edge of the conductor, the following data will be marked:

- Type of conductor,
- Mixed and net weight,
- length,
- size,
- lay characteristics,



And also every other characteristic that the manufacturer consider necessary.

2.6.2 The data of the marking described in par.2.6.1 of present specification, the ordering number the series number of the manufacturer (if there is any) and the shipment data shall be marked on the outer surface of the wooden drum .

3. TESTS

All required tests should be preformed in proper independent laboratories accredited according to International Standard ISO/IEC 17025 or to manufacturer's laboratory, if it is certified by ISO 9001. Test reports have to be written in Greek or English language and shall be certified by laboratory where the tests have taken place. The tests shall be in accordance with the requirements of par.6 of International Standard IEC 61089 or par.15 of ASTM B 232/B 232M, where they are applicable and don't confront with the requirements of present specification. If the conductor comprises from thermal-resistant aluminium wires, made from aluminium-zirconium alloy, they shall comply with the requirements of par.7 of International Standard IEC 62004. If the conductor comprises from annealed aluminium alloy wires fully annealed, they shall comply before annealing with the requirements of par.4, 5, 10, 11 of International standard IEC 889. If the conductor has been tested according to ASTM standards then the supplier shall subject a table that proves that the corresponding tests of IEC are satisfied. IPTO S.A. reserves the right to repeat some or all the tests according to IEC standards if this is considered to be necessary.

3.1 Test samples

The size and length of the samples which will be tested shall be those of the corresponding paragraphs of the International Standards IEC 61089, IEC 888, IEC 889 and IEC 62004, where they are applicable.

Samples of wires will be taken after stranding and will be cut in presence of the IPTO's representative and will be hand over to him for the prosecuting of the tests.

3.2 Type tests

Type tests for complete conductor shall comply with the requirements of par.6.5 of International Standard IEC 61089, where they are applicable and don't confront the requirements of present specification. The tests for evaluating the breaking strength of the complete conductor shall be done according IPTO's instructions and only if IPTO consider it expedient.

3.3 Sample tests

Sample tests shall comply with the requirements of par.6.6 of International Standard IEC 61089, where they are applicable and don't confront the requirements of present specification.

4. INSPECTION

4.1 The conductors shall be subjected to inspection and shall not be released for shipping without the approval of the Company's representative. The approval for shipping shall neither relieve the Manufacturer from responsibility of furnishing material conforming to all requirements of the Company nor invalidate any claim which the Company may make because of defective or unsatisfactory material.

4.2 All the tests in the factory which the purchaser considers as necessary for the confirmation of the materials ability to comply with present specification, shall be done with manufacturer's expenses, who must provide the necessary samples, organs and devices for the above tests. All the above tests that intend to validate the quality of the material shall be done with purchaser's expenses. Purchaser reserves the right to attend some or all the above tests.

4.3 The purchaser reserves the right to inspect all used materials and the production methods. At working hours purchaser's representative can enter at all departments of the factory accompanied by a representative of the supplier.

4.4 Manufacturer shall submit to the Company copies of the control and test reports of the material. The Company reserves the right to demand all the routine test reports from the manufacturer. The reports must be certified by a manufacturer's representative.

4.5 Purchaser has the right, with his own expenses, to pick up a proper length of any part which is



delivered from the manufacturer, according to present specification, and give them to a proper independent accredited laboratory of his own choice (the Purchaser's), for the certification of tests or characteristics or for additional research and tests which will be judged necessary from the purchaser.

4.6 In each delivery quantity, sample tests shall be performed in accordance with the requirements of paragraph 3.3 of present specification.

4.7 For type test reports that haven't been submitted or that aren't adequate according to the requirements of paragraph 3 of present specification, IPTO reserves the right to request the performance of any or all type tests specified in paragraph 3.2 of present specification on samples which shall be taken from the production of the offered items. The Company reserves the right to select test laboratory and witness any or all tests.

4.8 In order to check the correct conductor winding during inspection, it will be performed the "Test for ability of a conductor to be erected using tension stringing", which is referred to Annex E of EN 50182:2001 "Conductors for overheads lines – Round wire concentric lay stranded conductors". Test sampling will be according to ISO 2859-1, General Inspection Level I, AQL 4.0 – Normal inspection.

In case of failure during this test, the batch will be rejected and manufacturer has to rewind all the batch reels and test will be repeated. In this case the Company reserves the right to retest with sampling according to ISO 2859-1, General Inspection Level I, AQL 4.0 – Tightened inspection.

If this test is not possible to be performed in Manufacturer's plant, he will be obliged to rewind all reels which IPTO's inspector considers that don't meet the requirements of paragraph 2.5.4 of present specification.

4.9 All Bidders shall have to state the manufacturers of the material, as well as all related sub-contractors, if any.

They shall also have to submit along with their offer a Quality Assurance Plan (Q.A.P), for the manufacturing procedure of the stated manufacturer and all potential sub-contractors, by which it shall be evident in a detailed way the entire manufacturing procedure, the quality control equipment as well as all quality control stages, including all of the related printed material and referring to the specific international standards and regulations applied.

During the Technical Evaluation procedure, IPTO shall reserve itself the right to monitor the production procedure so as to ascertain the application of the Q.A.P. and, in general, to conclude on the production procedure, in a way that shall deem the offer technically acceptable or not.

4.10 Manufacturer is responsible for the conductor behaviour during installation at the T.L.

5. DATA TO BE SUBMITTED WITH OFFER

In the offers must be included the following data in a clear and unique way.

5.1. The technical characteristics of the conductor according to the data of Annexes A & B which shall be confirmed by the manufacturer at the corresponding columns.

5.2. The following charts shall be given for the proposed conductor in paper dimensions A3.

5.2.1. Tension and sag vs span chart for dead-end span (INITIAL)

In this chart the tension and sags will be given versus the span for various temperatures of initial setting. The corresponding temperatures will be from 0°C up to 40°C with step of 10°C.

The "NESC HEAVY" curve shall also be given (1/2" ice + 4 # wind at temperature -19°C)

5.2.2. Tension and sag chart for ruling span 350m and 500m (INITIAL)

In this Chart the tension will be given versus the various temperatures of initial setting and the sag versus the span for various temperatures, from 0°C up to 40°C with step of 10°C, for ruling span 350m and 500m.

5.2.3. Tension and sag vs span chart for dead-end span (FINAL)

In this chart the tension and sag will be given versus the span for various final temperatures of operation, with the final modulus of elasticity, for temperatures from 0°C up to the maximum operation temperature of the conductor with step of 10°C.

The "NESC HEAVY" curve shall also be given (1/2" ice + 4 # wind at temperature -19°C)

5.2.4. Tension and sag chart for ruling span 350m and 500m (FINAL)



In this chart the tension will be given for the various temperatures of operation and the sag versus the span for the same temperatures, both with final modulus of elasticity, for temperatures from 0°C up to the maximum operation temperature of the conductor with step of 10°C., for ruling span 350m and 500m.

5.2.5 Tension-strain curve (INITIAL AND FINAL)

The Tension in this chart shall be given in Newton (N).

5.3. Full description of the reels with all details and basic dimensions with scale. The drawing shall be submitted to IPTO from manufacturer for approval.

5.4. Detailed drawings of the necessary fittings for the proposed conductor. The design of the fittings shall comply with drawings of the specification TR-4. and the material shall be proper for the corresponding maximum temperature of the conductor. The accessories and assemblies will be tested according to the document of CIGRE: "Guide for qualifying high temperature conductors for use on overhead transmission lines" WG B2.26, August 2010, see Annex C.

5.5. Description of the manufacturing process shall be given. A quality assurance program (EN ISO 9001) for the factory, to verify the quality of the materials during the manufacturing process shall also be given. Also manufacturer/supplier must submit the place that each fitting will be manufactured.

5.6. Test reports concerning the type tests specified in par.3, of present specification, with full data in order to enable the Company to evaluate their offers in accordance with the requirements of present specification. Sample tests and ISO 9001 certificate shall also be submitted from the laboratory.

5.7. A reference list of at least three (3) Electrical Companies, who have bought the same or similar type of conductors with those that are offered, which have been used with excellent operation on overhead Transmission Lines, for a period of at least five (5) years followed by the corresponding certificates. At the reference list shall be reported the name of the electric company, the type of conductor, the voltage and the maximum current carrying capacity of the T.L., as well as the year of purchase or installation of the conductor. Certificates shall be original or validated copies and distinct regarding the Electrical Company that edit and guarantee the excellent operation of corresponding conductors.
IPTO S.A. reserves the right to accept offers with reference list less than three (3) Electrical Companies, as long as the quantities and the purchaser are taken into account.

5.8. Technical brochures for offered items.



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ANNEX – A

DESCRIPTION		LINNET	ACSS/TW LINNET
Aluminium cross-section	MCM	336.4	
Copper equivalent	mm ²	107.48	
Outer Diameter	mm	18.31	
Aluminium Strands	mm	26×2.89	
Core Strands-Material	mm	7×2.25	
Core Diameter	mm	6.75	
Nominal Weight	kg/km	700	
Minimum Breaking Load	kg	6050	
Standard Reel Length	m	3000	
Lengths per Reel		1	
Resistance DC at 20°C	Ω/Km	0.166	
*Coefficient of Linear Expansion/°C		19×10 ⁻⁶	
Modulus of Elasticity (Initial)	Kg/mm ²	6184	
Modulus of Elasticity (Final)	Kg/mm ²	7730	
Maximum Temperature of Continuous Operation	°C	50	
Maximum Allowable sag at ruling span 350m at maximum temperature of continuous operation	m	10.4	
Maximum Allowable sag at ruling span 500m at maximum temperature of continuous operation	m	20.8	

- * The coefficient of linear expansion shall be given for the various temperature ranges if it doesn't remain the same from 0°C up to the maximum operation temperature.



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ANNEX – B

Loading Conditions	Data	Maximum admissible tension
NESC Medium	1/4"(inch) ice+4 [‡] (lb/ft ²)wind+0.327Kg/m, -10°C	2575 kg
NESC Heavy	1/2"(inch) ice+4 [‡] (lb/ft ²)wind,-19 °C	3020 kg
NESC Light	0"(inch) ice+9 [‡] (lb/ft ²)wind+0.074Kg/m, 0°C	2050 kg
Everyday conditions	Ambient Temperature 20°C 0"(inch) ice 0 [‡] (lb/ft ²)wind Emissivity 0.5	
Summer conditions	Ambient Temperature 40°C Solar Radiation 0.1 W/cm ² Wind Velocity 0.5 m/sec Emissivity 0.5	



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ANNEX – C

ΤΕΧΝΙΚΗ ΠΕΡΙΓΡΑΦΗ ΕΞΑΡΤΗΜΑΤΩΝ

Τα υλικά θα αντικαταστήσουν τα υπάρχοντα στις αντίστοιχες συναρμογές των πύργων από την κεφαλή του τελευταίου μονωτήρα μέχρι και το αντίστοιχο εξάρτημα ανάρτησης ή τερματισμού του αγωγού.

Τα υλικά θα πρέπει να εξασφαλίζουν τη σωστή λειτουργία του αγωγού για τον οποίο προορίζονται και να μπορούν να διατηρούν την μηχανική αντοχή τους στις αντίστοιχες υψηλές θερμοκρασίες του αγωγού. Το συνολικό μήκος των συναρμογών θα πρέπει να είναι σύμφωνο με το αντίστοιχο προδιαγραφόμενο στην Τεχνική Προδιαγραφή της ΑΔΜΗΕ TR-4 και στα σχέδια TR-4/00-1, TR-4/00-2 και TR-4/00-3.

Τα υλικά θα ικανοποιούν τις απαιτήσεις της τεχνικής προδιαγραφής της ΑΔΜΗΕ TR-4 όπου αυτές εφαρμόζονται. Σε κάθε περίπτωση που τα υλικά αποκλίνουν από την προδιαγραφή TR-4 ο προσφερόμενος οίκος θα υποβάλλει αντίστοιχα πιστοποιητικά και δοκιμές τα οποία θα είναι σύμφωνα με τα διεθνή πρότυπα.

Οι σφιγκτήρες ανάρτησης του αγωγού φάσης πρέπει να είναι κατάλληλοι να φέρουν τον προσφερόμενο αγωγό, ο οποίος μπορεί να χρησιμοποιηθεί είτε γυμνός είτε εφοδιασμένος με μια δέσμη προδιαμορφωμένων ράβδων οπλισμού, κατάλληλη για τις θερμοκρασίες λειτουργίας του εν λόγω αγωγού.

Οι σφιγκτήρες τέρματος και συνδετήρες ευθυγραμμίας θα ικανοποιούν τις απαιτήσεις της τεχνικής προδιαγραφής της ΑΔΜΗΕ TR-4 και θα πρέπει να αποδεικνύεται η ικανότητα σωστής λειτουργίας αυτών στις υψηλές θερμοκρασίες λειτουργίας του αγωγού.

Οι αποσβέστες ταλάντωσης θα είναι τύπου Stockbridge και θα είναι ειδικά σχεδιασμένοι και ικανοί να χρησιμοποιηθούν με τον προσφερόμενο αγωγό ειδικού τύπου. Η οδηγία TR-18 της ΑΔΜΗΕ ισχύει ενδεικτικά. Ο κατασκευαστής θα πρέπει να προμηθεύσει την ΑΔΜΗΕ με οδηγίες εγκατάστασης προκειμένου να επιτευχθεί το βέλτιστο αποτέλεσμα.

Για όλα τα παραπάνω υλικά θα πρέπει να υποβάλλονται στοιχεία και δοκιμές (πχ. Δοκιμές σε θερμικούς κύκλους) που να αποδεικνύουν την ικανότητα λειτουργίας των εξαρτημάτων στις υψηλές θερμοκρασίες λειτουργίας του αγωγού και την κατανομή θερμότητας σε κάθε ένα ξεχωριστά.

Για τις δοκιμές των εξαρτημάτων θα ισχύει η Οδηγία της CIGRE: "GUIDE FOR QUALIFYING HIGH TEMPERATURE CONDUCTORS FOR USE ON OVERHEAD TRANSMISSION LINES" WG B2.26, AUGUST 2010.

Η εταιρεία διατηρεί το δικαίωμα εφόσον δεν αποδεικνύονται τα παραπάνω να κρίνει ως τεχνικά μη αποδεκτή την προσφορά.



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ANNEX – C

**TECHNICAL DESCRIPTION OF FITTINGS FOR
THERMAL RESISTANT CONDUCTORS**

Fittings will replace the existing ones at the corresponding assemblies on the towers, from the pin ball of the last insulator up to the corresponding compression dead end clamp or suspension clamp. The fittings shall ensure the proper operation of conductor for which the fittings are intended and shall retain specified mechanical strength at the high temperatures of the conductor.

The total length of each assembly shall be in accordance with drawings TR–4/00–1, TR–4/00–2 and TR–4/00–3 of Technical Specification TR–4.

The fittings shall comply with the requirements of Technical Specification TR–4, when applied and don't conflict with the requirements of present specification. In each case that they are not compliant with Technical Specification TR–4, manufacturer shall subject similar tests and corresponding reports which shall comply with International Standards.

Suspension clamps shall be designed for the proposed conductor and can be used bare or equipped with a set of preformed armor rods proper for the high temperatures of the conductor.

Especially for compression fittings and joints, manufacturer must prove their efficient operation at the high temperatures of the conductor.

Vibration dampers shall be of the "Stockbridge type" and proper to protect the special type conductor they offer, from aeolian vibrations. Generally Specification TR–18 shall be used indicatively. The manufacturer of the dampers shall provide IPTO S.A. with the proper installation guidelines for the dampers, in order to obtain optimum results.

Tests with the corresponding reports (certificates) for the above fittings shall prove their efficient operation at the high temperatures of the conductor and the allocation of the heat in each fitting.

The accessories and assemblies should be tested according to the document of CIGRE: "GUIDE FOR QUALIFYING HIGH TEMPERATURE CONDUCTORS FOR USE ON OVERHEAD TRANSMISSION LINES" WG B2.26, AUGUST 2010.

IPTO S.A. reserves the right to reject an offer if the above criteria are not matched.