ΑΔΜΗΕ

INDEPENDENT POWER TRANSMISSION OPERATOR S.A.

TRANSMISSION NEW PROJECTS DEPARTMENT

TRANSMISSION LINES EQUIPMENT ELECTRICAL DESIGN AND CABLES ENGINEERING SECTION

ATHENS - GREECE

SPECIFICATION TR - 5

FITTINGS FOR 400 kV TRANSMISSION LINES

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1. SCOPE

This specification covers the design, manufacturing and testing of the fittings for 400kV Transmission Lines.

The assemblies of the fittings in strings are shown in drawings TR-5/00-1 up to TR-5/00-10.

2. GENERAL REQUIREMENTS

2.1 General

The fittings shall be in accordance with the basic requirements of the drawings TR-5/01 up to TR-5/35 of present specification. The fittings shall also be in accordance with the requirements of paragraph 4.1 of IEC Standard 61284 when applied and don't conflict with the requirements of this specification. Both manufacturers and sub-contractors must be verified by standard EN ISO 9001.

Also the fittings must be designed so as to:

- be free from appearance defects such as cracks, burrs, notches, distortions, defective machining of the surfaces, bubbles and castings defects in general.
- be inherently resistant to atmospheric corrosion or be suitably protected against corrosion, such as can occur in transport, storage and in service.
- have breaking load not smaller than those referred to in the corresponding drawings.
- have all surfaces smooth, with rounded edges so that Corona and the development of R.I.V. will be limited. Also the heads of bolts, for the same reasons, shall have rounded edges.
- withstand a 40kA power arc of 0.5s duration.

Bolts used for tightening of fittings shall be equipped with spring – washers. Welded fittings are not acceptable if the welding is stressed during the operation of the fitting.

The design of all fittings shall be such as to minimize the risk of damage or deterioration in service of any part of the transmission line due to vibration.

2.2 Materials

2.2.1 Fittings shall be made of material suitable for the purpose that they are intended for and must meet the requirements of the corresponding drawings. Also material quality shall meet the requirements of International Standards ISO and DIN, such DIN 17100, DIN 17200, ISO 630, ISO 683, in order to achieve the required mechanical properties.

2.2.2 The material of cotter-pins, washers and spring-washers shall not cause galvanic corrosion with the adjacent parts. Especially the cotter-pins shall be made of brass or bronze except for cases of contact with aluminium where the cotter-pins shall be made of stainless steel. The stainless steel shall have great resistance to corrosion and its quality shall be 18Cr-8Ni or equivalent.

2.2.3 Iron and steel parts of the fittings shall be hot dip galvanized in accordance with the

EN ISO 1461/99 and ASTM A 143/A 143M – 03 Standards.

2.3 Dimensions

2.3.1 Dimensions of the fittings that constitute the assemblies shall conform to the requirements of the basic dimensions and tolerances indicated in the corresponding drawings. When no tolerances are specified should be limited to avoid excessive play between assembled items. These dimensions are final (after galvanization).

2.3.2 Tolerances applied to the dimensions shall ensure that the fittings meet their specified mechanical and electrical requirements of the present specification. Generally tolerances of the fittings shall be limited, especially between assembled items. When tolerances are not specified in the drawings, they shall meet the following requirements:

	Dimension	**Tolerance**
-	Up to and 35 mm	±0,7mm
-	Over 35 mm	±2%

2.3.3 Basic dimensions indicated in the drawings are indispensable for the assembling of the fittings in strings as indicated in drawings TR-5/00-1 up to TR-5/00-10. Rest dimensions are related with the specified strength of the fittings and shall be determined by the manufacturer.

2.3.4 It shall be responsibility of the contractor to furnish fittings that can be properly assembled to each other. The interchangeability of all fittings must be secured. The bolts that referred to the fittings and corresponding drawings shall be of the metric system.

2.4 Marking

2.4.1 Each fitting shall be marked in relief with the identification number of the fitting shown in the IPTO's corresponding drawing, the characteristic mark of the manufacturer and specified minimum failing load.

2.4.2 Compression fittings must be also marked with the conductor size or the code name for which they are intended, compression die sizes and the length to be compressed.

2.4.3 Parallel groove clamps and suspension clamps must be also marked with the conductor diameter or the code name for which they are intended and the specified installation torque of their bolts and nuts.

2.4.4 Each of the performed armor rods shall be clearly and indelibly marked with a tab where the specified data will be marked according to paragraph 2.4.1 of present specification. Also at each rod, it shall be marked the characteristic mark of the manufacturer, the conductor diameter or code name of conductor for which the set is intended and also the mark AR. Armor rods shall be centre marked in an approved manner (central marking).

2.5 Packing and Handling

2.5.1 Packing and handling of the fittings must be in such a manner that protects them from damage in transit (by sea, plane, rail way, on road), handling and outdoor storage.

2.5.2 Fittings must be packed in wooden pallet cases with proper modulation for easy longshoring with suitable forklifts. Each pallet case shall contain only one type of fitting and the maximum gross weight of each pallet case shall be equal to 500kg.

2.5.3 Especially compression fittings shall be packed properly, with film or individual sealed plastic case, in order to protect electrical contact surfaces of each sleeve and terminal.

2.5.4 Especially for the preformed armor rods, each set of rods shall be taped together as a

unit. It is not acceptable the tying/tightening with rope or wire.

2.5.5 Each case or pallet case shall be plainly and indelibly marked with distinctive markings of the following data:
- Manufacturer's name or trademark,
- Order/Contract number,
- Fitting code name or corresponding IPTO's drawing,
- Gross weight,
- Quantity.

3. TECHNICAL DATA OF FITTINGS

All the requirements shall be in accordance with paragraph 4.2 of IEC Standard 61284, when applied and don't conflict with the requirements of this specification. Every insulator assembly, complete with all fittings and all spacers, vibration dampers and armor rods shall show no visible Corona at 300 kV (30% higher than the nominal phase voltage). At this voltage no positive Corona plume is allowed.

Every insulator assembly, complete with all fittings and all spacers, dampers and armor rods shall have a radio noise level not higher than 60 db above 1 microvolt across 300 Ohms at 1 MHz measured at 277 kV (20% higher than the nominal phase voltage).

Every complete insulator assembly shall be designed to withstand a 40 kA power arc of 0.5s duration. All the steel parts of each assembly shall have proper dimensions in order that current density not exceeding the recommended values by EN 50341, in case of a 40kA power arc.

The manufacturer must submit with his offer official reports of power arc type tests that prove the efficiency of the design and verify the foregoing characteristics.

The Manufacturer shall provide IPTO with the assembly or installation instructions of T.L. fittings, as long as necessary. Also for specific types of fittings the followings are valid:

3.1 Compression fittings for phase conductor and shield wire

3.1.1 General

The compression fittings shall be of the hexagonal type and shall bear, without damage or slipping of strands of the conductor, the loads defined in the drawings which correspond to the 95% of the ultimate breaking strength of the corresponding conductor or shield wire. Values of the ultimate breaking strength of each type of the conductor or shield wire are referred to in Annex B of the present specification.

Compression dead end clamps and other compression fittings applied to conductor or shield wire shall be designed as to avoid any possibility of deforming the stranded conductors or separating the individual strands. Compression joints shall be used to connect individual lengths of conductor and shield wire. Each compression dead end clamp and compression joint shall consist of one steel sleeve and one aluminium sleeve. All the aluminium parts of compression dead-end clamps, joints and repair sleeves shall be of at least 99.5% pure aluminium.

The materials of compression fittings shall be capable of withstanding the cold working due to compression. Furthermore, the steel compression components shall have sufficient impact strength after the compression.

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

The exact dimensions of aluminium and steel sleeves, before and after the compression, shall be in accordance with Annex A of the present specification.

The manufacturer shall use for the tests suitable compression dies of hexagonal type so that the dimensions after compression shall be those shown in Annex A and the corresponding drawings.

3.1.2 Compression fittings for phase conductor

The compression fittings of phase conductor shall meet the requirements shown in the drawings TR-5/30, TR-5/32 and TR-5/34. Each joint and dead-end clamp or any part thereof shall have an electrical resistance not exceeding 75% of an equivalent length of the conductor. Any use of grease is prohibited.

Each compression dead end clamp of phase conductor is equipped with jumper terminal capable of withstanding a load equal to 200kg. Aluminum repair sleeves shall be used for the repair of damaged aluminium strands of conductor. These sleeves shall be of the compression type and shall be designed to make good a conductor of which less than one-third of the strands in the outer most layer have been severed. Fittings and connectors intended for the restoration of electrical and mechanical properties of a conductor shall have clearly defined the manufacturer's instructions as to the extent of damage which is intended to be repaired.

3.1.3 Compression fittings for shield wire

The compression fittings of the shield wire shall meet the requirements shown in the drawings TR-5/31 and TR-5/33.

3.2 Insulator set fittings and earth wire fittings

Insulator set fittings and earth wire fittings shall meet the requirements shown in the drawings TR-5/01 up to TR-5/19 and TR-5/23B. In case of the fitting shown in drawings TR-5/19 the cotter-pins shall be made of phosphor-bronze or of stainless steel. Dimensions of balls and sockets of the fittings shown in the drawings TR-5/13 up toTR-5/19 shall be designed and checked in accordance with IEC Standard 60120, for 20mm pin diameter (standard size 20).

Manufacturer shall submit with the offer of the Specified Minimum Damage Load (SMDL), Specified Minimum Failing Load (SMFL) and the permanent deformation at SMDL for the above fittings.

3.3 Suspension clamps

Suspension clamps shall meet the requirements shown in the drawings TR-5/25, TR-5/26 and TR-5/27. The suspension clamps shall be free to pivot in the vertical plane containing the conductor and shall permit the conductor to slip (20% of U.T.S. of conductor) before the failure of the aluminium strands occurs. The suspension clamps must be designed to avoid the localized pressure or damage to the conductor or the earth wire in service and shall have sufficient contact surface to avoid damage by fault currents. Also clamps shall be designed so that the effects of vibration, both on conductor or on the shield wire and on the clamps themselves, are minimized.

The phase conductor installed in the suspension clamps can be used bare or equipped with a set of aluminum preformed armor rods.

The Manufacturer shall submit to the offer of the Specified Minimum Damage Load (SMDL), the Specified Minimum Failing Load (SMFL) and also the values of Specified Minimum Slip Load and the specified installation bolts tightening torque.

3.4 Parallel groove clamps and earthing clamp

Parallel groove clamps and earthing clamp shall be in accordance with the requirements of drawings TR-5/24, TR-5/28, TR-5/29A and TR-5/29B. Also parallel groove clamps shall be snuffbox - type for two (2) conductors with proper self-retaining bolts and nuts made from stainless steel, which cannot be separated from each other when the clamp is disassembled. In case of parallel groove clamp for phase conductor, with drawing TR-5/29A and TR-5/29B, each part is made of aluminum alloy and for other cases are from steel. Manufacturer must submit the specified installation tightening torque of the bolts and nuts. Parallel groove clamps with different dimensions of body and keeper are also accepted after tests or proper test reports

which verify that they shall withstand the specified 40kA/0.5s power arc.

3.5 Protective fittings

Protective fittings are distinguished in preformed armor rods which shall meet the requirements shown in drawing TR-5/35 and guard devices which shall meet the requirements shown in the drawings TR-5/20, TR-5/21 and TR-5/22.

3.5.1 Preformed armor rods

Preformed armor rods only shall be used for reinforcing the phase conductor at the suspension clamp. Armor rods are required to reinforce the conductor at the suspension point and to protect it against bending, compression, abrasion and arcover damage. Performed rods are made of aluminum alloy and shall have right - hand lay direction, identical to lay - direction of the outer layer of the phase conductors ACSR CARDINAL.

Also preformed armor rods are required to restore full conductivity and mechanical strength to conductor where damage does not exceed 50% of the outer strand layer or 25% of outer and inner strand layers and is located at suspension point or within mid span area.

The length of the armor rods shall be calculated by the manufacturer for maximum reliability. The bidder has to compute the maximum span length, corresponding to different kind of terrain, for which, without use of dampers, the maximum allowable strain level is reached. All relative computations must be submitted to the Corporation. However the length of armor rods for ACSR CARDINAL conductor shall be at least 2500mm and up to 2800mm, in order to install the Stockbridge vibration dampers in their specified, by Corporation, placement.

The design of the performed fittings shall consider the optimum combination of the conductor diameter, inside diameter of helical rods, diameter of individual rods, number of rods, pitch length, number of pitch lengths, lay direction, rated breaking strength and material. The helical rod fitting shall have the inner diameter smaller than the outer diameter of the conductor, to which it is applied and will distribute the gripping pressure on the conductor over a large area, thus avoiding stresses and potential damage that exist when the pressure is applied at one point on the conductor. The maximum efficiency is maintained by each rod exerting a uniform low radial pressure inherent with spring tempered material.

The performed rods to be applied on conductor ACSR CARDINAL shall have the ends PARROT-BILLED in order to meet the Corona free up to 300 kV (phase to ground) and R.I.V. level up to 60 db above 1 microvolt across 300 Ohms at 1 MHz measured at 277 kV.

Material quality and manufacture methods shall be in such a way that there will be no relaxation and subsequent looseness after application.

3.5.2 Guard devices

Every insulator assembly must be equipped with guard devices properly designed to give sufficient protection in case of long duration power arcs. These devices have to prevent as much as possible any breakage of the insulators and any breakage or burns of the conductor strands. Also they shall be designed in such a way so as not to be subjected to breakage through fatigue due to vibrations caused by wind.

The guard devices after three 25 kA power arcs of 0.5 s duration must be eroded only lightly, while after three 40 kA power arcs of 0.5 s duration may be damaged but must still retain their protection characteristics. Every complete insulator assembly shall be designed to withstand a 40 kA power arc of 0.5 s duration.

In every case guard devices shall be properly designed to give sufficient protection for every insulator assembly. The drawings TR-5/20 up to TR-5/22 of guard devices are indicative.

In case that steel tubes are used as arcing horns, both the internal and external surfaces of the tubes shall be hot dip galvanized according to International Standards EN ISO 1461/99 and ASTM A 143/A 143M – 03.

4. TECHNICAL DATA OF ASSEMBLIES FOR DOUBLE CIRCUIT TOWERS

For double circuit towers (tower type 5) phase conductors strings shall meet the requirements shown in drawings TR-5/00-2, TR-5/00-3, TR-5/00-4, TR-5/00-7 and TR-5/00-8 and shield wire assemblies shall meet the requirements shown in drawings TR-5/00-9 and TR-5/00-10. In order to ensure the tower electrical clearances the length of each string shall meet the requirements of corresponding drawings. In every case the tower fittings that referred in general drawings of the assemblies are not included in offered assemblies.

4.1 Single suspension string of phase conductor

4.1.1 For suspension towers, type S, G and R, with vertical phase configuration (dwg.TR-5/A) each phase conductor (twin) shall be suspended from the crossarm through a suspension insulator set consisting of a single insulator string of 18 disc insulator units and a fittings assembly.

The general assembly of single suspension string for type towers S, G and R shall meet the requirements shown in drawing TR-5/00-2 and for special occasions for type tower R is selected the general assembly shown in drawing TR-5/00-3.

4.1.2 Every assembly must be free to swing longitudinally and transversely to the line. Each suspension clamp must be suitable to carry a subconductor covered with performed armor rods (the armor rods are not included in this item).

The distance between the axes of the two suspension clamps must be equal to 400mm.

4.1.3 Every assembly must be equipped, at the live part end, with a guard ring device for grading of the electrical field, corona protection and power arc protection and at the tower end with an arcing horn device.

The guard ring shall reduce the voltage across the lowest insulator unit to a maximum of 10% of the total 50 Hz voltage, across the insulator string. The guard ring and arcing horn devices must be designed in a way that the insulator string shall have the maximum withstand voltage against lightning and switching impulses. However, the 1.2×50 microsecond 50% impulse flashover voltage under dry condition for positive polarity must not be lower than 1560 kV.

4.1.4 The breaking strength of the assembly shall be 165kN.

4.2 Jumper suspension string

4.2.1 Jumper suspension string shall be suspended at tension towers, type T and Z (dwg.TR-5/B). The general requirements for jumper suspension string are the same as above for phase conductor single suspension string. The only difference is that each suspension clamp of jumper suspension string shall be suitable to carry a bare subconductor, without covering of performed armor rods.

4.2.2 The general assembly of jumper suspension string consisting of a single insulator string of 18 disc insulator units shown in drawing TR-5/00-4.

4.2.3 The breaking strength of the assembly shall be 165kN.

4.3 Shield wire suspension assembly

4.3.1 Each shield wire shall be suspended at suspension towers, type S, G and R (dwg.TR-5/A) by an assembly which shall meet the requirements shown in drawing TR-5/00-9.

4.3.2 In each assembly shall be included a parallel groove clamp and an earth clamp in order to secure a direct electrical connection between shield wire and tower with a length of shield wire.

4.3.3 The suspension clamp of shield wire must be free to swing in any direction.

4.4.4 The breaking strength of the assembly shall be 70 kN.

4.5 Single tension string of phase conductor

4.5.1 Each phase conductor (twin), in the case of a slack-span, shall be anchored to tension towers, type T and Z (dwg.TR-5/B), through a tension insulator set, consisting of one horizontal insulator string of 19 disc insulator units and the fitting assembly. The assembly shall meet the requirements shown in drawing TR-5/00-7.

4.5.2 Every assembly must be free to swing both vertically and transversely to the line.
The distance between the axes of the two compression dead-end clamps must be equal to 400 mm. Tension adjuster devices (turnbuckles) shall be included in the assembly, which shall allow the sag of each subconductor to be adjusted with full sagging tensile load on the conductor.

4.5.3 Every assembly must be equipped, at the live part end, with a guard ring device for field grading, corona protection and power arc protection, as well as an arcing horn device at the tower end.
4.5.4 The breaking strength of the assembly shall be 165 kN.

4.6 Double tension string of phase conductor

4.6.1 Each phase conductor (twin) shall be anchored to tension towers, type T and Z (dwg.TR-5/B), through a tension insulator set, consisting of two parallel and horizontal insulator string of 19 disc insulator units and the fitting assembly. The assembly shall meet the requirements shown in drawing TR-5/00-8.

4.6.2 Every assembly must be free to swing both vertically and transversely to the line.
The distance between the axes of the two compression dead-end clamps must be equal to 400 mm. Tension adjuster devices (turnbuckles) shall be included in the assembly, which shall allow the sag of each subconductor to be adjusted with full sagging tensile load on the conductor.

4.6.3 Every assembly must be equipped, at the live part end, with a guard ring device for field grading, corona protection and power arc protection, as well as an arcing horn device at the tower end.

4.6.4 The breaking strength of the assembly shall be 330 kN.

4.7 Shield wire tension assembly

4.7.1 Each shield wire shall be anchored to tension towers, type T and Z (drwTR-5/B) through an assembly which shall meet the requirements shown in drawing TR-5/00-10.

4.7.2 Every assembly must be free to swing both vertically and transversely to the line.

4.7.3 In each assembly shall be included a parallel groove clamp and an earth clamp in order to secure a direct electrical connection between shield wire and tower with a length of shield wire.

4.7.4 The breaking strength of the assembly shall be 120 kN.

5. TECHNICAL DATA OF ASSEMBLIES FOR SINGLE CIRCUIT TOWERS

For single circuit towers (tower type 6) phase conductors strings shall meet the requirements shown in drawings TR-5/00-1, TR-5/00-3, TR-5/00-4, TR-5/00-7 and TR-5/00-8 and shield wire assemblies shall meet the requirements shown in drawings TR-5/00-9 and TR-5/00-10. In order to ensure the tower electrical clearances the length of each string shall meet the requirements of corresponding drawings. In every case the tower fittings that referred in general drawings of the assemblies are not included in offered assemblies.

5.1 Single suspension string of phase conductor

5.1.1 For suspension towers, type S and R, with outer phases of towers with horizontal phase configuration (dwg.TR-5/C) each phase conductor (twin) shall be suspended from the crossarm through a suspension insulator set consisting of a single insulator string of 18 disc insulator units and a fittings assembly.

The general assembly of single suspension string for type tower S shall meet the requirements shown in drawing TR-5/00-5 and for type tower R shall meet the requirements shown in drawing TR-5/00-3.

5.1.2 Every assembly must be free to swing longitudinally and transversely to the line. Each suspension clamp must be suitable to carry a subconductor covered with performed armor rods (the armor rods are not included in this item).

The distance between the axes of the two suspension clamps must be equal to 400mm.

5.1.3 Every assembly must be equipped, at the live part end, with a guard ring device for grading of the electrical field, corona protection and power arc protection and at the tower end with an arcing horn device.

The guard ring shall reduce the voltage across the lowest insulator unit to a maximum of 10% of the total 50 Hz voltage, across the insulator string. The guard ring and arcing horn devices must be designed in a way that the insulator string shall have the maximum withstand voltage against lightning and switching impulses. However, the 1.2×50 microsecond 50% impulse flashover voltage under dry condition for positive polarity must not be lower than 1560 kV.

5.1.4 The breaking strength of the assembly shall be 165kN.

5.2 V - type suspension string of phase conductor

5.2.1 The middle phase conductor (twin) of single circuit towers with horizontal phase configuration (dwg.TR-5/C) shall be suspended by a V-string suspension insulator set. Each leg of this set comprises a single insulator string of 18 disc insulator units. The assembly of V – type suspension string for type tower S shall meet the requirements shown in drawing TR-5/00-5 and for type tower R shall meet the requirements shown in drawing TR-5/00-6.

Each leg of the V-string, for both types of towers, shall also include an adjustable extension link with proper length in order to increase the number of insulators from 18 to 24 without additional adjustments or fittings.

The clearances of the live parts of the assembly to the tower body shall not be less than 3.20m. Also, the minimum clearance from an arcing horn placed at the crossarm shall be 3.00m.

5.2.2 Every V-type suspension string must be free to swing longitudinally to the line. Each suspension clamp must be suitable to carry a subconductor covered with performed armor

rods (the armor rods are not included in the assembly). The distance between the axes of the two suspension clamps must be equal to 400 mm.

5.2.3 Every assembly must be equipped, at the live part end, with a guard ring device for grading of the electrical field, corona protection and power arc protection.

The guard ring shall reduce the voltage across the lowest insulator unit to a maximum of 10% of the total 50 Hz voltage, across the insulator string. The guard ring and arcing horn devices must be designed in a way that the insulator string shall have the maximum withstand voltage against lightning and switching impulses. However, the 1.2×50 microsecond 50% impulse flashover voltage under dry condition for positive polarity must not be lower than 1560 kV.

5.2.4 The breaking strength of each leg of the assembly shall be 165kN.

5.3 Jumper suspension string

5.3.1 Jumper suspension string shall be suspended at tension towers, type T and Z (dwg.TR-5/D). The general requirements for jumper suspension string are the same as above for phase conductor single suspension string. The only difference is that each suspension clamp of jumper suspension string shall be suitable to carry a bare subconductor, without covering of performed armor rods.

5.3.2 The general assembly of jumper suspension string consisting of a single insulator string of 18 disc insulator units shown in drawing TR-5/00-4.

5.3.4 The breaking strength of the assembly shall be 165kN.

5.4 Shield wire suspension assembly

5.4.1 Each shield wire shall be suspended at suspension towers, type S and R (dwg.TR-5/C) by an assembly which shall meet the requirements shown in drawing TR-5/00-9.

5.4.2 In each assembly shall be included a parallel groove clamp and an earth clamp in order to secure a direct electrical connection between shield wire and tower with a length of shield wire.

5.4.3 The suspension clamp of shield wire must be free to swing in any direction.

5.4.4 The breaking strength of the assembly shall be 70 kN.

5.5 Single tension string of phase conductor

5.5.1 Each phase conductor (twin), in the case of a slack-span, shall be anchored to tension towers, type T and Z (dwg.TR-5/D), through a tension insulator set, consisting of one horizontal insulator string of 19 disc insulator units and the fitting assembly. The assembly shall meet the requirements shown in drawing TR-5/00-7.

5.5.2 Every assembly must be free to swing both vertically and transversely to the line.
The distance between the axes of the two compression dead-end clamps must be equal to 400 mm. Tension adjuster devices (turnbuckles) shall be included in the assembly, which shall allow the sag of each subconductor to be adjusted with full sagging tensile load on the conductor.

5.5.3 Every assembly must be equipped, at the live part end, with a guard ring device for field grading, corona protection and power arc protection, as well as an arcing horn device at the tower end.

5.5.4 The breaking strength of the assembly shall be 165 kN.

5.6 Double tension string of phase conductor

5.6.1 Each phase conductor (twin) shall be anchored to tension towers, type T and Z (dwg.TR-5/D), through a tension insulator set, consisting of two parallel and horizontal insulator string of 19 disc insulator units and the fitting assembly. The assembly shall meet the requirements shown in drawing TR-5/00-8.

5.6.2 Every assembly must be free to swing both vertically and transversely to the line.
The distance between the axes of the two compression dead-end clamps must be equal to 400 mm. Tension adjuster devices (turnbuckles) shall be included in the assembly, which shall allow the sag of each subconductor to be adjusted with full sagging tensile load on the conductor.

5.6.3 Every assembly must be equipped, at the live part end, with a guard ring device for field grading, corona protection and power arc protection, as well as an arcing horn device at the tower end.

5.6.4 The breaking strength of the assembly shall be 330 kN.

5.7 Shield wire tension assembly

5.7.1 Each shield wire shall be anchored to tension towers, type T and Z (dwg.TR-5/D) through an assembly which shall meet the requirements shown in drawing TR-5/00-10.

5.7.2 Every assembly must be free to swing both vertically and transversely to the line.

5.7.3 In each assembly shall be included a parallel groove clamp and an earth clamp in order to secure a direct electrical connection between shield wire and tower with a length of shield wire.

5.7.4 The breaking strength of the assembly shall be 120 kN.

6. TESTS

All required tests should be preformed in proper laboratories, accredited according to International Standard ISO/IEC 17025 and must include the corresponding test reports. Test reports shall be written in Greek or English language and shall be certified by laboratory where the tests have taken place. All tests shall be in accordance with the requirements of International Standards IEC 61284, EN ISO 1461/99, ISO 2859, ASTM A 143/A 143M–03 and DIN VDE 0212 Part 51, where applicable and according to following paragraphs. Especially sample and routine tests can be performed to manufacturer's laboratory if it's certified by ISO 9001.

After the performance of the type tests and before bulk fabrication, all drawings with all dimensions marked, have to be approved by Corporation. After the approval of the drawings by Corporation, the Contractor must submit a complete set of drawings of all fittings and assemblies in printed and electronic form.

Tests for fittings (compression dead end clamps, repair sleeves, e.g.) shown in drawings TR-5/01 up to TR-5/35, shall meet general requirements of paragraph 6 of IEC 61284 and shall take place, depending on the type of fitting, in accordance with Table 1 of the same specification, where it's applicable and don't conflict with the requirements of this specification.

Especially for fittings, mechanical type tests shall be performed on 3 (three) fittings and electrical type tests shall be performed on 4 (four). All fittings shall pass the type tests.

Sample tests will take place in delivery of materials and the samples of single fittings to be tested shall come up from sampling plan procedure according to International Standard ISO 2859.

There will be inspection by attributes, with maximum Acceptable Quality Level AQL = 0.65, Inspection Level S–4, Normal Inspection and Single Sampling Plan.

6.1 Type tests

6.1.1 All the fittings that constitute the assemblies shall be subjected to the followings type tests:

a) Visual examination, according to requirements of paragraph 7 of IEC 61284.

b) Dimensional and material verification, according to requirements of paragraph 8 of IEC 61284.

c) Check of interchangeability of parts, where the fittings are installed according to manufacturer's instructions and they shall be adjusted to each other and shall be avoided the excessive play.

d) Hot dip galvanizing, if the fittings have iron or steel parts, according to requirements of EN ISO 1461/99 and ASTM A 143/A 143M – 03 Standards, when don't conflict with the requirements of this specification.

Also the assemblies and the fittings that constitute them shall be subjected to following type tests:

6.1.2 Tests of phase conductor strings

6.1.2.1 One phase conductor single suspension string, complete with all fittings, shall be impulse tested with a wave shape of 1.2/50 microseconds in order to determine the 50% flashover voltage under dry conditions for positive polarity.

6.1.2.2 One phase conductor single suspension string, complete with all fittings, shall be tested in order to determine the 50 Hz voltage across the lowest insulator unit.

6.1.2.3 One phase conductor single suspension string and one phase conductor double tension string, complete with all fittings, shall be tested in order to measure the radio noise level and to determine the starting and extinguishing 50 Hz voltages of visible Corona. The test shall meet the requirements of par.14 of IEC 61284, for corresponding assemblies of T.L. Also the centre – line spacing for both cases is greater than 7.50m.

6.1.3 Tests of compression fittings for phase conductor and shield wire

Fittings shown in drawings TR-5/30 up to TR-5/34 shall be subjected to following tests with corresponding acceptance criteria.

6.1.3.1 Tensile test

Tensile test shall be carried out by using the conductor for which compression fittings are intended. In case of repair sleeves, shown in drawing TR-5/34, they shall be assembled for the test in samples of conductor, where the number of severed strands shall be the nearest whole number to one third of the total number of strands in the outermost layer.

Procedure

Compression fittings, shown in drawings TR-5/30 up to TR-5/33, shall be subjected to type test according to par.11.5.1 of IEC 61284 and repair sleeves, shown in drawing TR-5/34 shall be subjected to type test according to par.11.7 of the same Standard.

Value M of load P which is required for the tensile test must be equal to M = 0.2×RTS (Rated Tensile Strength) of the conductor for which fittings are intended and the SMFL must be equal to SMFL = 0.95×RTS. Time T, for which the load will be maintained to a value equal to 60% of SMFL, must be equal to T = 30min. Test shall be completed according to alternative (a) and the load shall be steadily increased until it reaches the value of SMFL in 1min.

When the test is completed the load shall be steadily increased until failure of fittings occurs. Values of failure load shall be recorded.

Value of load RTS is the nominal tensile strength of the conductor and its values for each type of conductor are referred to Annex B of the present specification.

Acceptance criteria

Acceptance criteria shall comply with the requirements specified in paragraph 11.5.1 of IEC 61284, for type tests with alternative (a) method.

6.1.3.2 Heat cycle test

All compression fittings of phase conductor, that belong to class A of joints (class A: tension joints), shall be subjected to Heat Cycle test, according to par.13 of IEC 61284.

Procedure

Heat cycle test is carried out with the typical test circuit that is described in Annex B of IEC 61284. The procedure shall meet the requirements of par.13.5.2 with the following data of Table 3 of par.13.5:

N = 500 cycles
Tf = 10°C (temperature rise of the reference conductor above the ambient)

Acceptance criteria

Acceptance criteria shall comply with the requirements specified in paragraph 13.5.2.2 of IEC 61284.

6.1.3.3 Corona and radio interference voltage (R.I.V.) tests

Compression fittings of phase conductor shall be subjected to Corona and radio interference voltage (R.I.V.) tests and sample test according to paragraph 7 of IEC 61284, for the corresponding fittings.

6.1.4 Tests of insulator set fittings and earth wire fittings

Insulator set fittings and earth wire fittings, shown in drawings TR-5/01 up to TR-5/19 and TR-5/23B, shall be subjected to the following type test with relevant acceptance criteria.

6.1.4.1 Mechanical damage and failure load test

Insulator set fittings and earth wire fittings shall be loaded in a direction which is as close as possible to the direction of load in service.

Procedure

Insulator set fittings and earth wire fittings shall be subjected to mechanical type test according to paragraph 11.3.1 of IEC 61284. Values of SMDL, SMFL and permanent deformation of the fitting at SMDL, which are required for the tests, shall be given by the manufacturer, because these values depend on the quality of material and the treatment of each fitting, during fabrication.

Acceptance criteria

Acceptance criteria shall comply with the requirements specified in paragraph 11.3.1 of IEC 61284.

6.1.5 Tests of suspension clamps

6.1.5.1 Vertical damage load and failure load test

Procedure

Suspension clamps, shown in drawings TR-5/25 and TR-5/27, shall be subjected to vertical damage load and failure load test according to 11.4.1 of IEC 61284. Test will be carried out according to Method A of the same paragraph. The values of loads, permanent deformation and angle (α) shall be given by the manufacturer.

Acceptance criteria

Acceptance criteria shall comply with the requirements specified in paragraph 6.1.4.1 of present specification.

6.1.5.2 Slip test

The conductor used in the slip test shall be the one for which the clamp, shown in drawings TR-5/25 and TR-5/27, is intended.

Procedure

Suspension clamps shall be subjected to slip test, according to paragraph 11.4.3 of IEC 61284. The suspension clamp shall be placed according to figure 5(a) of IEC 61284 and the specified minimum slip load is equal to 20% of minimum failing load of the conductor, for which the clamp is intended.

Slip test shall be carried out according to step «f» and then step «h», of the same paragraph.

Values of minimum failing load for each type of conductor are referred to paragraph 7 of present specification.

Acceptance criteria

Acceptance criteria shall comply with the requirements specified in paragraph 11.4.3 of IEC 61284.

6.1.5.3 Clamp bolt tightening test

Suspension clamps, shown in drawings TR-5/25 and TR-5/27, shall be subjected to clamp bolt tightening test according to paragraph 11.4.5 of IEC 61284.

6.1.5.4 Corona and radio interference voltage (R.I.V.) tests

Suspension clamps of phase conductor shall be subjected to Corona and radio interference voltage (R.I.V.) tests and sample test according to paragraph 7 of IEC 61284, for the corresponding fittings.

6.1.6 Tests of parallel groove clamps and earth clamp

The conductor used in the mechanical tests shall be the one for which the clamps are

intended. If one size of fitting is offered for more than one (1) size of conductor, the test shall be carried out on both the largest and smallest size of conductors.

6.1.6.1 Tensile test

Parallel groove clamps, shown in corresponding drawings TR-5/24, TR-5/29A and TR-5/29B as well as the earth clamp, shown in drawing TR-5/28, shall be subjected to tensile test in accordance with the following procedure and relevant acceptance criteria:

Procedure

The test shall be performed by using proper tensile testing machine and the fitting anchored in such a way that the test load is applied in the direction of the conductor, which has the same size and type with that it is to be used. All bolts and nuts shall be tightened with the installation torque specified by the manufacturer.

A tensile load of 0.6kN shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Any relative movement less than 2mm is accepted. Without any subsequent adjustment of the fitting, the load shall be steadily increased up to 1.2kN. This load shall be maintained for 60s.

Acceptance criteria

Acceptance criteria for type tests are the following:

- There shall be no movement of the conductor relative to the fitting due to slip during the period of 60s.
- No failure of the fitting (sample) shall occur during test.

6.1.6.2 Clamp bolt tightening test

Parallel groove clamps and earth clamp shall be subjected to clamp bolt tightening test according to paragraph 11.4.5 of IEC 61284.

6.1.6.3 Heat cycle test and Short - time Overcurrent Pulse test

Parallel groove clamps, shown in corresponding drawings TR-5/29A and TR-5/29B, that belong to class B of joints, shall be subjected to Heat cycle and Short – time overcurrent pulse test according to paragraph 13 of IEC 61284.

Test is carried out with the typical test circuit that is described in Annex C of IEC 61284. The procedure shall meet the requirements of par.13.5.3 with the following data of Table 3 of par.13.5:

N = 500 cycles
T_f = 100°C (temperature rise of the reference conductor above the ambient)
N_{sc} = 3 pulses.

Acceptance criteria

Acceptance criteria shall comply with the requirements specified in paragraph 13.5.3.2 of IEC 61284, for corresponding tests.

6.1.6.4 Short – circuit test

Parallel groove clamps, shown in drawings TR-5/29A and TR-5/29B shall be subjected to short – circuit test by using the same conductor that the clamps are intended. In case that

clamp is offered for more than one (1) size of conductor, the test shall be carried out on both the largest and smallest size of conductors. Procedure and relevant acceptance criteria are the following:

Procedure

The installation of the clamp and the tightening of bolts and nuts are carried out according to manufacturer recommendations.

It shall be performed two short circuit withstand tests with a short circuit current having a value of 25 kA for a duration of 0.5s.

Acceptance criteria

Acceptance criteria are the following:

- There shall be no damage to clamp design.
- There shall be no permanent deformation which would impair the efficiency of the clamp's assembly, when the test has completed.

6.1.6.5 Corona and radio interference voltage (R.I.V.) tests

Parallel groove clamps, shown in drawings TR-5/29A and TR-5/29B, shall be subjected to Corona and radio interference voltage (R.I.V.) tests and sample test according to paragraph 7 of IEC 61284, for the corresponding fittings.

6.1.7 Tests of armor rods

6.1.7.1 Static test

Preformed armor rods shall be subjected to type test according to paragraph 3.1.2 of DIN VDE 0212 Part 51. Test shall be performed on 3 (three) sets and all tested sets shall pass successfully the test.

6.1.7.2 Dynamic test

Preformed armor rods shall be subjected to type test according to paragraph 3.1.3 of DIN VDE 0212 Part 51. Test shall be performed on 3 (three) sets and all tested sets shall pass successfully the test.

6.1.7.3 Endurance test

Preformed armor rods shall be subjected to type test according to paragraph 3.1.4 of DIN VDE 0212 Part 51. Test shall be performed on 3 (three) sets and all tested sets shall pass successfully the test.

6.1.7.4 Installation test

Preformed armor rods shall be subjected to installation test as follows:

- Fittings will be installed on samples of the conductors of suitable length under tension, in accordance with the application instructions submitted with the offer.
- Conductors shall not be greased.
- It shall be checked that rods are uniformly applied on the conductor, without distortions and the ends are aligned within the limits specified in the offer.
- The positive grip of the rods shall be checked, e.g. either by sliding individual rods along conductor axis, by hand pressure over the applied length and at the ends of rods, or by hitting over the applied length.

- No looseness of the rods applied on conductor shall be accepted.

6.2 Sample tests

6.2.1 Each quantity of material to be delivered shall be subjected to the tests that referred to par.6.1.1 of present specification. Also fittings that constitute the assemblies shall be subjected to following sample tests:

6.2.2 Tests of compression fittings for phase conductor and shield wire

Compression fittings shall be subjected to mechanical and electrical sample test according to par.6.1.3.1 and 6.1.3.2 of present specification.

6.2.3 Tests of insulator set fittings and earth wire fittings

Insulator set fittings and earth wire fittings shall be subjected to mechanical sample test according to par.6.1.4.1 of present specification, in case such testing has not been already performed for same design fittings that have been produced by the same factory within five (5) years of collaboration with IPTO S.A.

6.2.4 Tests of suspension clamps

Suspension clamps shall be subjected to mechanical sample tests according to par.6.1.5.1, 6.1.5.2 and 6.1.5.3 of present specification.

6.2.5 Tests of parallel groove clamps and earth clamp

Parallel groove clamps and earth clamp shall be subjected to mechanical and electrical sample tests according to par.6.1.6.1, 6.1.6.2 and 6.1.6.3 of present specification.

6.2.6 Tests of armor rods

Armor rods shall be subjected to installation test according to par.6.1.7.4 of present specification.

6.2.7 Test of guard devices

Guard devices, shown in drawings TR-5/20 up to TR-5/22, shall be subjected to tensile test. Arcing horns and rackets shall be placed properly and a load equal to 0.9kN shall be applied in a direction which is as close as possible to the direction shown in relevant drawings. This load shall be kept constant for T = 60s. The test is passed if no failure of the fitting occurs. All fittings shall pass successfully the test.

7. INSPECTION

Sample tests will take place in delivery of fittings and the samples to be tested shall come up from sampling plan procedure according to International Standard ISO 2859. There will be inspection by attributes, with Acceptable Quality Level AQL = 0.65, Inspection Level S–4, Normal Inspection and Single Sampling Plan.

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

7.2 Manufacturer shall submit to Corporation copies of the control and test reports of the material. Corporation reserves the right to demand all the routine test reports from the manufacturer.

7.3 In each delivery quantity, sample tests shall be performed in accordance with the requirements of par.6.2 of present specification.

7.4 For type test reports that haven't been submitted or that aren't adequate according to the requirements of par.6 of present specification, IPTO reserves the right to request the performance of any or all type tests specified in par.6.1 of present specification on samples which shall be taken from the production of the offered items. The Corporation reserves the right to select test laboratory and witness any or all tests.

7.5 All Bidders shall have to state the manufacturers of the material, as well as all related sub-contractors, if any. Both manufacturers and sub-contractors must be verified by standard EN ISO 9001. 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.

8. TECHNICAL DATA OF THE OFFER

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

8.1 Detailed drawing in full scale with all dimensions and tolerances, for every offered assembly and fittings that constitute them, as well as the drawings for every single fitting that referred in present specification.

8.2 Each drawing shall be accompanied with relevant data about:

- ✓ the breaking strength of each assembly and fitting, as well as the values of SMDL, SMFL, minimum slip load, permanent deformation of the fitting at SMDL, when it is required for the performance of all the specified type and sample tests,
- ✓ the material and the quality for every part of the fitting,
- ✓ the method of casting (malleable or cast, etc.) of every fitting,
- ✓ the weight of the fitting,
- ✓ the specified tightening torque of the bolts (when it is required),
- ✓ the visible Corona level,
- ✓ the radio noise level,
- ✓ the power arc behaviour,
- ✓ the flashover voltages for each phase assembly,
- ✓ the voltages across the insulator units for each phase assembly.

8.3 Test reports concerning the type tests specified in par.6.1 of present specification, by independent laboratory accredited according to International Standard ISO/IEC 17025. Test reports must be complete, with drawing of the tested assembly and fitting.

8.4 A reference list of at least three (3) Electrical Companies, who have buy enough quantities of the same or similar material 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.

Reference list and corresponding certificate shall include User, type of material, operation voltage, exact quantity and the date of selling or installation.

Certificates shall be original or validated copies and distinct regarding the Electrical Company that edit and guarantee the excellent operation of corresponding material.

Bidders that have supplied in the last decade, IPTO or PPC with the requested material, have no obligation of submitting the prerequisites of this paragraph, provided that it does not change the factory of manufacture.

ANNEX A

TECHNICAL DATA

INDEPENDENT POWER TRANSMISSION OPERATOR S.A.

TRANSMISSION NEW PROJECT DEPARTMENT

TRANSMISSION LINES EQUIPMENT ELECTRICAL
DESIGN AND CABLES ENGINEERING SECTION

ATHENS - GREECE

SPECIFICATION TR-5

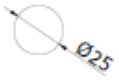
ANNEX A

DIMENSION OF THE SLEEVES OF
THE COMPRESSION DEAD - END CLAMPS AND
THE COMPRESSION JOINTS

BEFORE COMPRESSION		AFTER COMPRESSION	

SHIELD WIRE

ALUMINUM



STEEL

ALUMINUM

STEEL

PHASE CONDUCTOR

ALUMINUM

STEEL

ALUMINUM

STEEL

NOTE :
The eccentricity between internal and external diameter of the steel sleeve shall not be more than 1mm (Maximum difference of sleeve thickness 2mm).

ΑΔΜΗΕ

ANNEX B

TECHNICAL DATA

1. NOMINAL VOLTAGE OF T.L.	400	kV
2. INSULATOR STRINGS		
• Number of insulators per suspension string	18	
• Number of insulators per tension string	19	
• Coupling: according to IEC 60120 for pin diameter of 20mm		
• Diameter	280÷330	mm
• Length	170	mm
• Minimum leakage distance	370÷540	mm
• Minimum combined mechanical and electrical strength	160	kN
• Mechanical impact strength	10	Nm
• Routine tensile load	80	kN
• Power frequency withstand voltage :		
- dry, one minute	75÷90	kV
- wet, one minute	45÷55	kV
• Dry lightning impulse withstand voltage	110÷140	kV
• Power frequency puncture voltage	130	kV
R.I.V data:		
- power frequency test voltage,rms. to ground	10	kV
- maximum R.I.V. at 1000 kHz	50	μV
3. PHASE CONDUCTOR		
• Number of subconductors	2	
• Distance between subconductors	400	mm
• Equivalent code name	ACSR Cardinal	
• Copper equivalent	296	mm^2
• Overall diameter	30.42	mm
• Aluminum strands	54×3.38	mm
• Steel strands	7×3.38	mm
• Minimum breaking strength	160	kN
4. SUSPENSION OF PHASE CONDUCTOR		

The phase conductor is suspended with the suspension clamp and a set of performed armor rods with the following characteristics :

• Number of rods per set	13	
• Minimum length	2500	mm
• Diameter of each rod	7.9	mm
• Lay direction	Right - hand	
• Material	Aluminium alloy	
5. SHIELD WIRE		
• Overall diameter	12.6	mm
• Steel strands	7×4.19	mm
• Minimum breaking strength	120	kN

ΑΔΜΗΕ

SPECIFICATION TR – 5: DRAWINGS

No.	DESCRIPTION	Drawing No.
1.	Dimensions of double circuit suspension towers for 400kV T.L.	TR-5/A
2.	Dimensions of double circuit tension towers for 400kV T.L.	TR-5/B
3.	Dimensions of single circuit suspension towers for 400kV T.L.	TR-5/C
4.	Dimensions of single circuit tension towers for 400kV T.L.	TR-5/D
5.	Single suspension string of single circuit tower, type S_6, for 400kV T.L.	TR–5/00-01
6.	Single suspension string of double circuit towers for 400kV T.L.	TR–5/00-02
7.	Single suspension string of single circuit tower, type R_6, and special occasions of double circuit tower, type R_5, for 400kV T.L.	TR–5/00-03
8.	Jumper suspension string for 400kV T.L.	TR–5/00-04
9.	V – type suspension string of single circuit tower, type S_6, for 400kV T.L.	TR–5/00-05
10.	V – type suspension string of single circuit tower, type R_6, for 400kV T.L.	TR–5/00-06
11.	Single tension string for 400kV T.L.	TR–5/00-07
12.	Double tension string for 400kV T.L.	TR–5/00-08
13.	Shield wire suspension assembly for 400kV T.L.	TR–5/00-09
14.	Shield wire tension assembly for 400kV T.L.	TR–5/00-10
15.	Shackle for suspension strings	TR-5/01
16.	Attachment shackle for double tension string	TR-5/02
17.	Shackle for double tension string	TR-5/03
18.	Shackle for single tension string	TR-5/04
19.	Shackle for shield wire tension assembly	TR-5/05
20.	Yoke	TR-5/06
21.	Upper Yoke for double tension string	TR-5/07
22.	Yoke for double tension string	TR-5/08
23.	Yoke for V – type suspension string	TR-5/09
24.	Connector for suspension strings	TR-5/10
25.	Adjustable extension link	TR-5/11
26.	Chain link for double tension string	TR-5/12
27.	Ball tongue	TR-5/13
28.	Ball eye	TR-5/14
29.	Ball tongue twisted	TR-5/15
30.	Ball clevis	TR-5/16
31.	Ball tongue	TR-5/17
32.	Ball clevis	TR-5/18
33.	Socket clevis	TR-5/19
34.	Arcing horn for single tension string	TR-5/20
35.	Arcing horn	TR-5/21
36.	Racket type arcing device	TR-5/22
37.	Turnbuckle for single tension string	TR-5/23A
38.	Turnbuckle for double tension string	TR-5/23B
39.	Parallel groove clamp	TR-5/24
40.	Suspension clamp for phase conductor	TR-5/25
41.	Jumper suspension clamp	TR-5/26
42.	Suspension clamp for shield wire	TR-5/27
43.	Earth clamp	TR-5/28
44.	Parallel groove clamp for ACSR conductors	TR-5/29A
45.	Parallel groove clamp for ACSR conductors	TR-5/29B
46.	Compression dead – end clamp for phase conductor	TR-5/30

47.	Compression dead – end clamp for shield wire	TR-5/31
48.	Compression joint for phase conductor	TR-5/32
49.	Compression joint for shield wire	TR-5/33
50.	Repair sleeve for phase conductor	TR-5/34
51.	Set of preformed armor rods	TR-5/35