# HIGH CAPACITY BARE CONDUCTORS

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## 1 SCOPE OF THE DOCUMENT

The aim of this document is to define the technical requirements for the different technologies of high capacity concentric stranded bare conductors to be used in the high voltage overhead lines of the Enel Group Distributions Companies, listed below:

LATAM

- Ampla (AM) — Brazil
- Chilectra (CH) — Chile
- Codensa (CD) — Colombia
- Coelce (CE) — Brazil
- Edelnor (EN) — Perú
- Edesur (ES) — Argentina

EUROPE

- Endesa Distribución Eléctrica (EE) — España
- Enel Distributie Banat (ER) — Romania
- Enel Distributie Dobrogea (ER) — Romania
- Enel Distributie Muntenia (ER) — Romania
- Enel Distribuzione (ED) — Italy

The document also includes the tests to be satisfied by the supplier.

## 2 LIST OF COMPONENTS

The list of components includes the four technologies of high capacity bare conductors selected for the high voltage lines from Enel Group Distribution Companies:

| GS Type Code | Type Technology | Material Core | Material Outside core wires |
|---|---|---|---|
| GSCH007/1 | Aluminum Conductor PMC Core | Polymer Matrix Composite Core | Aluminum (fully annealed or thermal resistant) wires |
| GSCH007/2 | Aluminum Conductor MMC Core | Metal Matrix Composite Core wires | Thermal resistance Aluminum Alloy wires |
| GSCH007/3 | ACSS/TW | Zn95Al5 Coated Steel wires | Aluminum fully annealed trapezoidal wires |
| GSCH007/4 | GAP | Al Clad Steel Core wires | Thermal resistance Aluminum Alloy trapezoidal & round wires |

These technologies can carry electricity at higher temperature than a conventional conductor keeping sag, then it can be increased their ampacity (they are known as HTLS conductors, High Temperature Low Sag). This characteristic makes of the High Capacity Conductors a very suitable alternative for repowering a line or for spans with special requirements. The Annex 1 attaches a table with a list of cross-sections of the different

technologies which are suggested to cover the complete range for the different Enel Group Distribution Companies.

It is recommended a study for each project in order to confirm the chosen conductor cross section or to propose the most appropriate one in terms of technical and economical requirements. This type of study should consider the required ampacity, the ambient conditions (temperature, sun radiation, wind speed, etc.) and the characteristics from the line (actual towers, distances, etc.).

## 3 REFERENCE STANDARDS

- EN 50182 Conductors for overhead lines. Round wire concentric lay stranded conductors
- EN 61232 Aluminum-clad steel wires for electrical purposes (IEC 1232)
- EN 62004 Thermal-resistant aluminum alloy wire for overhead line conductor (IEC 62004)
- EN 50540 Conductors for overhead lines. Aluminum conductors steel supported (ACSS)
- EN 62420 Concentric lay stranded overhead electrical conductors containing one or more gap(s) (IEC 62420)
- EN 10244-2 Steel wire and wire products. Non-ferrous metallic coatings on steel wire. Zinc or zinc alloy coatings.
- ASTM B502: Standard Specification for Aluminum Clad Steel Core Wire for aluminum conductors
- ASTM B609: Standard specification for Aluminum 1350 wire, annealed and intermediate tempers, for electrical purposes
- ASTM B803: Standard specification for High_Strength Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Core wire for aluminum and aluminum-alloy conductors, steel reinforced.
- ASTM B856: Standard Specification for Concentric-Lay-Stranded Aluminum Conductors Steel Suported (ACSS)
- ASTM B857: Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors Steel Suported (ACSS/TW)
- ASTM B941 Standard Specification for Heat Resistant Aluminum-Zirconium Alloy Wire for Electrical Purposes
- ASTM B958 Standard draft specification for Extra-High_and Ultra-High Strength Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Core wire for aluminum and aluminum-alloy conductors, steel reinforced.
- ASTM B976: Standard Specification for Fiber Reinforced Aluminum Matrix Composite (AMC) Core Wire for Aluminum Conductors, Composite Reinforced (ACCR)
- ASTM B978: Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Composite Reinforced (ACCR)
- ASTM B987 Standard Specification for Carbon Fiber Composite Cores
- IEC 60121 Recommendation for commercial annealed aluminum electrical conductor wire
- EN 50326 Conductors for overhead lines. Characteristics of greases
- IEC 60468 Method of measurement of resistivity of metallic materials

## 4 SERVICE CONDITIONS

The selected conductors have all of them an appropriate behaviour against pollution adverse conditions due to its technical characteristics.

In case of extreme conditions, it will be useful analyze the site with each supplier in order to have a better estimation for the expected life of the conductor.

# 5 TECHNICAL CHARACTERISTICS

## 5.1 Conductors with composite core (PMC & MMC)

This chapter describes the aluminum conductors (annealed or thermo resistant) with composite core.

This composite core can be polymer matrix composite or metal matrix composite. Attached are the proposed technologies:

| GS Type Code | Type Technology | Registered name | Material Core | Material Outside core wires |
|---|---|---|---|---|
| GSCH007/1 | Aluminum Conductor PMC Core | ACCC | Carbon fiber in epoxi resin matrix protected by glass fiber | Aluminum fully annealed T wires |
| | | ACPR-Lo Sag | Carbon fiber in epoxi resin matrix protected by aluminum | Thermo-resistant aluminum zirconium alloy Z or Z&T wires |
| | | OHC-HV | Carbon fiber in epoxi resin matrix wires protected by aluminum | Thermo-resistant aluminum zirconium alloy round or T wires |
| GSCH007/2 | Aluminum Conductor MMC Core | ACCR | Aluminum oxide fibers embedded in aluminum | Thermo-resistant aluminum zirconium alloy round or T wires |

### 5.1.1 Aluminium Conductor Polymer matrix composite Core (GSCH007/1)

*Note: Describes the materials included in the different proposed technologies (ACCC, ACPR-Lo Sag, OHV-HV)*

#### *5.1.1.1. Polymer Matrix Composite core*

Core made of carbon fibers embedded in high-temperature epoxy resin matrix.

This core can be protected in different ways:

- Glass fibers to improve flexibility and toughness. It also prevents galvanic corrosion
- Aluminum, which prevents therm-oxidation and mechanic and chemical damage.

#### *5.1.1.2. Annealed Aluminum Trapezoidal Wires*

Outside core, wires are formed by fully annealed aluminum trapezoidal wires, aluminum AL0 or 1350-O, which keeps his characteristics at high temperature and also improves conductivity and fatigue resistance.

Reference Standard for the material: EN 50540[1] and/or ASTM B609[2].

The different layers of aluminum wires are twisted around the core composite alternatively in one direction and another such that the outer layer rotates clockwise.

#### *5.1.1.3. Thermal resistance Aluminum Alloy Trapezoidal, Z-shape or round Wires*

Outside core, wires are formed by Zirconium-Aluminum alloy. Zirconium confers a better mechanical behaviour at higher operating temperatures and prevents the aluminum from becoming annealed when operating at high temperatures.

Reference Standard for the material: IEC 62004 and/or ASTM B941.

The different layers of aluminum wires are twisted around the core alternatively in one direction and another such that the outer layer rotates clockwise.

### 5.1.2 Aluminium Conductor Metal matrix composite Core (GSCH007/2)

*Note: It is described the only option included in the standard (ACCR)*

#### *5.1.2.1. Aluminum Matrix Composite Core Wires*

The core is formed by round wires made of Aluminum oxide continuous fibers embedded in pure aluminum. It is a very high strength material with a very low thermal expansion coefficient.

#### *5.1.2.2. Thermal resistance Aluminum Alloy Trapezoidal or round Wires*

Outside core, wires are formed by Aluminum-Zirconium alloy. Zirconium confers a better mechanical behaviour at higher operating temperatures and prevents the aluminum from becoming annealed when operating at high temperatures.

Reference Standard for the material: IEC 62004 and/or ASTM B941.

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[1] ¨Chapter 5.

[2] After stranding, the trapezoidal aluminum wires shall conform to the requirements of ASTM B609 except for the shape and the diameter tolerance.

The different layers of aluminum wires are twisted around the core alternatively in one direction and another such that the outer layer rotates clockwise.

### 5.2 Conductor ACSS/TW (GSCH007/3)

Reference Standard for the conductor: EN50540.

#### 5.2.1 Aluminum-Zinc Coated Steel Core Wires[3]

The core is formed by round wires made of steel coated with Aluminum-Zinc alloy (95% Zinc-5% Aluminium), with an excellent mechanical behaviour at high temperature (steel type EHST).

Reference Standard for the material: EN 50540.

#### 5.2.2 Annealed Aluminum Trapezoidal Wires

Outside core, trapezoidal wires are formed by fully annealed aluminum, type AL0 or 1350-O, which doesn't loose its properties at high temperatures and improves conductivity and fatigue resistance. Alternatively, it may be used round wires if it is more convenient.

Reference Standard for the material: EN 50540[4] and/or ASTM B609[5].

The different layers of aluminum wires are twisted around the core composite alternatively in one direction and another such that the outer layer rotates clockwise.

### 5.3 Conductor GAP GZTACSR (GSCH007/4)

Reference Standard for the conductor: IEC 62420.

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[3] ACCS conductor core can be designed with different materials. It has been chosen this one because of his good behavior at high temperature.

[4] ¨Chapter 5.

[5] After stranding, the trapezoidal aluminum wires shall conform to the requirements of ASTM B609 except for the shape and the diameter tolerance.

### 5.3.1 Aluminum cladded Steel Core Wires

The core is formed by round wires made of Aluminum steel coated, for a better behavior before corrosion (steel type 14EHSA).

Reference Standard for the material: EN50540 and/or ASTM B502.

### 5.3.2 Thermal resistance Aluminum alloy Trapezoidal wires

Outside core, wires are formed by Aluminum-Zirconium alloy (steel type AT3). Zirconium confers an excellent mechanical behaviour at higher operating temperatures and prevents the aluminum from becoming annealed when operating at high temperatures. It can be used steel type AT1, with less thermal resistance, then the conductor is known as GTACSR and it has an inferior maximum continuous operating temperature.

Reference Standard for the material: IEC 62004 and/or ASTM B941.

The first layer will be formed with trapezoidal wires, creating a gap which will be filled with high thermal resistance grease.

The other layers could be made of round or trapezoidal wires and they are twisted around the core alternatively in one direction and another such that the outer layer rotates clockwise

## 6 CONSTRUCTION CHARACTERISTICS

High capacity bare conductors work at very high temperatures, for that reason the design of accessories (specially clamps and dead-ends) must be prepared to withstand high temperatures.

On the other hand, these conductors sometimes are made of materials not used in conventional conductors, such as composites. The accessories must be specific for every particular material.

As a consequence, this type of conductor must be treated with all their accessories as a whole system.

## 7 TESTING

### 7.1 Type test

Type test shall be carried out over the conductor in order to verify its main characteristics, which depend on its design.

Each manufacturer shall make this test once to obtain the technical assessment for each conductor, and they should be repeated only when the design or manufacturing process has been modified.

### 7.2 Sample test

Sample test shall be carried out over final product samples to guarantee the quality of the conductors and compliance with the requirements of this standard.

#### 7.2.1 Sample size

Sample test will carried out over in at least 10% of the reels, being tested all the wires.

If the supplier demonstrates ability to exceed the requirements, the sample can be reduced even until 10% of wires, although the size of the sample must assure the quality control of the batch.

### 7.3 Test description

See Annex 2.

## 8 SUPPLY REQUIREMENTS

### 8.1 Conductor packing

The conductor shall be properly protected against damage which may occur in ordinary handling and shipping.

The reels must support the conductor weight without deformations. The reel design shall respect the minimum bend radio and it will allow cranes to manipulate them.

The reel diameter will be at least 30 times the conductor diameter or 60 times the core diameter, the maximum of both values. In the case of composite core conductors, the reel diameter shall be at least 50 times the conductor or 150 times the core diameter, the maximum of both values.

For more sensitive conductors, such as fully annealed aluminum designs, it is recommended a special care: protection inside the reel, use of staves, paper between layers of conductors or similar…

Both ends of the conductor shall be secured to the spools and they will remain accessible, preventing accidental unrolling.

### 8.2 Conductor marking

Each reel shall be identified with a indelible and easily legible plate on the external face and in the inside, with the name of the final Enel Group distribution company. The plate shall include:

- Manufacturer name
- Conductor type
- Gross mass, net mass and tare
- Conductor length in metres
- Order number
- Reel number
- Serial number
- Manufacturing year
- Direction of rotation of the reel (with an arrow)
- Unwinding direction (if the reel is packed)

*Note:* The manufacturer shall use length measurement equipment with an accuracy of ± 1%

## ANNEX 1 – COMPLETE LIST OF COMPONENTS WITH SUGGESTED CROSS-SECTIONS

- Data for complete conductor

| GS Type Code | Standard | Type | Code Words | Size ($mm^2$) | Outside diameter (mm) | Mass (kg/km) | Rated strength (kN) | DC resistence (W/km) | Grease |
|---|---|---|---|---|---|---|---|---|---|
| GSCH007/1 | N/A | ACCC | ROVINJ | 217,3 | 17,1 | 576 | 60,4 | 0,1487 | No |
| | | | CASABLANCA | 313,3 | 20,5 | 834 | 85,7 | 0,1024 | |
| | | | LISBON | 349,6 | 21,79 | 931 | 85,7 | 0,0916 | |
| | | | BRUSSELS | 473,3 | 25,15 | 1265 | 112 | 0,0666 | |
| | | | WARSAW | 567,8 | 25,14 | 1519 | 153,8 | 0,069 | |
| | | | ROME | 595,8 | 28,14 | 1774 | 153,8 | 0,0534 | |
| | | ACPR Lo Sag | 186-AT1/28 | 224,7 | 18 | 591 | 65,5 | 0,1506 | No |
| | | | 289-AT1/38 | 339,5 | 21,8 | 898 | 94,9 | 0,102 | |
| | | | 377-AT1/64 | 465,6 | 25,4 | 1219 | 139,4 | 0,0738 | |
| | | | 549-AT1/64 | 548,1 | 27,7 | 1450 | 152,6 | 0,0611 | |
| | | | 574-AT1/64 | 662,7 | 30,4 | 1769 | 170,8 | 0,0494 | |
| GSCH007/2 | N/A | ACCR/TW | 315-T20 | 191,2 | 18 | 552 | 64,5 | 0,17 | No |
| | | | HAWK 477TW | 281 | 20 | 801 | 85,148 | 0,1134 | |
| | | | OSWEGO | 390 | 23,6 | 1111 | 115,017 | 0,0814 | |
| | | | WABASH | 449 | 25,2 | 1280 | 139,09 | 0,0705 | |
| | | | CURLEW 1053 TW | 590 | 28,8 | 1672 | 158,706 | 0,0531 | |
| GSCH007/3 | EN 50540 ASTM B857 | ACSS/TW | ACSS/TW-198 | 197,9 | 16,82 | 686 | 64 | 0,161 | No |
| | | | ACSS/TW-280 | 280,9 | 20,04 | 974 | 88,2 | 0,1134 | |
| | | | ACSS/TW-364 | 364 | 22,62 | 1215 | 97,3 | 0,0853 | |
| | | | ACSS/TW-455 | 454,9 | 25,24 | 1519 | 119,8 | 0,683 | |
| | | | ACSS/TW-198 | 546 | 27,53 | 1822 | 143,8 | 0,0569 | |
| GSCH007/4 | IEC 62420 | GAP GZTACSR | GZTACSR-186 | 186,47 | 16,8 | 634 | 60,55 | 0,1794 | Yes |
| | | | GZTACSR-293 | 292,95 | 22 | 1000 | 96,76 | 0,1146 | |
| | | | GZTACSR-385 | 384,5 | 25,24 | 1273 | 113,21 | 0,0856 | |
| | | | GZTACSR-462 | 462,1 | 27,6 | 1521 | 135,2 | 0,0711 | |
| | | | GZTACSR-553 | 553,25 | 30,47 | 1828 | 164,53 | 0,0595 | |

- Data for core and for outside core wires

| GS Type Code | Standard | Type | Code Words | Material Core | Description core | Cross section core ($mm^2$) | Standard core | Material Outside core wires | Description outside core wires | Cross section out core ($mm^2$) | Standard out core |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GSCH007/1 | N/A | ACCC | ROVINJ | Composite Core (PMC) | Hybrid carbon and glass fiber composite | 28 | N/A | Aluminium fully annealed | Trapezoidal wires, Aluminum AL0/1350-O | 187,8 | EN50540 ASTM B609 |
| | | | CASABLANCA | | | 39,7 | | | | 273,6 | |
| | | | LISBON | | | 39,7 | | | | 309,9 | |
| | | | BRUSSELS | | | 51,9 | | | | 421,4 | |
| | | | WARSAW | | | 71,3 | | | | 406,4 | |
| | | | ROME | | | 71,3 | | | | 524,5 | |
| | | ACPR Lo Sag | 186-AT1/28 | | Carbon fiber composite, aluminum cladded | 38,6 | N/A | Thermal resistance Al Zr Alloy | Z-shape wires, Aluminum AT1 | 185,9 | IEC 62004 ASTM B941 |
| | | | 289-AT1/38 | | | 50,6 | | | | 289 | |
| | | | 377-AT1/64 | | | 88,7 | | | | 376,8 | |
| | | | 549-AT1/64 | | | 88,7 | | | | 459,4 | |
| | | | 574-AT1/64 | | | 88,7 | | | | 574 | |
| GSCH007/2 | N/A | ACCR/TW | 315-T20 | Composite Core (MMC) | Aluminium oxid fibers within pure Aluminium wires | 31,5 | ASTM B976 | Thermal resistance Al Zr Alloy | Trapezoidal wires, Aluminum AT3 | 159,7 | IEC 62004 ASTM B941 |
| | | | HAWK 477TW | | | 39 | | | | 242 | |
| | | | OSWEGO | | | 53 | | | | 337 | |
| | | | WABASH | | | 62 | | | | 387 | |
| | | | CURLEW 1053 TW | | | 67 | | | | 523 | |
| GSCH007/3 | EN 50540 ASTM B857 | ACSS/TW | ACSS/TW-198 | Al-Zn coated steel wires | EHST wires (Zn95Al5 coated steel) | 27,7 | EN50540 | Aluminium fully annealed | Trapezoidal wires, Aluminum AL0/1350-O | 170,2 | EN50540 ASTM B609 |
| | | | ACSS/TW-280 | | | 39,3 | | | | 241,6 | |
| | | | ACSS/TW-364 | | | 41,8 | | | | 322,2 | |
| | | | ACSS/TW-455 | | | 52,2 | | | | 402,7 | |
| | | | ACSS/TW-198 | | | 62,6 | | | | 483,4 | |
| GSCH007/4 | IEC 62420 | GAP GZTACSR | GZTACSR-186 | Al Clad Steel wires | 14EHSA steel wires | 23,1 | EN50540 ASTM B502 | Thermal resistance Al Zr Alloy | Trapezoidal & round wires , Aluminum AT3 | 163,37 | IEC62004 ASTM B941 |
| | | | GZTACSR-293 | | | 37,17 | | | | 255,78 | |
| | | | GZTACSR-385 | | | 40 | | | | 244,5 | |
| | | | GZTACSR-462 | | | 47,81 | | | | 414,3 | |
| | | | GZTACSR-553 | | | 58,07 | | | | 495,18 | |

## ANNEX 2 – TESTING LIST

- Test for GS Type Code GSCH007/1

| GSCH007/1 | | Type Test | Sample Test | Standard/paragraph |
|---|---|---|---|---|
| Conductor | Surface condition | X | X | EN 50540 p. 6.4.1 & 5.3 |
| | Conductor diameter | X | X | EN 50540 p. 6.4.2 & 5.4 |
| | Lay inalterability | X | X | EN 50540 p. 6.4.3 & 5.2.4 |
| | Lay ratio and direction ratio | X | X | EN 50540 p. 6.4.4 & 5.2 |
| | Number and type wire | X | X | EN 50540 p. 6.4.5 |
| | Aluminum cross section | X | X | EN 50540 p. 6.4.6 |
| | Mass per unit length | X | X | EN 50540 p. 6.4.7 |
| | Resistivity (DC) | X | - | EN 50540 p. 6.4.8 & IEC 60468 |
| | Stress-strain curve | X | - | EN 50540 p. 6.4.9 & Annex A |
| | Tensile test | X | - | EN 50540 p. 6.4.10 |
| | Laying test | X | - | EN 50540 p. 6.4.11 & Annex C |
| Aluminum Wires | Appearance | X | X | EN 50540 / ASTM B609* |
| | Diameter | X | X | EN 50540 / ASTM B609* |
| | Strength | X | X | EN 50540 / ASTM B609* |
| | Elongation | X | X | EN 50540 / ASTM B609* |
| | Resistivity | X | X | EN 50540 / ASTM B193* |
| | Cross-section | X | X | EN 50540* |
| | Wrapping test | X | X | ISO 7802* |
| | Welding | X | - | IEC 50182 p. 6.5.3* |
| Heat resistant Aluminum-Zr Wires | Condition | X | X | EN 62004 p. 7.3.1* / ASTM B941 |
| | Diameter | X | X | EN 62004 p. 7.3.2* / ASTM B941 |
| | Strength | X | X | EN 62004 p. 7.3.3* / ASTM B941 |
| | Elongation | X | X | EN 62004 p. 7.3.4* / ASTM B941 |
| | Resistivity | X | X | EN 62004 p. 7.3.5* / ASTM B941 |
| | Thermal resistance | X | X | EN 62004 p. 7.3.6* / ASTM B941 |
| | Wrapping test | X | X | EN 62004 p. 7.3.7 & ISO 7802* / ASTM B941 |
| PMC Composite core | Appearance | X | X | ASTM B987 method a |
| | Dimension | X | X | ASTM B987 method b |
| | Tensile test | X | X | ASTM B987 method c |
| | Glass transition temperature test | X | X | ASTM B987 method d |
| | Density | X | - | ASTM B987 method e |
| | Bending test | X | - | ASTM B987 method f |
| | Dye penetrant testing after bending test | X | - | ASTM B987 method g |
| | Tensile test after bending test | X | - | ASTM B987 method h |
| | Heat exposure test | X | - | ASTM B987 method i |
| | Heat/stress test | X | - | ASTM B987 method j |
| | Galvanic protection barrier layer thickness | X | - | ASTM B987 method k |

- Test for GS Type Code GSCH007/2

| **GSCH007/2** | | Type Test | Sample Test | Standard/paragraph |
|---|---|---|---|---|
| Conductor | Surface condition | X | X | EN 50540 p. 6.4.1 & 5.3 |
| | Conductor diameter | X | X | EN 50540 p. 6.4.2 & 5.4 |
| | Lay inalterability | X | X | EN 50540 p. 6.4.3 & 5.2.4 |
| | Lay ratio and direction ratio | X | X | EN 50540 p. 6.4.4 & 5.2 |
| | Number and type wire | X | X | EN 50540 p. 6.4.5 |
| | Aluminum cross section | X | X | EN 50540 p. 6.4.6 |
| | Mass per unit length | X | X | EN 50540 p. 6.4.7 |
| | Resistivity (DC) | X | - | EN 50540 p. 6.4.8 & IEC 60468 |
| | Stress-strain curve | X | - | EN 50540 p. 6.4.9 & Annex A |
| | Tensile test | X | - | EN 50540 p. 6.4.10 |
| | Laying test | X | - | EN 50540 p. 6.4.11 & Annex C |
| Heat resistant Aluminum-Zr Wires | Condition | X | X | EN 62004 p. 7.3.1 / ASTM B941 |
| | Diameter | X | X | EN 62004 p. 7.3.2 / ASTM B941 |
| | Strength | X | X | EN 62004 p. 7.3.3 / ASTM B941 |
| | Elongation | X | X | EN 62004 p. 7.3.4 / ASTM B941 |
| | Resistivity | X | X | EN 62004 p. 7.3.5 / ASTM B941 |
| | Thermal resistance | X | X | EN 62004 p. 7.3.6 / ASTM B941 |
| | Wrapping test | X | X | EN 62004 p. 7.3.7 & ISO 7802 / ASTM B941 |
| MMC Composite core | Appearance | X | X | ASTM B976 |
| | Dimension | X | X | ASTM B976 |
| | Mass per unit length | X | X | ASTM B976 |
| | Strength | X | X | ASTM B976 |

- Test for GS Type Code GSCH007/3

| **GSCH007/3** | | Type Test | Sample Test | Standard/paragraph |
|---|---|---|---|---|
| Conductor | Surface condition | X | X | EN 50540 p. 6.4.1 & 5.3 |
| | Conductor diameter | X | X | EN 50540 p. 6.4.2 & 5.4 |
| | Lay inalterability | X | X | EN 50540 p. 6.4.3 & 5.2.4 |
| | Lay ratio and direction ratio | X | X | EN 50540 p. 6.4.4 & 5.2 |
| | Number and type wire | X | X | EN 50540 p. 6.4.5 |
| | Aluminum cross section | X | X | EN 50540 p. 6.4.6 |
| | Mass per unit length | X | X | EN 50540 p. 6.4.7 |
| | Resistivity (DC) | X | - | EN 50540 p. 6.4.8 & IEC 60468 |
| | Stress-strain curve | X | - | EN 50540 p. 6.4.9 & Annex A |
| | Tensile test | X | - | EN 50540 p. 6.4.10 |
| | Laying test | X | - | EN 50540 p. 6.4.11 & Annex C |
| Aluminum Wires | Appearance | X | X | EN 50540 / ASTM B609 |
| | Diameter | X | X | EN 50540 / ASTM B609 |
| | Strength | X | X | EN 50540 / ASTM B609 |
| | Elongation | X | X | EN 50540 / ASTM B609 |
| | Resistivity | X | X | EN 50540 / ASTM B193 |
| | Cross-section | X | X | EN 50540 |
| | Wrapping test | X | X | ISO 7802 |
| | Welding | X | - | IEC 50182 p. 6.5.3 |
| Aluminum - Zinc Coated Steel Wires | Diameter | X | X | EN 50540 p.6.5.2 |
| | Strength | X | X | EN 50540 p.6.5.2 |
| | Elongation or torsion | X | X | EN 50540 p.6.5.2 |
| | Zinc mass | X | X | EN 50540 p.6.5.2 |
| | Zinc immersion test | X | X | EN 50540 p.6.5.2 |
| | Zinc coating adhesion test | X | X | EN 50540 p.6.5.2 |

- Test for GS Type Code GSCH007/4

| **GSCH007/4** | | Type Test | Sample Test | Standard/paragraph |
|---|---|---|---|---|
| Conductor | Surface condition | X | X | EN 50540 p. 6.4.1 & 5.3 |
| | Conductor diameter | X | X | EN 50540 p. 6.4.2 & 5.4 |
| | Lay inalterability | X | X | EN 50540 p. 6.4.3 & 5.2.4 |
| | Lay ratio and direction ratio | X | X | EN 50540 p. 6.4.4 & 5.2 |
| | Number and type wire | X | X | EN 50540 p. 6.4.5 |
| | Aluminum cross section | X | X | EN 50540 p. 6.4.6 |
| | Mass per unit length | X | X | EN 50540 p. 6.4.7 |
| | Resistivity (DC) | X | - | EN 50540 p. 6.4.8 & IEC 60468 |
| | Stress-strain curve | X | - | EN 50540 p. 6.4.9 & Annex A |
| | Tensile test | X | - | EN 50540 p. 6.4.10 |
| | Laying test | X | - | EN 50540 p. 6.4.11 & Annex C |
| | Gaps | X | - | EN 62420 p. 6.2.3 |
| | Creep curve | X | - | EN 62420 p. 6.2.6 |
| Heat resistant Aluminum-Zr Wires | Condition | X | X | EN 62004 p. 7.3.1 / ASTM B941 |
| | Diameter | X | X | EN 62004 p. 7.3.2 / ASTM B941 |
| | Strength | X | X | EN 62004 p. 7.3.3 / ASTM B941 |
| | Elongation | X | X | EN 62004 p. 7.3.4 / ASTM B941 |
| | Resistivity | X | X | EN 62004 p. 7.3.5 / ASTM B941 |
| | Thermal resistance | X | X | EN 62004 p. 7.3.6 / ASTM B941 |
| | Wrapping test | X | X | EN 62004 p. 7.3.7 & ISO 7802 / ASTM B941 |
| Aluminum Cladded Steel Wires | Condition | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.2 & 4.2 |
| | Diameter | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.2 & 4.4 |
| | Strength | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.3.1 |
| | Elongation | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.3.2 |
| | Torsion | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.3.3 |
| | Aluminum thicknes | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.3.4 |
| | Resistivity | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.3.5 |
| | Tensile test at 1% elongation | X | X | EN 50540 p.6.5.2 & EN 61232 p. 6.3.6 |

## ANNEX 3- OPERATING TEMPERATURES AND AMPACITY RELATED

*Maximum permissible temperatures*

| °C | ACCC | ACPR Lo-Sag | ACCR/TW | ACSS/TW | GAP GZTACSR |
|---|---|---|---|---|---|
| MAXIMUM CONTINUOUS OPERATING TEMPERATURE | 180 | 150 | 210 | 250 | 210 |
| MAXIMUM EMERGENCY TEMPERATURE | 200 | 180 | 240 | | 240 |

*Ampacity at usual and maximum operating temperature:*

| Código Tipo GS | Tipo | Sección (mm²) | Nombre | Ampacidad a Tª usual operación (75°C) | T Max Cont | Ampacidad a T max cont |
|---|---|---|---|---|---|---|
| GSCH007/1 | ACCC | 217,3 | ROVINJ | 448 | 180 | 880 |
| GSCH007/1 | ACCC | 313,3 | CASABLANCA | 564 | 180 | 1120 |
| GSCH007/1 | ACCC | 349,6 | LISBON | 611 | 180 | 1226 |
| GSCH007/1 | ACCC | 473,3 | BRUSSELS | 734 | 180 | 1479 |
| GSCH007/1 | ACCC | 567,8 | WARSAW | 824 | 180 | 1673 |
| GSCH007/1 | ACCC | 595,8 | ROME | 905 | 180 | 1850 |
| GSCH007/1 | ACPR-Lo Sag | 224,7 | 186-AT1/28 | 450 | 150 | 820 |
| GSCH007/1 | ACPR-Lo Sag | 339,5 | 289-AT1/38 | 540 | 150 | 1040 |
| GSCH007/1 | ACPR-Lo Sag | 465,6 | 377-AT1/64 | 658 | 150 | 1270 |
| GSCH007/1 | ACPR-Lo Sag | 548,1 | 549-AT1/64 | 750 | 150 | 1430 |
| GSCH007/1 | ACPR-Lo Sag | 662,7 | 574-AT1/64 | 875 | 150 | 1625 |
| GSCH007/2 | ACCR/TW | 191,2 | 315-T20 | 422 | 210 | 907 |
| GSCH007/2 | ACCR/TW | 281 | HAWK 477TW | 530 | 210 | 1148 |
| GSCH007/2 | ACCR/TW | 390 | OSWEGO | 650 | 210 | 1427 |
| GSCH007/2 | ACCR/TW | 449 | WABASH | 709 | 210 | 1564 |
| GSCH007/2 | ACCR/TW | 590 | CURLEW 1053 TW | 841 | 210 | 1881 |
| GSCH007/4 | GAP GZTACSR | 186,47 | G(Z)TACSR-186 | 440 | 210 | 860 |
| GSCH007/4 | GAP GZTACSR | 292,95 | G(Z)TACSR-293 | 540 | 210 | 1180 |
| GSCH007/4 | GAP GZTACSR | 384,5 | G(Z)TACSR-385 | 640 | 210 | 1420 |
| GSCH007/4 | GAP GZTACSR | 462,1 | G(Z)TACSR-462 | 720 | 210 | 1610 |
| GSCH007/4 | GAP GZTACSR | 553,25 | G(Z)TACSR-553 | 800 | 210 | 1750 |

*Conditions: 40 °C ambient temperature, wind 0,61m/s, elevation 0m, sun radiation 1033W/m², emissivity and absorption, 0,5*