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	HIGH CAPACITY BARE CONDUCTORS	GSCH007 Rev. 00 01/04/2018

### 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

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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 Supported (ACSS)
- ASTM B857: Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors Steel Supported (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.

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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 epoxy resin matrix protected by glass fiber	Aluminum fully annealed T wires
		ACPR-Lo Sag	Carbon fiber in epoxy resin matrix protected by aluminum	Thermo-resistant aluminum zirconium alloy Z or Z&T wires
		OHC-HV	Carbon fiber in epoxy 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.

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Reference Standard for the material: EN 50540<sup>1</sup> and/or ASTM B609<sup>2</sup>.

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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<sup>1</sup> Chapter 5.

<sup>2</sup> After stranding, the trapezoidal aluminum wires shall conform to the requirements of ASTM B609 except for the shape and the diameter tolerance.

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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<sup>3</sup>

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 lose 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<sup>4</sup> and/or ASTM B609<sup>5</sup>.

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

<sup>4</sup> "Chapter 5.

<sup>5</sup> After stranding, the trapezoidal aluminum wires shall conform to the requirements of ASTM B609 except for the shape and the diameter tolerance.

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### 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.

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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 be 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 radius 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.

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## 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  $\pm 1\%$

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

- Data for complete conductor

GS Type Code	Standard	Type	Code Words	Size (mm <sup>2</sup> )	Outside diameter (mm)	Mass (kg/km)	Rated strength (kN)	DC resistance (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	



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- Data for core and for outside core wires

GS Type Code	Standard	Type	Code Words	Material Core	Description core	Cross section core (mm <sup>2</sup> )	Standard core	Material Outside core wires	Description outside core wires	Cross section out core (mm <sup>2</sup> )	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 clad	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	14EHS 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*
Heat resistant Aluminum-Zr Wires	Welding	X	-	IEC 50182 p. 6.5.3*
	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

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- 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

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- 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



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- 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	

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### 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 (mm <sup>2</sup> )	Nombre	Ampacidad a T <sup>a</sup> 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/m<sup>2</sup>, emissivity and absorption, 0,5