

High temperature low sag ACCFCs overhead conductors & fittings

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1 Purpose

The purpose of this Specification is to detail minimum requirements for aluminium conductor carbon fibre supported (ACCFCS) high temperature low sag (HTLS) conductor for use on Endeavour Energy's 33kV - 132kV sub-transmission overhead network.

2 Scope

This specification covers the design, engineering, manufacture, testing, supply and delivery of ACCFCS HTLS conductors for use on Endeavour Energy's 33kV - 132kV sub-transmission overhead network.

All associated line fittings include but are not limited to

- Compression dead-ends
- Armour grip suspension units
- Conductor splices
- Armour / protector rods
- Vibration dampers

3 References

External Regulations	
Electricity Supply Act 1995 (NSW)	
NSW Work Health and Safety Act 2011	
NSW Work Health and Safety Regulation 2017	
ENA National Electricity Network Safety Code (Doc 001-2019)	

External Standards		
Standard No.	Year	Title
AS/NZS 2857	1996	Timber drums for insulated electric cables and bare conductors
AS/NZS 3983	1991	Metal drums for insulated electric cables and bare conductors
AS 4436	1996	Guide for the selection of insulators in respect of polluted conditions
ASTM B193	2025	Standard Test Methods for Resistivity of Electrical Conductor Materials
ASTM B354	2023	Standard Terminology Relating to Uninsulated Metallic Electrical Conductors
ASTM B609	2012	Standard Specification for Aluminium 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes

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ASTM B857	2023	Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminium Conductors, Coated-Steel Supported (ACSS/TW) (most sections are applicable except for the sections on steel core requirements)
ASTM B987	2025	Standard Specification for Carbon Fiber Composite Core (CFC) for Use in Electrical Overhead Conductors
ASTM B1008-18	2026	Standard Test Method for Stress-Strain Testing for Overhead Electrical Conductors
EN 50540	2010	Conductors for Overhead Lines – Aluminium conductor steel supported (ACSS) (most sections are applicable except for the sections on steel core requirements)
IEC 60468	1974	Method of measurement of resistivity of metallic materials
IEC 61089	1991	Round Wire Concentric Lay Overhead Electrical Stranded Conductors
IEC 61395	1998	Overhead electrical conductors – Creep test procedures for stranded conductors
IEC 62641	2022	Conductor for overhead lines – Aluminium and aluminium alloy wires for concentric lay stranded conductors
IEC 61284	1997	Overhead lines – Requirements and tests for fittings
IEC 61854	2001	Overhead lines – Requirements and tests for spacers
IEC 61897	2020	Requirements and tests for Stockbridge type Aeolian Vibration dampers
ANSI C119.4	2022	Connectors for Use Between Aluminium-to-Aluminium or Aluminium-to-Copper Bare Overhead Conductors
IEEE 738	2023	IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors
ISO 9001	2015	Quality Management System
ISO 14001	2026	Environmental Management Systems

Company Policies and Procedures

Company Policy 9.2.1	Network Planning
Company Policy 9.2.5	Network Asset Design
Company Policy 9.2.10	Network Asset Ratings
Company Policy 9.7.1	Network Asset Construction
Company Policy 9.9.1	Network Asset Maintenance

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Company Procedure ENG 002	Network Standard Framework: Preparation and Amendment of Network Standards
Company Procedure GSY 0026	Work Health & Safety Risk Assessment
Company Form FAM 0001	Standards checklist
Branch Procedure PAE 1004	Product Approval Process

Company Standards	
MCI 0005	Overhead construction standards manual
MDI 0031	Overhead line design
MDI 0042	Overhead conductor ratings

4 Definitions and Abbreviations

Term	Definition
/A0	A suffix for ACCFCS type conductors representing 1350 O Temper aluminium material in accordance with Specification B609/B609M.
/CS2	A suffix for ACCFCS type of conductors representing High Strength Carbon Fiber Thermoset Polymeric Matrix core in accordance with Specification B987/B987M.
Accessory	Any device that connects to the ACCFCS conductor for joining, repairing and protecting. This includes tension dead end and splices, suspension clamps, terminal pads, repair sleeves, T-Connectors, spacers and vibration dampers.
ACCFCS	Aluminium Conductor Carbon Fibre Composite Supported bare overhead electrical conductor.
ACSR	Aluminium conductor steel reinforced
AGS	Armour grip suspension
AMP	Authorized manufacturing partner
ANSI	American National Standards Institute
Armour rods	Individual round aluminium spiral rods that when applied to the outside of conductor effectively increase the outside diameter and act as a strain relief to help limit the bending radii of the conductor, typically used under suspension clamps and other devices.
ASTM	ASTM International

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Bird caging	Lantern-effect of aluminium strands being excessively loose or open at the exit of a connector giving the appearance of a lantern or bird cage, rather than smooth uninterrupted conductor.
CFC	Carbon Fibre Composite (core)
Connector	A device joining two or more conductors to provide a continuous electrical path. It can be tension or non-tension.
Dead-end	A connector termination at a tower. Also known as a tension clamp.
Emergency operating temperature	The absolute maximum temperature at which conductor is designed and specified to operate under emergency conditions of a temporary duration.
EN	European Norm Standards
Full tension	95% of compression strength.
Galvanic protection barrier layer	Non-conductive layer that prevents the carbon fibre of the composite core from contacting the aluminium strands used in the conductor.
Glass transition temperature (T _g)	Temperature where the polymer matrix properties transition from a hard, glassy state to a rubbery state. This temperature is defined to be the temperature at which a curve defined by plotting loss modulus versus temperature reaches its peak value.
HTLS	High Temperature Low Sag
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
Joint	A connector and that part of the conductor that has been brought into intimate contact with it by compression or other mechanical means.
Rated conductor strength	The tensile strength of a conductor as furnished by the conductor manufacturer.
Rated operating temperature	The maximum continuous operating temperature of a conductor.
Routine test	Tests that are performed by the manufacturer and are intended to prove conformance to the specific requirements.
Sample	Length of composite core removed from the start or end of a CFC lot and considered to have properties representative of the lot.
Specimen	A length of composite core taken from a lot of CFC for testing purposes.
Splice	A connector joining two or more conductor ends. Also known as mid-span joint.
Type test	Tests that are performed to verify the main characteristics of the conductor. Type tests shall be carried out once.

5 General requirements

ACCFCS conductor sizes currently proposed for use in Endeavour Energy's 33kV – 132kV sub-transmission overhead network are tabled in Appendix 1. The electrical and mechanical characteristics of supplied conductors shall be equal to or better than the values specified in Appendix 1.

5.1 Drum marking requirements exceeding Australian Standards

Additional markings required on drums are: -

- Standards that the conductors comply with
- Purchase order number.
- Net mass of the conductor on the drum.
- Manufacturer's name
- Drum number
- Year of manufacture of the conductor, and
- An arrow with the words "CONDUCTOR PULLING DIRECTION".
- Conductor length

5.2 Storage

ACCFCS conductor may be stored indefinitely and there are no ambient temperature limits for storage. All-steel drums are recommended for storage greater than one year and required for storage exceeding six (6) months if average humidity is greater than 80%. ACCFCS conductor shall never be submerged or allowed to remain wet during storage.

5.3 Drum handling

Drum handling shall be properly controlled during the loading, unloading and staging processes. Proper equipment shall be available to hoist and handle conductor drums. Cranes or other equipment of adequate capacity shall be used to avoid damage and safety hazards.

Drums may be handled with forklift equipment of adequate capacity. It is important that drums of ACCFCS conductor are not lifted by placing the forks of the forklift under the drum area of the reel, which would allow the forks to come in direct contact with the conductor or its wrapping material. Slings, winch lines, nylon straps or any other types of lifting devices shall never be placed around the conductor to lift the reel. The ACCFCS Conductor will be damaged if such devices are used.

5.4 Conductor handling

To prevent damage to the conductor during handling and installation, the supplier shall provide minimum bending radius along with applicable sheave working diameter and tensioner sizes for each conductor size included in offer.

5.5 Operational conditions

ACCFCS conductor operational conditions are specified in Endeavour Design Standard MDI 0042 Overhead Conductor Ratings.

Conductor maximum continuous operating temperature and emergency operating temperature shall be equal to or better than the values specified in Appendix 1.

The supplier shall stipulate maximum cumulative hours permitted at emergency operating temperature and the resulting degree of degradation or reduction of conductor life.

6 Technical requirements

6.1 Applicable standards

All HTLS conductors and associated fittings installed as part of Endeavour Energy's 33kV – 132kV overhead network, shall comply with:

- ASTM B193 – Standard Test Method for Resistivity of Electrical Conductor Materials
- ASTM B609 – Standard Specification for Aluminium 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes
- ASTM B857 – Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminium Conductors, Coated-Steel Supported (ACSS/TW) (most sections are applicable except for the sections on steel core requirements)
- ASTM B987 – Standard Specification for Carbon Fiber Composite Core (CFC) for Use in Electrical Overhead Conductors
- ASTM B1008 – Standard Test Method for Stress-Strain Testing for Overhead Electrical Conductors
- EN 50540 – Conductors for Overhead Lines – Aluminium conductor steel supported (ACSS) (most sections are applicable except for the sections on steel core requirements)
- IEC 60468 – Method of Measurement of Resistivity of Metallic Materials
- IEC 61089 – Round Wire Concentric Lay Overhead Electrical Stranded Conductors
- IEC 61395 – Overhead electrical conductors – Creep test procedures for stranded conductors
- IEEE 738 – IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors
- IEC 62641 - Conductor for overhead lines – Aluminium and aluminium alloy wires for concentric lay stranded conductors
- IEC 61284 - Overhead lines – Requirements and tests for fittings
- IEC 61854 - Overhead lines – Requirements and tests for spacers
- ISO 9001 or equivalent - Quality Management System
- ISO 14001 - Environmental Management System

Other relevant standards where specifically mentioned in the following sections. Where the standards and this specification differ, the requirements of this specification will prevail.

6.2 ACCFCS conductors and fittings

6.2.1 ACCFCS conductor requirements

The conductor to be supplied shall be of the Smooth Body Type, round and compact. The conductor shall not exhibit any key-stone effect among the individual strands. All the annealed aluminium strands shall be uniform and free from imperfections such as splits, cracks, die marks, scratches etc., after drawing and stranding.

6.2.2 Core materials

ACCFCS Conductors shall consist of a supporting single stranded carbon fibre composite core (CFC) that meets one of the following strength grades in Table 1.

The core shall consist of carbon fibres combined with a suitable heat-resistant thermoset polymer matrix to achieve the properties listed in Table 1. The carbon material shall be encased by a non-conductive galvanic protection barrier layer.

The galvanic protection barrier shall meet the requirements set forth in this specification including thickness, minimum bending diameter, and dye penetrant inspection after bending.

It shall meet the requirements set forth in this specification, including tensile strength, minimum bending diameter, dye penetrant inspection after bending, glass transition temperature (T_g), and heat exposure capability.

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It shall be smooth, continuous, and free of imperfections consistent with good manufacturing practices.

Its materials may be furnished in either of two grades, High or Extra High Strength, in conformance with the requirements of this specification. It shall meet the minimum requirements shown in Table 1.

Table 1 - Physical properties of single stranded CFC core

Property	High Strength Grade	Extra High Strength Grade
Ultimate tensile strength, min	2137 MPa (310 ksi)	2586 MPa (375 ksi)
Thermoset polymer matrix T _g , min	180°C (355°F) to 250°C (482°F)	180°C (355°F) to 250°C (482°F)
Galvanic layer thickness, min	5% of nominal radius	5% of nominal radius
Heat exposure capacity, min	95 % retention of rated tensile strength after 52 weeks of heat exposure	95 % retention of rated tensile strength after 52 weeks of heat exposure
Bending diameter, min	50 times diameter of CFC	60 times diameter of CFC
Tensile modulus, nominal	111.7 GPa (16.2 Msi)	146 GPa (21.2 Msi)
Thermal expansion coefficient, nominal	1.61 x 10 ⁻⁶ /°C	1.0 x 10 ⁻⁶ /°C
Density at 20°C, nominal	1.88 g/cc	1.60 g/cc
Maximum continuous operating temperature	Heat Exposure Capability temperature minus 20°C	Heat Exposure Capability temperature minus 20°C

6.2.3 Stranding material

Over the supporting single stranded CFC core, ACCFCS conductors shall have two or more layers of trapezoidal fully annealed aluminium wires (1350-O) that are helically stranded. The trapezoidal wires shall have the properties listed in Table 2 for all ranges and sizes.

Wires shall be drawn into a trapezoidal shape that allows them to fit tightly together during stranding. Each concentric layer of wire shall fit closely to the layer(s) above or below it.

The surface of the aluminium wires shall be smooth, without foreign particles, copper dust or any other material that can cause aluminium corrosion. Wires shall not have cosmetic defects, irregular surface (scales), breaks or any other defects visible to the unaided eye.

To reduce the propensity for the surface of the conductor to collect dust, or other surface contaminants from accumulating on the surface of the conductor, the manufacturer shall minimize the amount of stranding lubricant utilised in the manufacture of the ACCFCS conductor. Any excess lubricant shall be removed prior to delivery using a process that does not harm the strands or the composite core material.

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Table 2 - Properties of Stranding Material

Parameters	Value
Type of aluminium	A0 (1350-O)
Shape of wire	Trapezoidal
Tensile strength	Minimum 60 MPa
Conductivity	Minimum 63% IACS
Resistivity @ 20C	$\leq 27.37 \text{ n}\Omega\cdot\text{m}$
Elongation	Minimum 20%

6.2.4 Dead ends and splices

Connectors for the purpose of dead-ending and splicing ACCFCS conductor are compression type connectors used for full tension. Connectors used for electrical continuity connections shall meet the testing requirements of Table 4.

The components and installation equipment shall be engineered to minimise moisture ingress and maximise compaction.

Connectors shall be provided with an oxidation inhibitor compound, included in each connector kit or test results demonstrating that no oxidation inhibiting compound is required.

Connectors shall be supplied with installation instructions in English.

6.2.5 Suspension clamps

ACCFCS conductor installed in suspension clamps shall be equipped with armour rods or an equivalent apparatus that limits the conductor to bending to less than 30° of total bending radius. Suspension clamps shall be armour grip suspension (AGS) type. The material of AGS shall have good performance under the maximum operating temperature of ACCFCS conductor without permanent loss. The AGS shall be capable of holding the conductor without slipping under an unbalance tension of 20 percent of the rated ultimate strength of the ACCFCS conductor.

Note - suspension clamp and elastomeric cushion will be at a lower temp than the conductor.

The suspension clamps shall have sufficient contact surface to avoid damage by fault currents to strands and core. Suspension clamps shall be supplied with installation instructions in English.

6.2.6 Vibration dampers

Vibration dampers shall provide satisfactory performance under the maximum operating temperature of ACCFCS conductor without permanent loss. Dampers shall be sized to not damage ACCFCS conductor strands and core. Damper study shall be supplied along with damper kit instructions in English.

6.2.7 Spacers

Spacers shall have good performance under the maximum operating temperature of ACCFCS conductor without permanent loss. Elastomeric mounting is preferred; mounting shall not damage the ACCFCS conductor strands or core. Spacers shall be supplied with instructions in English.

6.2.8 T-connectors

Connectors for the purpose of tapping off the ACCFCS conductor shall be compression type T-connectors.

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Compression-type T-connectors shall be designed to minimise internal voids and to prevent the ingress or entrapment of moisture during service. T-connectors shall be provided with an oxidation inhibitor compound, included in each connector kit or test results demonstrating that no oxidation inhibiting compound is required. Each kit shall be supplied with instructions in English.

7 Testing requirements

7.1 HTLS ACCFCS conductor

Tests for ACCFCS conductor consist of type tests and routine tests stipulated in Table 3.

Table 3 – Type and routine tests

Test Description	Type Test	Routine Test	Applicable Test Standards
Conductor tests			
Surface condition	X	X	EN 50540 / ASTM B857
Diameter	X	X	EN 50540 / ASTM B857
Lay ratio and direction of lay	X	X	EN 50540 / ASTM B857
Number and type of wires	X	X	EN 50540 / ASTM B857
Mass per unit length	X	X	EN 50540 / ASTM B857
Conductor DC electrical resistance	X	-	IEC 60468 / ASTM B193
Conductor stress-strain curve	a	-	ASTM B1008
Conductor ultimate tensile test	a	-	EN 50540 / ASTM B857
Creep test ¹	a	-	IEC 61395
Stranding material tests (before and after stranding)			
Tensile strength	X	X	IEC 62641 / ASTM B609
Elongation	X	X	IEC 62641 / ASTM B857
Resistivity	X	X	IEC 62641 / ASTM B193
Cross-section	X	X	IEC 62641 / ASTM B857
Single stranded CFC core material tests			
Tensile test	X	X	ASTM B987
Glass transition temperature	X	X	ASTM B987
Density	X	X	ASTM B987
Dimensions	X	X	ASTM B987
Heat/Stress test	X		ASTM B987
Heat exposure test	X		ASTM B987
Bending test	X		ASTM B987
Dye penetrant after bending test	X		ASTM B987
Tensile test after bending test	X		ASTM B987

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Galvanic protection barrier layer thickness test	X	X	ASTM B987
Core integrity test			b
Note 1: Creep test in fully annealed aluminium conductors is typically not necessary. The largest load the conductor is expected to experience will typically drive the aluminium to relieve its entire load at the everyday tension. With the aluminium not carrying load, it will not creep. The composite core does not creep. Note a: By agreement between the purchaser and AMP. Note b: The contractor is required to offer a system to confirm the integrity of composite core immediately after conductor stringing. The contractor shall submit reports from past field measurement or a third-party report providing that integrity confirmation does work through proposed system. Further the line(s) where this proposed system has been deployed to confirm the integrity of composite core shall have been in satisfactory operation for a period of at least one year in any power utility. Contractor shall submit necessary documentation, training material and manuals to support this system shall be submitted within 30 days from date of LOA.			

7.1.1 Properties of the stranding materials (before and after stranding)

Properties of the aluminium wires before and after stranding shall meet the requirements of EN 50540 Section 5.1.2 or ASTM B609. Refer to Table 2 of this Specification for aluminium wire requirements. Testing of the aluminium wire properties listed in Table 3 shall be performed according to IEC 62641.

7.1.2 Properties of the ACCFCS conductor

Required testing and the applicable test standards for the completed conductor are listed in Table 3. The conductor diameter shall not vary from the nominal value by more than $\pm 1\%$. The cross-section area of the aluminium wires making up the ACCFCS conductor shall be $\pm 2\%$ of the nominal value. The mass per unit length of a 1 m sample of conductor shall be determined using an apparatus capable of achieving an accuracy of $\pm 0.1\%$. The test value obtained shall be within a tolerance of $\pm 2\%$ of the nominal value.

7.1.3 Properties of the single stranded CFC core

Physical properties of single stranded CFC core are listed in Table 1. Required tests and applicable test standards are listed in Table 3.

Specific test procedures for single-stranded CFC core are as follows.

7.1.3.1 Tensile Test

The single stranded CFC core shall conform to the tensile strength requirements given in Table 1 - Physical properties of single stranded CFC core.

Tensile tests on the single stranded CFC core shall be conducted in accordance with the Test Methods and Definitions section of ASTM D 3916. It is suggested to consult with the manufacturer of the single stranded CFC core for the best gripping method for testing. The suggested length of the test specimen is 1.2 m.

Calculation of single stranded CFC core tensile properties shall be based on the total cross-sectional area of the composite core including the galvanic protection layer.

7.1.3.2 Glass Transition Temperature (T_g)

The glass transition temperature (T_g) shall be determined using a dynamic mechanical analysis (DMA) instrument in accordance with ASTM D 7028. T_g shall be defined as the peak in the loss modulus curve.

The single stranded CFC core DMA specimen shall be machined into a rectangular shape that meets the requirements described in ASTM D 7028.

7.1.3.3 Density

Density can be calculated from mass divided by volume.

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7.1.3.4 Dimensions

The specified diameter of the single stranded CFC core shall be expressed in decimal fractions of millimetres (mm) to two decimal places.

The diameter shall be the average of the largest and smallest measured diameters at the same cross section, rounded to the nearest 0.01 mm. Measurements shall be evenly spaced around the circumference of the cross section, and a minimum of three measurements shall be taken.

The average diameter shall not differ by more than ± 0.05 mm from the nominal diameter of the single stranded CFC core.

7.1.3.5 Heat Exposure Test

The purpose of this test is to determine the thermal endurance capability of the polymer matrix resin system used to fabricate the single stranded CFC core material. The test may be performed on any class of CFC Core to qualify the resin system for all classes of composite core provided the same resin formula and processing conditions are used.

Three specimens shall be exposed to a temperature of T_g minus 5°C (10°F) for 52 weeks, in air circulating oven. No stress is applied during the exposure period. All specimens in a test group shall be heat exposed at the same time. The ends of the composite core specimens are allowed to extend 150 mm outside the oven walls.

After the exposure period, the specimens shall be bonded to suitable fixtures for tensile testing following the manufacturer's suggested method. After exposure, the following conditions shall be met:

- Specimen shall show no signs of cracking or wrinkling after exposure.
- Specimen shall retain a minimum of 95% of its rated tensile strength, according to Table 1 - Physical properties of single stranded CFC core.

7.1.3.6 Heat Stress Test

A specimen of single stranded CFC core of sufficient length shall be subjected to a tensile load of 25% of the rated tensile strength for 1000 hours while simultaneously being exposed to a test temperature set by the calculation: Heat/Stress Exposure Temp = T_g minus 5°C (10°F).

After the exposure period, the specimens shall be bonded to suitable fixtures for tensile testing following the manufacturer's suggested method. After exposure, the following conditions shall be met:

- Specimen shall show no signs of cracking or wrinkling after exposure.
- Specimen shall retain a minimum of 95% of its rated tensile strength, according to Table 1 - Physical properties of single stranded CFC core.

7.1.3.7 Bending Test

Bending tests shall be performed once at the start and once at the end of the lot. Testing consists of wrapping the single stranded CFC core 180 degrees around a cylindrical mandrel and loading to 15% of its rated tensile strength for a period of 60 seconds. Test details are as follows:

- The diameter of the cylindrical mandrel shall be equal to the minimum bending diameter specified in Table 1 - Physical properties of single stranded CFC core.
- The section of the composite core that is in direct contact with the mandrel shall be marked so that after the bending test, this section can be easily identified to perform post-testing analysis.
- After completion of the bending test, the specimen shall be checked visually for damage, such as peeling of the fibres from the surface of the composite or a compressive failure. These types of fractures constitute a failure.
- Test specimens shall not fracture, including the galvanic protection barrier, after it is tested. If the specimens exhibit no visible fractures as described in ASTM B987, then the test specimens shall be subjected to the dye penetrant and tensile test.

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7.1.3.8 Dye Penetrant after Bending Test

Specimens for dye penetrant testing shall be taken from the part of the bending test specimen that was in direct contact with the mandrel. Dye penetrant specimens shall be taken as close as possible to the centre of this region.

To detect the presence of any cracks that may have formed inside the composite core during the bending test, a minimum of 5 specimens shall be taken from the test section and tested per ASTM D 5117.

Specimens shall be placed vertically in a dye penetrant bath with the bottom surface submerged in the dye penetrant for a period of 5 minutes.

During the test period the presence of small ($< .5\text{mm}$ Dia), separated, wicking dots on the top surface is acceptable. If the dots merge and the top surface of the single stranded CFC core is covered in dye penetrant to a level of 50% of the surface area or greater, then the sample has sustained damage and has failed the test. If fibre optics are present in the core, wicking can sometime occur and these wicking dots around the fibre optics does not constitute a failure.

7.1.3.9 Tensile Test after Bending Test

The specimen for the tensile test shall be selected from the part of the sample that was in direct contact with the mandrel (where the highest stresses would occur) and subjected to the tensile testing. The specimen shall be bonded to suitable fixtures for tensile testing following the manufacturer's suggested method. After exposure the following conditions shall be met:

- Specimen shall show no signs of cracking or wrinkling after exposure.
- Specimen shall retain a minimum of 95% of its rated tensile strength, according to Table 1 - Physical properties of single stranded CFC core.

7.1.3.10 Galvanic Protection Barrier Layer Thickness

Determination of the minimum thickness of the galvanic protection barrier layer shall be done by microscopic examination. Specimens shall be polished and the minimum thickness determined using an optical comparator and in accordance with Figure 1, where the nominal radius, R , is defined as one-half of the nominal strand diameter.

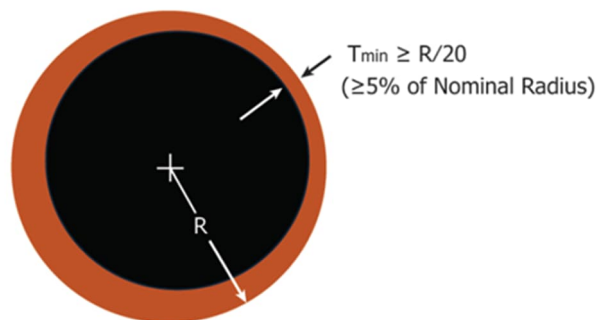


Figure 1 - Measurement of Protection Layer Thickness

7.1.3.11 Core Integrity Test

The supplier is required to offer a system to confirm the integrity of composite core immediately after conductor stringing. The supplier shall submit reports from past field measurement or a third-party report providing that integrity confirmation does work through proposed system. Further, the line(s) where this proposed system has been deployed to confirm the integrity of composite core shall have been in satisfactory operation for a period of at least one year in any power utility. The supplier shall submit

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necessary documentation, training material and manuals to support this system within 30 days from date of LOA.

7.2 ACCFCS conductor fittings

Tests for ACCFCS conductor fittings consists of type tests and routine tests stipulated in Table 4.

Table 4 – Required tests for ACCFCS conductor fittings

Test Description	Type Test	Routine Test	Suggested Standards for Testing
Dead end and splices tests			
Heat cycle test ¹	X		IEC 61284
Tensile test	X		IEC 61284
Visual examination	X	X	IEC 61284
Dimensional and material verification	X	X	IEC 61284
Suspension clamps tests			
Tensile test	X		IEC 61284
Slip test	X		IEC 61284
Clamp bolt tightening test	X		IEC 61284
Visual examination	X	X	IEC 61284
Dimensional and material verification	X	X	IEC 61284
Vibration dampers			
Slip test	X		IEC 61897
Clamp bolt tightening test	X		IEC 61897
Breakaway bolt test	X		IEC 61897
Corona and RIV test	X		IEC 61897
Damper performance test	X		IEC 61897
Damper fatigue test	X		IEC 61897
Visual examination	X	X	IEC 61897
Dimensional and material verification	X	X	IEC 61897
Spacer			
Clamp slip test	X		IEC 61854
Clamp bolt tightening test	X		IEC 61854
Breakaway bolt test	X		IEC 61854
Corona and RIV test	X		IEC 61854
Electrical resistance test	X		IEC 61854
Fatigue test	X		IEC 61854

High temperature low sag ACCFCS overhead conductors & fittings

Visual examination	X	X	IEC 61854
Dimensional and material verification	X	X	IEC 61854
T- connectors			
Heat cycle test ¹	X		IEC 61284
Visual examination	X	X	IEC 61284
Dimensional and material verification	X	X	IEC 61284
Note 1: Heat cycle test requires running either to ANSI C119.4 or IEC 61284 for 500 thermal cycles 195°C min, 200°C max temperature.			

7.3 Testing accreditation

All type tests shall be carried out by a testing authority/laboratory holding accreditation: -

- By NATA Australia; or,
- By an accreditation authority recognised by NATA Australia; or,
- By independent laboratories/institutes which are accredited according to TIS 17025 or ISO/IEC 17025 with the scope of accreditation covering the relevant test items, standard and equipment. The certification and scope of accreditation of the independent laboratories/institutes shall be submitted with the bid for consideration.

Type tests may be conducted at the manufacturing facility's test laboratory on the condition that sufficient evidence is provided to demonstrate the testing facility's capability to perform the specified tests. As a minimum, the following information is to be provided:

- Qualifications/experience of the testing staff.
- Test procedures for all routine tests.
- Testing facility quality control procedures, and
- Test instrument calibration certificates/procedures

Tests from other testing authorities may be accepted at the discretion of Endeavour Energy's Asset Engineering Manager.

7.4 Test report requirements

All type test reports are to be accompanied by copies of the accreditation certificate(s) issued to the testing laboratory. The accreditation certificate(s) shall be valid for the relevant test(s) and for the duration of the test(s).

Type tests shall be less than ten years old. Type tests beyond this limit may be submitted, provided sufficient information to demonstrate that the manufacturing process, raw materials, design and quality control processes have not significantly changed since the original test date is also submitted with the offer.

All documentation submitted (including reports, tests, testing procedures/policies, calibration certificates and the like) written in any language other than English will not be accepted unless the reports are translated into English by an accredited translator.

7.5 Type test requirements

The supplier shall provide type test reports for Endeavour Energy to review prior to a conductor being approved for use on its network. A type test report shall comprise of one set of routine and special tests as defined in:

- Type test report of the proposed ACCFCS conductor as specified in Table 3.
- Type test report of the ACCFCS conductor fittings as specified in Table 4.

Type test to be carried out on a prototype of the conductor prepared by the manufacturer to verify it meets the standards defined in Table 3 and Table 4. A conductor is considered identical to its prototype if:

- Same material used (core and stranding material)
- Same dimensions
- Same mechanical and electrical properties

For ACCFCS core with a maximum diameter difference of 15%, type test on the ACCFCS core shall only be performed for the following tests: dimension/diameter, density, tensile test, and galvanic protection barrier layer thickness test.

7.6 Routine tests

7.6.1 ACCFCS conductors

The individual wires of a conductor shall be tested, before stranding, under a routine test procedure. Dimensions and ultimate tensile strength tests shall be completed on specimens taken from the first and every tenth spool of wire prepared for loading on to the stranding machine.

All other Routine Tests listed in Table 3 (except the lay ratio test) shall be completed on 10% of the specimens selected. The lay ratio test shall be completed at the beginning and end of each production run.

If a specimen fails any of these tests, that test shall be repeated on two further specimens taken from the same spool. If either of these fails, the spool is to be rejected, and the five spools produced sequentially before and after the reject spool is to be individually tested.

7.6.2 ACCFCS core

List of routine tests for ACCFCS core is provided in Table 3. The ACCFCS core manufacturer shall test each production lot using samples of core of sufficient length to run all testing and potential retests. The samples shall be taken from the start and end of the lot. Specimens from each sample shall be subjected to the required testing.

Upon request from purchaser, the ACCFCS core manufacturer shall provide test reports that support the ACCFCS core meets the requirements in these sections.

8 Additional documentation

Manufacturers/suppliers shall also provide documentation supporting the quality of the products to be supplied, sustainability and life cycle, and the additional information detailed in clause 8.3

8.1 Quality assurance

The supplier and/or manufacturer shall provide the following documentation for review:

- Conductor drawings and data sheets.
- Safety data sheet (SDS) for each material used in the manufacturing of the conductor.
- Quality Management System Certification in accordance with AS/NZS ISO 9001 or similar, and/or
- Environmental Management System Certification in accordance with AS/NZS ISO 14001 or similar.

8.2 Sustainability

The supplier and/or manufacturer shall provide the following information for review:

- Environmental product declaration (EPD) for ACCFCS conductors and associated fittings.
- Information on each component of the conductor as to whether it can be recycled and/or disposed of at the end of products life (e.g. recycling of CFC core). Any materials that cannot be recycled shall be disclosed along with any recommendations regarding the disposal / handling process of such materials.
- Climate change adaptability and resilience outcomes associated with ACCFCS conductor, including fire performance considerations, high-temperature operation impacts, and resilience benefits relative to ACSR.

8.3 Additional information

At Endeavour Energy's discretion, the following items/documents may be requested to be reviewed:

- A 300mm sample of each conductor type being offered for further inspection by Endeavour Energy.
- The period of service of the items being offered within the Australian environmental conditions.
- Australian customers or Electricity Supply Authorities who have a service history of the items being offered.
- Contact details of relevant referees of those customers/electricity supply authorities who can verify the service performance claimed.

9 Authorities and Responsibilities

Listed below are the positions or groups of positions that have specific authorities and responsibilities associated with this Specification.

General Manager Future Grid and Asset Management has the authority and responsibility for:

- approving major changes to this Specification in accordance with Table 4 of ENG 002;
- making all major decisions concerning compliance with this Specification;
- delegating any of these authorities and responsibilities to the Head of Asset Management and Digital.

Head of Asset Management and Digital has the authority and responsibility for:

- approving minor changes to this Specification in accordance with Table 4 of ENG 002;
- Making recommendations to the General Manager Future Grid & Asset Management for major changes in respect to this Specification.

Asset Engineering Manager has authority and responsibility for:

- reviewing this Specification for suitability in Endeavour Energy's network;
- making recommendations to the Head of Asset Management and Digital based on industry best practice;
- managing dispensation requests for variations to requirements of this Specification.

Manufacturers/Suppliers are responsible for:

- creating awareness of their responsibilities under this Specification;
- determining that the contractor/s under their control have provided suitable training for their staff;
- implementing an effective quality auditing system;
- implementing this Specification and keeping the Portfolio Manager of Endeavour Energy informed of any factors that may prevent them from accepting responsibility for its full implementation.

Appendix 1

Table of proposed ACCFCS conductors

ACCFCS Conductor	Size	Diameter	Core Diameter	Approx Weight			Rated Strength	Resistance			Ampacity			Geometric Mean Radius	Inductive Reactance @50Hz	Capacitive Reactance @50Hz
				Total	Al	Core	Std core	DC @20°C	AC @25°C	AC @200°C	75°C	180°C	200°C			
	(mm ²)	(mm)	(mm)	(Kg/km)	(Kg/km)	(Kg/km)	(kN)	(Ω/km)	(Ω/km)	(Ω/km)	(amps)	(amps)	(amps)	(mm)	(Ω/km)	(MΩ/km)
Brussels	421.4	25.15	8.13	1263.8	1166.7	97.1	135.7	0.0666	0.0687	0.1152	904	1549	1633	10.21	0.213	0.183
Milan*	567.7	29.10	8.76	1685.6	1572.6	113.0	162.1	0.0494	0.0514	0.0857	1086	1880	1984	11.73	0.205	0.174
Paris	813.7	34.16	8.76	2365.8	2252.8	113.0	176.0	0.0345	0.0368	0.0603	1344	2358	2493	13.66	0.195	0.165
Athens*	1409.7	44.75	10.54	4064.4	3901.4	163.0	267.6	0.0199	0.0231	0.0357	1844	3336	3540	17.83	0.178	0.150

*Milan and Athens have been included to round out range – final approval subject to provision of prequalification reports.

