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TITLE	SPECIFICATION FOR OVERHEAD POWER LINES GROUND WIRE WITH OPTICAL FIBER	REFERENCE	REV
		CP_TSSPEC_060	2
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FOREWORD

Recommendations for corrections, additions or deletions should be addressed to the:

Technology Services Manager
City Power Johannesburg (SOC) Ltd
P O Box 38766
Booyens
2016

INTRODUCTION

Overhead ground wire with optical fiber cable forms an integral part of City Power transmission network; it's used for tele-control, protection and telephone. OPGW is compound of cables which serves both as a conventional overhead ground wire with the added benefit of providing optical fiber communication.

1 SCOPE

The purpose of this specification is to detail the essential mechanical, electrical and optical requirements to be met when manufacturing or supplying a metallic armoured optical ground wire (OPGW) for an application with a nominal voltage from 11 kV up to and including 275 kV.

2 NORMATIVE REFERENCES

The following standards and specifications contain provisions that, through reference in the text, constitute requirements of this specification. At the time of publication the editions indicated were valid. All standards and specifications are subject to revision and parties to agreements based on this specification are encouraged to investigate the possibility of applying the most recent editions of the standards and specifications listed below.

ITU-T G.652D; *Characteristics of a single-mode optical fiber and cable*

SANS 60793-1; *Measurement methods and test procedures.*

SANS 60793-2; *Optical fibers. Part 2: Product specifications – General.*

NRS 061-1; *Specification for overhead ground wire with optical fiber. Part 1: Product specification*

SANS 60815; *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions.*

SANS 60793-2; *Optical fibers. Part 2: Product specifications – General.*

SANS 60794-4-1; *Optical fiber cables. Part 4: Sectional specification – Aerial optical cables along electrical power lines.*

SANS 60793-2-30; *Optical fibers Part 2-30: Product specifications - Sectional specification for category A3 multimode fibers.*

TIA/EIA-598-A; *The Telecommunications Industry Association's TIA-598-C Optical Fiber Cable Color Coding*

IEC 60889, - *Hard-Drawn Aluminium Wire for Overhead Line Conductor*

IEC – 61233; *High-Voltage Alternating Current Circuit-Breakers - Inductive Load Switching*

SANS 60794-2:2003 (Ed. 2.00) *Sign up for alerts Optical fibre cables Part 2: Indoor cables - Sectional specification*

IEC 60794-1-2:2017 *Optical fiber cables – part 1-2 Generic Specification – Basic Optical Cable Test Procedures. – General Guidance.*

3 DEFINITIONS AND ABBREVIATIONS

The definitions and abbreviations in the above documents shall apply to this specification.

4 SERVICE CONDITIONS

The OPGW shall be designed for use under the following service conditions:

- a) Route altitude: 1800 m (Above sea level).
- b) Maximum temperature : 50 °C;
- c) Minimum temperature : -10 °C;
- d) Maximum wind speed : 36 m/s; and
- e) Relative humidity : 36

5 GENERAL REQUIREMENTS

- 5.1 The specific requirements for OPGW are specified below, where conflicting requirements with NRS 061-1 occur, this specification shall take precedence.
- 5.2 The OPGW shall have the necessary protective outer layer to prevent damage to the fiber due to mechanical elongation, bending, twisting and crushing forces.
- 5.3 The earth wire shall be of 7 strands of 3.25mm stainless steel wire.
- 5.4 The stranded bare conductor shall consist of the same electrical and mechanical characteristics as a conventional overhead ground wire.
- 5.5 Full details of the construction of the fiber cable offered shall be provided, as well as the measures taken to minimize hydrogen absorption in the fibers.
- 5.6 The minimum short circuit (1s) current rating shall be 7kA (kilo-Ampere).
- 5.7 Each fiber shall be measured for continuity and length, while the cable is on a drum, prior to delivery.
- 5.8 Sample tests shall be performed to ensure that the material used and the manufacturing processes are without defect.
- 5.9 Each fiber shall be uniquely identified in an approved manner as per TIA/EIA-598-A.
- 5.10 There shall be no fiber splices in any individual drum length of OPGW.
- 5.11 The fiber carrier design shall be such that no moisture shall be able to penetrate and come in contact with the fibers and no grease shall be applied on the conductor.
- 5.12 The wires shall be stranded in such a manner that, when the complete conductor is cut, the individual layers can easily be regrouped

6 DESIGN DETAILS

6.1 Fiber optic

- 6.1.1 These shall be single mode fibers as in accordance with (ITU-T Recommendations G 652 D), IEC 60793-1 and IEC 60793-2.
- 6.1.2 The fiber carrier shall house the optical fibers, and also protect them from damage caused by large temperature variations as a result of over-current conditions.

6.1.3 The fiber carrier shall consist of an aluminium alloy tube and the type of fiber carrier shall be either G.652.

6.2 Armour

6.2.1 The OPGW armour shall be designed to provide similar mechanical and electrical characteristics as a conventional shield wire, and meet short-circuit current requirement.

6.2.2 The basic construction of the armour shall comprise bare metallic wires of unique or combined metals stranded in one or more layer(s). The stranding shall be made up of one or more layers and shall be any of the following materials:

- a) Galvanized steel (only in exceptional circumstances¹⁾; or;
- b) Alloy in accordance with IEC 60889; or
- c) Aluminium-clad steel in accordance with IEC 61232, or
- d) A combination of (a), (b) or (c) above.

6.2.3 The stranded wires shall be made of one or more layers, and can be of combined metal types in each layer. The stranding and wire diameter shall be specified in schedule B.

6.2.4 The finished wires shall contain no joints or splices.

6.2.5 The direction of lay shall be reversed in successive layers.

6.2.6 The finished wires shall contain no joints or splices.

6.2.7 The wires shall be so stranded that, when the complete OPGW is cut, the strands shall maintain their original form and shall not spring apart, such that individual layers can easily be regrouped.

6.3 Tensile performance

The OPGW shall be so designed that it can withstand a specified tensile load without deleterious influence on the optical fibers.

6.4 Macro-bend resistance

The macro-bend resistance shall comply with NRS 061-1 clause 4.2.5 for G.652 fibers respectively.

6.5 Crush resistance

During stringing, the conductor is subjected to side compression when it passes over metal pulleys or when clamps are installed. To endure these stresses, the fiber shall have a high anti-crushing resistance. When tested there shall be no measurable permanent changes in optical attenuation coefficient at 1310 nm and 1550 nm (nanometer), while any temporary change in attenuation shall be less than 0,1 dB (deci-bells).

Note: *Attenuation is the reduction of signal strength during transmission.*

¹⁾ Galvanized steel is not recommended due to potential corrosion problems that can arise in coastal and heavily polluted environments.

6.6 Tensile performance

The conductor shall be designed in such a manner that it can withstand a specified tensile load without deleterious influence on the optical fibers. The tensile performance shall comply with NRS 061-1

6.7 Cable deformation

During installation the cable shall be subjected to passing, under tension, over several metal pulleys. The cable deformation shall comply with NRS 061-1

6.8 Stress-strain

There shall be no visual change to the cable strands. The stress-strain shall comply with NRS 061-1

6.9 Impact

The impact shall comply with NRS 061-1 and there shall be no measurable permanent changes in optical attenuation at 1 550 nm, while any temporary change in attenuation shall be less than 0,1 dB

6.10 Aeolian vibration

The optical attenuation increase shall be less than 0, 05 dB/km at 1 550 nm and, any significant damage to the components of the cable shall constitute non-compliance.

6.11 Conductor creep

The manufacturer shall submit records of a long term (>1 000 h) elongation test, with extrapolation to 15 years of a conductor sample tensioned at 20 % RTS.

6.12 Temperature cycle

When tested in accordance with 5.1.2.8, the changes in attenuation over the last four cycles shall not exceed 0,10 dB/km from the mean. The mean attenuation shall be defined as the average attenuation encountered at 20 °C over the last 4 cycles. See figures 1(a) and 1(b).

6.12.1 A temperature cycle shall be:

Starting temperature in chamber = + 20 °C

6.12.2 First and three subsequent cycles (see figure 1(a)):

- a) T_A is -10 °C
- b) T_B is +50 °C

Soak time t_1 : see table 1

6.12.3 Last cycle (see figure 1(b))

- a) T_{A1} is -10° C
- b) T_{A2} is -20° C
- c) T_{B1} is +50° C
- d) T_{B2} is +70° C

Soak time t_1 : see table 1

The cooling and heating processes shall be as rapid as possible, appropriate to the capabilities of the environmental chamber.

6.13 Short - circuit current

The short-circuit current shall comply with NRS 061-1

6.14 Lightning

The lightning shall comply with NRS 061-1

7 DESIGN INFORMATION OPTICAL FIBER

The required attenuation, chromatic dispersion coefficient, (Polarization mode dispersion) PMD characteristics, mode field diameter and concentricity error shall be detailed below.

1	2
Attributes	Values
1. Cladding diameter	125µm ± 1,0µm
2. Cladding non-circularity	≤ 1,0 %
3. Attenuation coefficient at a) 1290 nm to 1340 nm b) 1525 nm to 1575 nm	< 0.36 dB/km < 0.25 dB/km
4. Chromatic dispersion coefficient at a) 1310 nm b) 1550 nm	< 3.5 ps/nm.km < 18 ps/nm.km
5. Polarization mode dispersion (PMD)	< 0.5 ps/√km
6. Mode field diameter at a) 1310 nm b) 1550 nm	9.2 ± 0,4 µm 10.50 ± 1,0 µm
7. Mode field concentricity error	≤ 0,5 µm
8. Proof test	≥ 1%
9. Fiber Curl (ROC)	≥ 4,0 m
10 Marco-bend test on fiber at 1550 nm	≤ 0,1 dB

Table 1: Specifications for G.652 fiber

8 TESTS

8.1 Type tests

- a) Stress-strain test
- b) Crush test
- c) Tensile performance test
- d) Sheave test
- e) Impact test
- f) Temperature cycle test

- g) Water penetration tests
- h) Short-circuit test
- i) Lightning test

8.2 Routine test and Factory Acceptance test

8.2.1 The routine test shall be carried out in accordance with SANS 60794-1-2

8.2.2 Factory Acceptance test shall also be carried out as to SANS 60794-1-2 and City Powers personnel shall be presented to witness unless stated otherwise.

8.2.3 The presence of City Power's personnel shall not relieve the supplier of his responsibility for the satisfactory performance of the cable during subsequent testing at site, and thereafter, up to the end of the warranty period.

8.2.4 The tests to be witnessed shall be as follows.

- a) Cruch resistance
- b) Sheave test
- c) Tensile performance
- d) Cable deformation
- e) Stress Strain
- f) Impact
- g) Conductor creep
- h) Temperature Cycle
- i) Short Circuit Current
- j) Resistance test
- k) Lightning test

8.3 Sample tests

The following sample tests shall be done:

8.3.1 on wire before stranding: in accordance with IEC 60889 and IEC 61232;

8.3.2 on the completed cable:

- a. cross-sectional area;
- b. overall
- c. surface condition;
- d. lay ratio and direction of lay; and
- e. d.c. resistance.

Factory acceptance test shall be carried out in presence of City power Personal

9 MARKING, LABELLING, PACKAGING

9.1 Marking and labelling

Each reel shall be labelled with at least one water-resistant tag that contains the following minimum information:

- a) The name of the manufacturer;

- b) The place of manufacture;
- c) The size of the OPGW and the number of fibers;
- d) The shipped length of the OPGW (standard or specified);
- e) The gross tare and net weight;
- f) The drum number;
- g) The order or the contract number (or both);
- h) The type of cable;
- i) The destination;
- j) The stock code;
- k) The words "Not to be laid flat" unless the manufacturer guarantees that the drum or reel may be laid flat without damage to the OPGW;
- l) an arrow or the words "Roll this way" to indicate the direction in which the drum or reel is to be rolled in order to prevent the OPGW from unwinding, unless the manufacturer guarantees that the drum or reel may be rolled in either direction without damage to the OPGW; and
- m) The outer end of the cable shall be accessible for testing purposes.
- n) Greased or ungreased.

9.2 Packaging

- 9.2.1 OPGW shall be supplied tightly and uniformly wound onto wooden cable reels. The supplier shall determine the optimal cable drum lengths for the OPGW installation. The purchaser will provide the correct line profiles etc., to the supplier and invite the supplier to perform a site survey if deemed necessary.
- 9.2.2 The supplier shall specify the maximum drum length of the OPGW, and the total mass of the drum including the maximum length of the OPGW cable in schedule B.
- 9.2.3 The reel shall be constructed in such a way that the OPGW will not be damaged during shipping and handling. Wooden battens shall be fitted around the periphery of the drum to ensure adequate protection. The outer layer of the OPGW on the reel shall be protected by a water-resistant wrapping over the exposed surface, to prevent ingress of moisture and dirt during shipping and handling.
- 9.2.4 Each end of the OPGW shall be properly sealed to prevent the ingress of moisture into the optical fiber unit during shipment or storage, i.e. a heat shrink end-cap shall be used for sealing.

10 DOCUMENTATION

- 10.1 Documentation shall be provided in both electronic and paper version
- 10.2 Technical product catalogue and manuals shall be provided.
- 10.3 Full detailed dimensions drawings shall be provided.
- 10.4 Copies of all type test reports and certificates shall be provided.
- 10.5 A copy of the proposed routine test certificates in English shall be provided.

11 TRAINING

- 11.1 A necessary certified training course shall be offered to relevant City Power staff. The training shall include, amongst other things, the handling, storage and installation of the OPGW.
- 11.2 The associated costs for the certified training course in 11.1 shall be given per person and shall be fixed for the period of the contract.

12 QUALITY MANAGEMENT

A Quality management system shall be set up in order to assure the quality the OPGW cables during design, development, production and servicing. Guidance on the requirements for a Quality management system may be found in the following standards: ISO 9001:2015. The details shall be subject to agreement between the purchaser and supplier.

13 HEALTH AND SAFETY

A Health and Safety plan shall be set up in order to ensure proper management and compliance of the OPGW cables during installation, operation, maintenance, and decommissioning phases. Guidance on the requirements of a Health and Safety plan may be found in ISO 45001:2018 Standards. This is to ensure that the asset conforms to standard operating procedures and City Power SHERQ Policy. The details shall be subject to agreement between City Power and the Supplier.

14 ENVIRONMENTAL MANAGEMENT

An Environmental management plan shall be set up in order to ensure the proper environmental management and compliance of the OPGW cables during their entire life cycle (i.e. during design, development, production, installation, operation and maintenance, decommissioning as well as disposal phases). Guidance on the requirements for an Environmental management system may be found in ISO 14001:2015 Standards. The details shall be subject to agreement between City Power and the Supplier. This is to ensure that the asset created conforms to Environmental standards and City Power SHEQ Policy

Annexure A - Bibliography

NONE

Annexure B - Revision information

DATE	REV. NO.	NOTES
June 2008	0	First issue
August 20018	1	Second issue
		Clause 6: Updated requirements
		Clause8: Listed type tests
		Added Clause 8.2
		Added Clause 8.3
March 2022	2	Third issue
		Update Annexure C
		Removed 6.3 duplicate

Annexure C - Technical schedules A and B

for

Overhead Ground Wire with Optical Fiber (OPGW)

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Sub-clause of CP_TSSPEC_060	Description	Schedule A	Schedule B
1	4	Name of manufacturer	XXXX	
		Place of manufacturer	XXXX	
2		Manufacturer's reference number	XXXX	
3		Service conditions		
		a) Route altitude (Above sea level) m	2000	
		b) Maximum temperature °C	50	
		c) Minimum temperature °C	-10	
		d) Maximum wind speed m/s	36	
		e) Pollution level	Very heavy	
		f) Relative humidity %	100	
4	4.3.2.2	System fault level kA	31.5	
5	5.6	Short circuit current rating @ (1s) kA	7	
6	4.2.1.2	Type of fiber carrier	ITU-T G652	
7	5.3	Earth wire strands and wire diameter mm	Required	
8	4.3.1.1	Number of fibers	48	
9	4.1.4	Conductor grease Yes/No	No	
10	4.3.1.8	Is fiber carrier gel required Yes/No	Yes	

NOTE: TICKS [✓✗], ASTERISK [*], WORD [NOTED], OR TBA [TO BE ADVISED] WILL NOT BE ACCEPTED.

Tender Number: _____

Tenderer's Authorised Signatory: _____
Name in block letters Signature

Full name of company: _____

Annexure C - Technical schedules A and B

Overhead Ground wire (OPGW) (Continues)

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Sub-clause of NRS 061-1	Description	Schedule A	Schedule B
11	4.3.2	OPGW Conductor material		
		a) Nominal cross-sectional area mm ²	Required	
		b) Actual cross-sectional area mm ²	Required	
		c) Maximum overall diameter mm	Required	
		d) Maximum mass per meter of cable Kg/m	500	
		e) Rated tensile strength (RTS) kN	Required	
12	4.3.2	Conductor material (Continues)		
		f) Initial modulus of elasticity	Required	
		g) Final modulus of elasticity	Required	
		h) Direction of lay of outer layer	Required	
		i) DC resistance at 20°C/km Ω	Required	
		j) Continuous current carrying capability A	Required	
13	4.3.2.1	Complete details of OPGW construction including measures to minimise hydrogen absorption and water ingress	Information on separate sheet	
14	4.4.1	Sample required	Required	
15	6.2.1	Wound length of OPGW m	Required	
16	10	Documentation required	Required	

NOTE: TICKS [✓✗], ASTERISK [*], WORD [NOTED], OR TBA [TO BE ADVISED] WILL NOT BE ACCEPTED.

Tender Number: _____

Tenderer's Authorised Signatory: _____
Name in block letters Signature

Full name of company: _____

**Technical schedule A and B for Overhead Ground wire (OPGW)
Deviation schedule**

Item	Proposed deviation

Tender Number: _____

Tenderer's Authorised Signatory: _____
Name in block letters Signature

Full name of company: _____

Annexure D - Stock Items

Item	SAP No.	SAP Short Description	SAP Long Description
1	4144	OPGW Fiber optic cable	OVERHEAD POWER LINES GROUND WIRE WITH OPTICAL FIBER. 7 STRANDS with 3.25mm STAINLESS STEEL WIRE. ITEM SPECIFICATION NO1. CP_TSSPEC_060