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Compiled by

DP Malan

Daniel Malan

**Mechanical Engineer
Lines Engineering Services**

Date: 14/03/2022

Approved by

Bharat Haridass

Bharat Haridass

**Senior Consultant
Lines Engineering Services**

Date: 14/03/2022

Authorized by

Faith Mokhonoana

Faith Mokhonoana

**Senior Manager (Acting)
Lines Engineering Services**

Date: 28/03/2022

Supported by SCOT/SC

Faith Mokhonoana

Faith Mokhonoana

**Overhead Lines SCOT/SC
Chairperson**

Date: 28/03/2022

Content

	Page
Executive Summary.....	3
1. Introduction.....	4
2. Supporting clauses	4
2.1 Scope	4
2.1.1 Purpose.....	4
2.1.2 Applicability	4
2.2 Normative/informative references	4
2.2.1 Normative.....	4
2.2.2 Informative	5
2.3 Definitions.....	5
2.3.1 General	5
2.3.2 Disclosure classification.....	5
2.4 Abbreviations.....	5
2.5 Roles and responsibilities	5
2.6 Process for monitoring	6
2.7 Related/supporting documents	6
3. Cable Requirements.....	6
3.1 The Joint Enclosure Encasing.....	6
3.2 The Joint Enclosure Interior	7
3.3 The Mounting “S” Bracket	8
3.4 Testing.....	8
3.4.1 Routine Tests	8
3.4.2 Type Tests	8
3.5 Environmental	13
3.6 Identification and Labelling.....	13
3.7 Packaging.....	13
3.8 Documentation	13
4. Authorization.....	14
5. Revisions	14
6. Development team	14
7. Acknowledgements	14
Annex A – Schedule A/B (Technical Particulars for Joint Enclosure)	15
Annex B – Statement of Non - Compliance.....	16

Figures

Figure 1: Test set-up for determining change in insertion loss.....	12
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Executive Summary

Fibre optic joint enclosures are devices used to encase the joints between different drums of OPGW cables. The joint boxes provide support and protection for the splicing which is required to bond the individual cores in the OPGW cables and also provide a means to optically connect different types of fibre cables such as OPGW, duct and ADSS. This document details the technical requirements for joint boxes which are to be used on Eskom power lines and outlines the testing which is to be carried out on these devices to ensure they are fit for operation.

1. Introduction

This specification provides for the manufacture, testing at works, delivery to site, off-loading and if called for, installation and testing, of fibre optic cable joint enclosures. The enclosures are required principally for use with OPGW installations, but on occasion also required to permit the use of ADSS and duct.

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

- a) This specification provides for the manufacture, testing at works, delivery to site, off-loading and if called for, installation and testing, of fibre optic joint enclosures.
- b) The following Annexures are attached to and form part of the specification:
 - 1) Annexure A: Schedule A/B (Technical Particulars)
 - 2) Annexure B: Statement of Non-Compliance

Notes:

- 1) This specification overrides any other Recommendation or Specification.
- 2) In cases of conflicting requirements, Column B to the Tender or Contract Documents only override this Specification and Schedule A/B.
- 3) Nevertheless, nothing in this specification shall lessen the obligations of the supplier detailed in any other document forming part of the contract.

2.1.2 Applicability

This specification is applicable to all Transmission and Distribution Group fibre systems.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001:2000 , Quality Management Systems
- [2] IEC 61073-1: Splices for optical fibres and cables. (ED2-94).
- [3] IEC 60068-2-6, Basic Environmental Testing Procedures: Test Fc: Vibration (Sinusoidal).
- [4] IEC 60068-2-14, Basic Environmental Testing Procedures: Test Nb: Change of Temperature with Specified Rate of Change.
- [5] IEC 60068-2-17, Basic Environmental Testing Procedures: Test Qc: Sealing Tests - Gas Leakage (Bubble Test).
- [6] IEC 60068-2-27: Basic Environmental Testing Procedures: Test Ea: Shock Test.
- [7] IEC 60794-1-2, Optical fibre cables - Part 1-2: Generic Specification – Basic Optical Cable Test Procedures
- [8] IEC 61300-2-1, Fibre Optic interconnecting devices and passive components - Basic test and measurement procedures: Tests – Vibration (Sinusoidal).
- [9] IEC 61300-2-22, Fiber Optic interconnecting devices and passive components - Basic test and measurement procedures: Tests – Change of Temperature.

- [10] IEC 61300-3-3, Examination and measurements – Monitoring change in attenuation and in return loss (multiple paths).
- [11] TST41-168, Quality assurance requirements for procurement of assets, goods and services
- [12] TST32-245, Eskom waste management procedure

2.2.2 Informative

- [13] ITU-T G.652, Characteristics of a Single Mode Optical Fibre Cable.
- [14] IEC 60793-2-10, Characteristics of a 50/125µm multimode graded index fibre optic cable
- [15] EIA/TIA 598-A, Colour Coding of Fibre Optic Cables
- [16] IEC Guide 104, Preparation of safety publications and the use of basic safety publications and group safety publications.

2.3 Definitions

2.3.1 General

Definition	Description
Eskom Transmission	A division of Eskom Holdings Limited (Reg. No. 2002/015527/06) a juristic person incorporated in terms of the company laws of the Republic of South Africa, with its registered office at Megawatt Park, Maxwell Drive, Sandton, herein referred to as Eskom.
Technical Terms	For the purpose of this specification, technical terms used shall be as defined in the documents listed in clause 2.2 (Normative and Informative References).

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
ADLash	All Dielectric Lashed Fibre Optic Cable
ADSS	All Dielectric Self-Supporting
GRP	Glass-reinforced plastic
HDPE	High Density Poly-Ethylene
OPGW	Optical Ground Wire
OTDR	Optical Time Domain Reflectometer
PMD	Polarization Mode Dispersion
UV	Ultra Violet

2.5 Roles and responsibilities

This document shall provide the guidelines which suppliers will refer to when supplying Eskom with fibre joint enclosures. As a result, all Eskom employees involved in the evaluation of suppliers' products as well as the inspection of installations on site will be responsible for the implementation of the requirements outlined in this document.

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2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

This document supersedes the previous version titled Fibre Optic Cable Joint Enclosure (TSP41-692).

3. Cable Requirements

3.1 The Joint Enclosure Encasing

The enclosure shall be made of high quality polyethylene material that is strong, non-corrosive and UV resistant. The same material shall not be used for base plate. The base plate shall be stainless steel.

The enclosure must be capable to accommodate 24 core, 48 core, 72 core and 96 core respectively.

The enclosure shall consist out of the following items:

- Polymeric Dome
- Polymeric Collar For Dome
- Base Cable Clamp Body
- Base Cable Keeper (4 cables)
- Base Cable Entry Plate
- Slack Storage Bracket
- Cable Retention Bracket
- 24 Fibre Splice Tray (up to 4 trays for 96core cables)
- Fan-Out Tray With Clear Cover
- Cable Gland (4 cables)
- Oring 4x160mm
- Cast Aluminium Clamp Bracket
- Range Adjustable Tower Clamp Up To 15mm
- Four Entry Ports To Accommodate OPGW
- Sizes From 8mm Up To 23mm With A
- Maximum 96 Fibres Splice Capacity.
- Included with the unit must be;
 - Cable Ties
 - Felt
 - Heat Shrink Tubing
 - Transition Tubing
 - Splice Protectors
 - Ferrules
 - Silicon Sealant

The enclosure shall have the following characteristics:

- a) The enclosure shall be compact and light weight, and easy to open and close without the need for specialised tools.
- b) The joint box shall allow easy fibre access during installation, maintenance and addition of the fan-out tray.
- c) If special installation tools are required, suitable tools / devices shall be specified.
- d) The base plate shall have a bracket for tower fixation or for mounting on other metal structures. This shall be a universal type, non-corrosive mounting bracket that can be clamped directly to the steelwork or via suitable stand-off insulators as required. The bracket shall be fitted with a swivel seat to prevent damage to the galvanising on the tower.
- e) The joint box shall come with a suitable mechanism for mounting the removable casing to the base.
- f) The joint enclosure shall come with a cable clamp arrangement capable of clamping up to four fibre cables. The clamps shall be adjustable for various diameters of optical cable (from 10mm to 18mm diameter), and shall be threaded to accommodate a number 0 compression gland.
- g) The base plate shall have four entry ports and shall come with two disposable plugs to temporarily protect the cable ports, and a minimum of two aluminium (or material similar to joint enclosure base) caps to seal the unused cable ports.
- h) There shall be adequate sealing between the base plate and the removable casing, and all cable entrances. This sealing shall ensure that the joint box is water-tight, pressure-tight and able to be opened when needed. The enclosure shall come with four compression glands and associated adapters.
- i) All component materials shall be non-toxic and shall not be a potential environmental hazard.
- j) If mounted on insulated earth-wire towers, a minimum clearance of 15mm shall be maintained between the joint enclosure and the structure.

3.2 The Joint Enclosure Interior

The interior of the joint box shall have the following components:

- a) An internal mounting bracket shall be provided for the splice and fan-out trays. This shall allow modular and flexible mounting of all trays.
- b) The joint box shall have an assembly with a minimum of 1 fan-out tray and multiple organiser trays for the splices required. Each tray shall serve to accommodate spare fibre length (1m to 2m) for further splicing.
- c) Each splice tray shall be able to accommodate a minimum of 12 fibres each. The trays shall be provided with a facility to secure the fibres.
- d) Four fibre optic transportation tubes shall be provided per splice organising tray.
- e) The splice and fan-out trays shall be suitable for both single and multi-mode fibres, allowing for an optical fibre minimum bending radius of 45mm in the fan-out and organiser trays.
- f) The correctly sized splice protectors shall be supplied with the splice tray.
- g) The joint box shall come with a strain relief clamping bracket which shall allow mechanical fastening of different sizes of the optical fibre cable in the enclosure, including the GRP strength member (where applicable).

3.3 The Mounting “S” Bracket

The joint box requires a mounting bracket in the shape of an “S” to enable the joint box to be installed in a vertical/upright position.

- a) Surface between the S bracket and the join must have a keyed/grooved to prevent joint from moving from its set position under vibrations.
- b) Shall be strong enough to handle the forces created by the hanging OPGW or fibre cable.

3.4 Testing

The joint enclosure shall be able to undergo traction, compression, flexure and torsion stresses acting on the splice cables, as outlined in the following paragraphs:

3.4.1 Routine Tests

3.4.1.1 Visual Appearance

This is included to ensure that no obvious defects are present that would affect product performance.

Testing shall be performed in accordance with IEC 61073-1.

The closure system and components shall be inspected for flaws, defects, pinholes, cracks or inclusions visible to the naked eye.

3.4.2 Type Tests

The mechanical and optical tests called for in this specification are considered as type tests. Eskom is prepared to review the results of similar tests which the supplier may have performed in the past and possibly waive the requirements for one or more of the tests specified in this document.

3.4.2.1 Sealing Performance (Tightness)

This is the criterion test to check the integrity of the seals both after installation and after mechanical or environmental testing. Testing shall be performed in accordance with IEC 60068-2-17 Test Qc. The tightness of installed closures shall be checked by pressurizing to 40 kPa for a period of 15 minutes while immersed in water at room temperature. A sample shall be considered tight if there is no continuous stream of air bubbles escaping from it.

3.4.2.2 Axial Tension

This test is designed to stimulate cable / closure manipulation. It specifically addresses seal performance. The enclosure shall be tested in accordance with IEC 61073-1. Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure shall be measured and recorded. The base assembly shall be clamped, and a force shall be applied to each of the extending cables individually for a period of one hour. The force per cable shall be calculated according to the equation:

$(D \text{ (cable outer diameter in mm)} / 45\text{mm}) \times 1000 \text{ N}$, with a maximum of 1000 N.

After completion of the test, internal pressure shall be checked and specimens shall be subjected to the tightness test described in this document. The cable displacement shall be less than or equal to 3 mm.

3.4.2.3 Impact Resistance

This test is included to cover the effect of falling objects (by accident), e.g. tools, etc. on the metal closure. The enclosure shall be tested as per IEC 61073. Testing shall be at room temperature.

- a) Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure will be measured and recorded.
- b) A sample shall be placed on a smooth, flat, horizontal surface with its longitudinal axis parallel to it.

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- c) A steel ball weighing 1 kg shall be suspended at a height of 2 meters above the centre of the test specimen then allowed to fall under the influence of gravity.
- d) After visual inspection with the naked eye (as described above), pressure is checked and samples shall be subjected to the tightness test described in this document.

3.4.2.4 Re-Entry

This is the criterion test to check the tightness performance of closure which will be re-entered several times during its lifetime.

- a) Testing shall be performed in accordance with IEC 61073-1.
- b) Samples shall be pressurized internally at 40 kPa regulated.
- c) Samples shall be supported in racks during testing in such a way that they are thermally isolated.
- d) There shall be free circulation of air both between specimens and between the specimens and the chamber surfaces.
- e) They shall be subjected to at least 1 cycle defined as follows:

Time	Temperature or Range
4 hrs	+20°C
1 hr	+20°C to +60°C
4 hrs	+60°C
2 hrs	+60°C to -30°C
4 hrs	-30°C
1 hr	-30°C to +20°C
4 hrs	+20°C

- f) The closures are opened, resealed and pressurized again at 40 kPa regulated and the whole sequence is repeated.
- g) In total 10 re-entries will be carried out on each test sample.
- h) After testing, samples shall be examined with the naked eye for signs of defects and subjected to the tightness test described in this document.

3.4.2.5 Shot Gun Damage

This test specifically addresses an aerial closure's resistance when shot at.

- a) Testing shall be performed in accordance with IEC 60794-1-2 Method E13.
- b) Samples shall not be pressurized.
- c) 3mm lead pellets (calibre: 12/70, Size Nr. 5) will be fired at the closure from a distance of 20 meters.
- d) After completion of the test, the closure shall be subjected to the tightness test described in this document.
- e) The closure shall be opened and checked for internal damage (visual appearance). No ammunition shall be found inside the closure.

3.4.2.6 Torsion

This test simulates cable/closure manipulation and focuses on the performance of seal integrity.

- a) Testing shall be performed in accordance with IEC 61073-1.
- b) Testing shall be done at -15°C and +45°C.
- c) Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure will be measured and recorded.
- d) Samples shall be conditioned at -15°C or +45°C.
- e) Each extending cable shall in turn be clamped rigidly at a distance of 400 mm, measured from the cable seal sleeve.
- f) The closure system shall be axially rotated through 90° and retained in that position for a period of 5 minutes. The torque applied shall not exceed 50 Nm.
- g) It shall then be returned to its original position and the procedure repeated in the opposite direction.
- h) After 5 cycles, specimens shall be examined with the naked eye (visual appearance). internal pressure is checked and then subjected to the tightness test described in this document.

3.4.2.7 Temperature Cycling

This is an accelerated ageing test designed to highlight possible material incompatibility. It is also a lifetime simulation of seal integrity. The temperature range selected covers both indoor and outdoor closure applications but may be modified to accommodate cable specifications as necessary. Testing shall be according to IEC 60068-2-14, Test Nb.

- a) For mechanical evaluation (using tightness as the criterion test) installed closure systems shall be pressurized internally at 40 kPa regulated.
- b) Samples shall be supported in racks during testing in such a way that they are thermally isolated.
- c) There shall be free circulation of air both between specimens and between the specimens and the chamber surfaces.
- d) They shall be subjected to 20 cycles defined as follows:

Time	Temperature or Range
2 hrs	-30°C to +60°C
4 hrs	+60°C
2 hrs	+60°C to -30°C
4 hrs	-30°C

- e) After testing, specimens will be subjected to the tightness test described in this document and samples shall be examined with the naked eye (visual appearance).

3.4.2.8 Vibration (Tightness)

This test simulates cable movement in the ports and tests the performance of the seals. The conditions relate to vibration caused by passing traffic.

- a) Testing shall be in accordance with IEC 60068-2-6, Test Fc.
- b) Samples shall be pressurized internally at 40 kPa regulated.
- c) The dome shall be mounted horizontally on a vibration bank while the cables shall be clamped at a distance of 500 mm from the cable seal sleeves.

- d) The closure shall be subjected to a vibration test with the following parameters:

Parameter	Value
Frequency	(10 ±1) Hz
Cycle	Sinusoidal
Amplitude	3 mm
Duration	10 days

- e) After testing, specimens shall be examined with the naked eye and then subjected to the tightness test described in this document.

3.4.2.9 Shock

This checks the effect of sudden, sharp movements during transport or closure handling. Testing shall be according to IEC 60068-2-27, Test Ea.

- a) Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure will be measured and recorded.
- b) Samples shall be strapped onto a vibration bank and subjected to 3 shocks in each direction (up and down) for 3 mutually perpendicular axes.
- c) Shocks shall have a half-sine waveform and an acceleration of 150 m/s² and a duration of 11 ms.
- d) After the test, samples shall be examined with the naked eye (visual appearance), and then be subjected to the pressure loss test and the tightness test described in this document.

3.4.2.10 Vibration

- a) This vibration test highlights possible problems caused by resonance effects. The effect on fibre and splice storage is checked. The conditions relate to vibration caused by passing traffic.
- b) Testing shall be in accordance with IEC 61300-2-1.
- c) The optical test sample shall be built as described in this document.
- d) The optical circuit will be connected to optical transient test equipment as described in this document.
- e) The closure shall be mounted on a vibration bank and shall be subjected to a sweep range of 5-500 Hz at 1 octave/minute with the following parameters:

Parameter	Value
Crossover frequency	9 Hz
Amplitude below 9 Hz	3.5 mm
Acceleration above 9 Hz	10 m/s ² (~ 1 g)

- f) The test shall be repeated for each of 3 mutually perpendicular axes, for a total of 10 cycles per axis.
- g) During and after the test the optical signal will be monitored for transient optical losses. After completion of the test specimens shall be examined with the unaided eye for damage that would impair product functionality.

3.4.2.11 Temperature Cycling

This is a lifetime simulation of optical performance. The temperature range selected covers both indoor and outdoor closure applications but may need to be modified (to less severe extremes) to accommodate cable specifications as necessary.

- a) The optical test samples shall be built as described in this document.
- b) The circuit of the test sample will be connected to optical test equipment.
- c) Temperature cycling test shall be according to IEC 61300-2-22.
- d) Samples for optical evaluation are sealed but not pressurized.
- e) Samples shall be supported in racks during testing in such a way that they are thermally isolated, and there shall be free circulation of air both between specimens and between the specimens and the chamber surfaces.
- f) They shall be subjected to 20 cycles defined as follows:

Time (in hrs)	Temperature or Range (°C)
2	-30 to +60
4	+60
2	+60 to -30
4	-30

- g) The change in optical signal during and after the test is checked for each circuit.
- h) After the test, samples shall be examined with the naked eye (visual appearance).

3.4.2.12 Change in Insertion Loss

This is the criterion test for optical measurements during and after the test. The value quoted assumes the use of a stable qualified splice/protector, well installed. Testing shall be performed in accordance with IEC61300-3-3 Method 1. This is defined as a measured attenuation which is exhibited by stable transmission measurements taken before, during and after a test. It shall be measured using an optical source and a detector operating at 1310 nm and 1550 nm. The test set-up is shown below in figure 2:

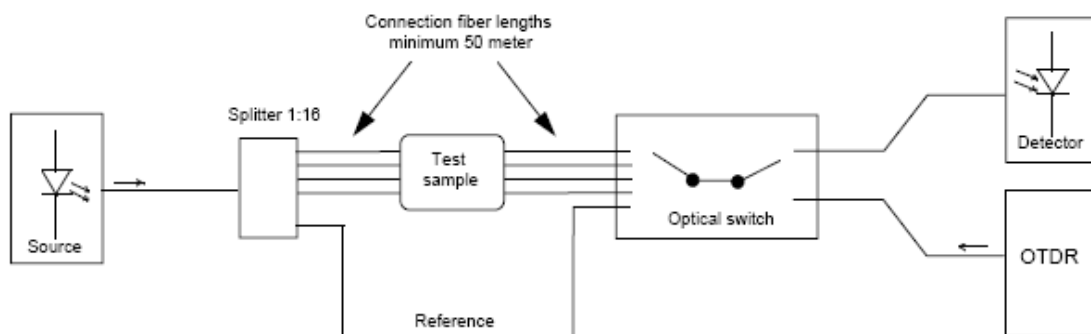


Figure 1: Test set-up for determining change in insertion loss

- a) The in and out-going fibres of each circuit are spliced onto the connection fibres of the equipment. Splices shall be made using good-quality fusion splices.
- b) During the test the optical signal in each fibre of the fibre circuit shall be monitored with the light source and detector at both wavelengths.
- c) A change of more than 0.2 dB per incoming fibre (during the test) from the initial value constitutes a failure.
- d) A change of more than 0.1 dB per incoming fibre (after the test) from the initial value constitutes a failure.

Note: The abovementioned loss criteria are per incoming fibre. Since one circuit can contain several incoming fibres it is possible that the total circuit generates higher losses. In this case the loss contribution per incoming fibre needs to be checked. This can be done using an OTDR or by reducing the number of incoming fibres per circuit.

3.4.2.13 Ultra Violet (UV) Test

All relevant ultra violet tests shall be produced. The material shall be HDPE UV stabilised.

3.5 Environmental

The performance of the fibre optic enclosure shall not be degraded under the following ambient conditions:

- a) Temperature : -10° to 50°C
- b) Altitude : 0 to 2500 metres (ASL)
- c) Relative Humidity : 100%
- d) Barometric Pressure : 76 - 104 kPa

IEC Guide 104 should be taken into account as far as possible in regard to environmental and product safety requirements. If requested the manufacturer shall provide details on the environmental impact of the cable. Waste resulting from fibre joints and off-cuts shall be disposed in accordance with TST 32-245.

3.6 Identification and Labelling

The following information shall be clearly marked on the cable joint box:

- a) The marking must be permanent (name of manufacturer).
- b) Electrical Hazard Marker such as a Lightning flash or the traditional skull and bones logo.
- c) Date of manufacture.
- d) Laser radiation warning sticker.

3.7 Packaging

The joint box shall be packaged such that it incurs no damage during shipping and handling.

The additional enclosure components shall be sealed and packaged within the overall packaging. Each package shall be labelled to outline what is contained inside.

3.8 Documentation

- a) Upon request the supplier shall supply one copy of the type test report.
- b) On delivery of the enclosure, the supplier shall supply installation guidelines with each joint box.
- c) All documentation called for shall be provided in soft copy which comply with the following requirements:
 - Supplied in English.
 - A4 Paper Size.
- d) Any drawings and descriptions included shall conform to the A4 series (295mm x 220mm).
- e) The documentation shall include the following:
 - Index.
 - Manufacturer's specification sheet, including details of the joint box construction.
 - Test Certificates for tests done in compliance with clause 3.3.

The manufacturer shall supply this, together with full installation instructions, to the project manager.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Vanessa Naidu	Senior Engineer
Lesiba Buthane	Dx TCM

5. Revisions

Date	Rev	Compiler	Remarks
March 2022	2	D Malan)	Change from metallic dome enclosure to plastic one
Sept 2016	1	Hussain Khan	Information from old document has been included in this updated template.

6. Development team

The following people were involved in the development of this document:

- Hussain Khan
- Bharat Haridass
- Vanessa Naidu
- Daniel Malan

7. Acknowledgements

Not applicable.

Annex A – Schedule A/B (Technical Particulars for Joint Enclosure)

DESCRIPTION	COLUMN A PARTICULARS OF ESKOM'S REQUIREMENTS	COLUMN B GUARANTEED TECHNICAL PARTICULARS OFFERED	REMARKS
1) Joint enclosure dimensions (mm) (Section 3.1)	Specify		
2) Weight of joint box (g) (Section 3.1)	Specify		
3) Type of material used: • Enclosure • Mounting Brackets • Cable clamps • Base plate (Section 3.1)	Specify		
4) Mounting brackets universal? (Section 3.1)	Yes		
5) Specialised installation tools required? (Section 3.1)	Specify		
6) Installation guidelines supplied with enclosure? (Section 3.7)	Yes		
7) Maximum capacity (Section 3.1)	4 cables		
8) Fibre fan-out tray bending radius (Section 3.2)	45mm		
9) Retained fibre length (Section 3.2)	1m to 2m		
10) Cable clamps entry adjustable (Section 3.1)	Yes		
11) Type test results available? (Section 3.7)	Yes / No		
12) If not available, by when?	Specify		
13) Applicable temperature range?	Specify		

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Annex B – Statement of Non - Compliance

The equipment supplied on this contract complies in all respects with the requirements of the specification and Schedule A/B with the exception of the following points:

Page	Paragraph	Deviation or Non-Compliance