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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Optical fibre cables – Cable structure and characteristics

Optical fibre cables for in-home applications

Recommendation ITU-T L.111

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.111

Optical fibre cables for in-home applications

Summary

Recommendation ITU-T L.111 aims to provide the requirements of optical fibre cables for in-home applications. Compared to requirements of optical fibre cables in traditional "indoor" applications, the requirements of cables in "in-home" applications have their own specialized characteristics. This Recommendation describes characteristics, cable construction and test methods of optical cables with minimum visibility for in-home applications.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.111	2020-10-29	15	11.1002/1000/14514

Keywords

FTTH, ILU, in-home, MDU, minimum visibility.

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Introduction

In recent years, fibre to the home (FTTH) has been developing rapidly in many areas of the world. More and more homes have been accessed by the optical network instead of the copper wire network. With this background, a new type of optical fibre cable application environment, which can be called "in-home applications" has emerged. The "in-home" applications particularly refer to optical fibre cable applications inside household living spaces that are also referred to as "indoor living units" (ILU). These new applications are significant for the further development of FTTH, fibre to the room (FTTR) and fibre to the desk (FTTD).

Recommendation ITU-T L.111

Optical fibre cables for in-home applications

1 Scope

This Recommendation:

– refers to optical fibre cables with minimum visibility to be used for telecommunications access networks in the household living spaces of end users;

– covers mechanical and environmental characteristics of optical fibre cable for in-home applications;

– focuses on characteristics of the optical fibre cables that are related to in-home environment harmonization.

The optical fibre cables described in [ITU-T L.103], [ITU-T L.104] and [ITU-T L.105] may also be used in relevant environments, which are not included in this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.657] Recommendation ITU-T G.657 (2016), *Characteristics of a bending-loss insensitive single-mode optical fibre and cable*.

[ITU-T L.103] Recommendation ITU-T L.103 (2016), *Optical fibre cables for indoor applications.*

[ITU-T L.104] Recommendation ITU-T L.104/L.67 (2006), *Small count optical fibre cables for indoor applications*.

[ITU-T L.105] Recommendation ITU-T L.105/L.87 (2010), *Optical fibre cables for drop applications*.

[ITU-T L.404] Recommendation ITU-T L.404 (2017), *Field mountable single-mode optical fibre connectors*.

[IEC 60793-1-1] IEC 60793-1-1:2017, *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance.*

[IEC 60793-1-21] IEC 60793-1-21:2001, *Optical fibres – Part 1-21: Measurement methods and test procedures – Coating geometry*.

[IEC 60793-1-31] IEC 60793-1-31:2019, *Optical fibres – Part 1-31: Measurement methods and test procedures – Tensile strength.*

[IEC 60793-1-32] IEC 60793-1-32:2018, *Optical fibres – Part 1-32: Measurement methods and test procedures – Coating strippability*.

[IEC 60793-2-50] IEC 60793-2-50:2018, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*.

[IEC 60794-1-1] IEC 60794-1-1:2015, *Optical fibre cables – Part 1-1: Generic specification – General*.

[IEC 60794-1-2] IEC 60794-1-2:2017, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures – General guidance*.

[IEC 60794-1-21] IEC 60794-1-21:2015, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods.*

[IEC 60794-1-22] IEC 60794-1-22:2017, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test methods*.

[IEC 60794-2] IEC 60794-2:2017, *Optical fibre cables – Part 2: Indoor cables – Sectional specification.*

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

FDH Fibre Distribution Hub

FR Flame Retardant

FTTD Fibre to The Desk

FTTH Fibre to The Home

FTTR Fibre to The Room

ILU Indoor Living Unit

LSZH Low Smoke Zero Halogen

MDU Multi-dwelling Unit

NID Network Interface Device

POE Point Of Entry

SFU Single Family Unit

5 Conventions

None.

6 Characteristics of optical fibres and cables

6.1 Optical characteristics

6.1.1 Transmission characteristics

The typical transmission characteristics are described in the appropriate Recommendations. Unless specified otherwise by the users of the Recommendations, optical fibres and transmission characteristics should comply with [ITU-T G.657].

6.1.2 Fibre microbending

Extreme bending of an optical fibre, involving local axial displacement of a few micrometres over short distances caused by localized lateral forces along its length, is called microbending. This may be caused in cabled fibres by manufacturing and installation strains, as well as dimensional variations of cable materials due to temperature changes during operation. Microbending can cause an increase in optical loss. In order to reduce microbending loss, stresses randomly applied to a fibre along its axis should be minimized during the incorporation of the fibres into the cable, as well as during and after cable installation.

6.1.3 Fibre macrobending

Macrobending is the curvature of an optical fibre resulting after cable manufacturing and installation. Macrobending may cause an increase in optical loss. Optical loss increases if the bending radius is too small.

6.2 Mechanical characteristics

6.2.1 Bending

Cable bending during installation and operation may impose strain on fibres. This may affect fibres strength and lifetime and cause increased losses. Therefore, when designing cables and accessories for installation, the cable bending radius should be kept large enough to avoid damage to the fibre and excessive losses. When installed in and into household living spaces, the cables may have numerous bends with small radius. The minimum cable bending radius and the number of turns should be designed to minimize cable loss and maintain mechanical fibre reliability, which is ensured in accordance with operators' policy, see [b-ITU-T G-Sup.59] for further information.

The bending test should be performed according to Annex A.

6.2.2 Tensile strength

Optical fibre cable is subjected to short-term loading during manufacture and installation and may be affected by continuous static loading and/or cyclic loading during operation (e.g., temperature variation). Proper installation methods should be used to reduce tensile forces on optical fibre cables during installation and operation. With proper installations, the tensile forces applied on cables for in-home applications can be sufficiently small, and the cables may need not to have intentional strength members. In this condition, the fibres may temporarily bear most of the applied forces during the installation, and care should be taken to avoid fibre damage during installation. Fibre reliability should also be considered, see [b-ITU-T G-Sup.59] for further information.

The tensile strength test should be performed according to Annex A.

6.2.3 Torsion

Under the dynamic conditions encountered during installation and operation, the cable may be subjected to torsion, resulting in residual strain in the fibres and/or sheath damage. The cable design should allow a specified number of cable twists per unit length without exceeding a level of specific limits for loss increase and/or any damage to the cable.

The torsion test should be performed according to Annex A.

6.2.4 Crush

The cable may be subjected to crush during its installation and operational life. This crush may increase optical loss (permanently or for the duration of crush applied) and excessive stress may break the fibre. The optical fibre cables for in-home applications may not have a sufficient protection layer for minimum visibility.

Proper pathways in the living space should be chosen to install the optical cable to reduce the chance of crush during its lifetime.

The crush test should be performed according to Annex A.

6.2.5 Impact

The cable may be subjected to impact during its installation and operational life. This impact may increase optical loss (permanently or for the duration of the impact applied) and excessive stress may break the fibre. Optical fibre cables for in-home applications may not have a sufficient protection layer for minimum visibility.

Proper pathways in the living space should be chosen to install the optical cable to reduce the chance of impact during its lifetime. A small impact may leave an imprint in the cable sheath without causing excess loss. However, the integrity of the cable sheath should not be compromised.

The impact test should be performed according to Annex A.

6.2.6 Kink

The cable may be subjected to kink during installation. The kink test should be performed according to Annex A.

6.2.7 Vibration

The possibility of vibration for the in-home environment may be neglected. If the vibration is considered, cables should be able to withstand these vibrations without failure or signal degradation. Care should be exercised in the choice of installation method.

6.3 Environmental characteristics

6.3.1 Temperature variations

When the cable is subjected to temperature variations for operation, the increase in fibre attenuation should not exceed the specified limits. The environmental conditions experienced by optical fibre cables for in-home applications are weather-protected, and partly temperature-controlled. The normal temperature range shown in Table 1 should be considered.

The conditions may differ depending on the users' environment. The locations of connections between in-home cables and other cables may be placed in uncontrolled environments such as corridors and outside passages. In such cases, the extended temperature range should be agreed between the customers and manufacturers.

Testing of the response to temperature variations should be performed according to Annex A.

Table 1 – Temperature variations of optical fibre cable for in-home applications

Temperature range (°C)	
Lower temperature (T_A)	**Higher temperature (T_B)**
−10	+60

6.3.2 Biotic damage

The cable may be subjected to rodent attack during operational life. Rodent attack may cause fibre fracture. The optical fibre cables for in-home applications may not have a sufficient anti-rodent protection layer for minimum visibility. Proper pathways in the living space should be chosen to install the optical cable and reduce the chance of rodent attack during its lifetime.

6.3.3 Fire safety

Fire safety is an important problem in homes. There are two major issues. The first is that the cables and cable elements should be difficult to burn. In other words, the cables and cable elements should have flame retardant characteristics. The second is that the cables and cable elements should not generate toxic gases or smoke when burning. Fire performance requirements may differ from country to country. Optical cables for in-home applications should meet fire safety regulations in each country and in accordance with each telecommunication carrier.

7 Cable construction

7.1 Fibre coatings

7.1.1 Primary coating

For harmonization with in-home environments, the primary coating is recommended to be colourless (transparent).

Primary-coated fibres should comply with relevant optical fibre specifications in [IEC 60793-2-50].

7.1.2 Secondary coating

If a secondary coating is used, it should comply with the requirements given in [IEC 60794-2]. For in-home applications, the secondary coating can be the outmost protection layer of the optical fibre cable. For harmonization with in-home environments, the secondary coating is recommended to be uncoloured or a colour which is neutral in order to blend into the building interior.

NOTE – The mechanical characteristics should be considered under the conditions of fibre splicing, installation and assembling field mountable connectors [ITU-T L.404] using secondary coating to avoid high fibre stress.

7.2 Cable element

The optical fibre cables for in-home applications may or may not have cable elements such as tubes, strength members and sheaths for minimum visibility. If cable elements are used for their protection and for packaging more than one fibre, the cable construction and materials should be agreed between the customer and manufacturer.

7.3 Limitation of hazardous substances in materials

Cable materials for in-home applications as well as cable attaching materials to the wall should be non-noxious and harmless to human health. Restriction on hazardous substances may differ from country to country. Optical cables for in-home applications should meet hazardous substances regulations in each country and in accordance with each telecommunication carrier.

7.4 Cable visibility

The cable construction, materials used and installation accessories should make the cable have minimum visibility for harmonization with the in-home environment. Any specific requirements or testing methods for the aspect/colour should be agreed between the customers and manufacturers.

7.5 Identification of cable

Optical fibre cables for in-home applications may or may not provide a visual identification of optical fibre cables for minimum visibility. If necessary, appropriate ways for identification of cables should be agreed between the customers and manufacturers.

Annex A

Test methods and criteria

(This annex forms an integral part of this Recommendation.)

Test methods require consideration of the general and guidance documents, [IEC 60793-1-1], [IEC 60794-1-1] and [IEC 60794-1-2].

Test methods and criteria stated herein should be used to assess conformance in the tests, unless a different agreement has been established between the manufacturer and customer.

A.1 Tests applicable to cable element

Table A.1 lists test methods for cable elements.

Table A.1 – Test methods for cable elements

Test method	Description	Criteria
Dimension [IEC 60793-1-21]	7.1 and 7.2	See [IEC 60793-2-50] for optical fibres.
Coating strippability [IEC 60793-1-32]	7.1 and 7.2	Striping length: 15 mm, stripping force: 5~18 N (if the primary and secondary coating are removed together.)

A.2 Tests applicable to cable

Table A.2 lists test methods for mechanical characteristics.

Table A.2 – Test methods for mechanical characteristics

Test method	Description	Criteria
Cable bending [IEC 60794-1-21] method E11A	6.2.1	Number of turns in the helix: 4. Mandrel diameter: minimum bend diameter (see clause 6.2.1) +10%. Test temperature: −10 °C. Maximum attenuation change: 0.20 dB during the test, no change after the test at 1550 nm. No fibre and cable breakage.
Tensile strength [IEC 60794-1-21] method E1	6.2.2	Length under test: 0.5 m. Test equipment per [IEC 60793-1-31] with mandrel diameter per clause 6.2.1. Test loads: rated tensile load, TS = 5 N, long term load, TL = 30% of TS. Attenuation change: no change at 1550 nm No fibre and cable breakage.
Torsion [IEC 60794-1-21] method E7	6.2.3	Test gauge length: 0.5 m. Tensioning: minimum tension; support the specimen as needed. Test temperature: expanded ambient per [IEC 60794-1-1]. Attenuation change: no change at 1550 nm No fibre and cable breakage.

Table A.2 – Test methods for mechanical characteristics

Test method	Description	Criteria
Crush [IEC 60794-1-21] method E3	6.2.4	Compressive force: 490 N/100 mm. Compression time: 1 min. Attenuation change: 0.20 dB under the load, no change after test at 1550 nm. No fibre and cable breakage.
Impact [IEC 60794-1-21] method E4	6.2.5	Impact energy: 0.3 kg at 0.1 m height. Hammer: flat hammer. Number/location of impacts: 3 places separated at least 0.5 m, 1 impact at each place. Maximum attenuation change: no change after the test at 1550 nm. No fibre and cable breakage, imprint on cable could be compromised.
Kink [IEC 60794-1-21] method E10	6.2.6	Minimum bend diameter: per clause 6.2.1. No kink and fibre/cable breakage.
Vibration (optional)	6.2.7	For further study.
Repeated bending [IEC 60794-1-21] method E6	6.2.1	Number of cycles: 10. Tensioning: minimum tension; support the specimen as needed. Bending radius: per clause 6.2.1. Maximum attenuation change: no change after the test at 1550 nm. No fibre and cable breakage.

Table A.3 list test methods for environmental characteristics.

Table A.3 – Test methods for environmental characteristics

Test method	Description	Criteria
Temperature cycling [IEC 60794-1-22] method F1	6.3.1	Sample test length: appropriate to achieve the desired accuracy of attenuation measurement. Test temperatures: T_A, T_B in Table 1. Number of cycles: 2. Attenuation change at 1550 nm: $\leq$ 0.10 dB/km at T_A, T_B, no change after the test at 1550 nm.
Fire safety [b-IEC TR62222]	6.3.3	Specified according to the unique condition of each country. (if no fire safety specifications are provided, see [b-IEC TR62222].)
Ageing (optional) [IEC 60794-1-22] method F9		For further study.

Appendix I

Test method for robustness of in-home cable attached to the wall surface

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction

The purpose of this appendix is to introduce a test method to determine the robustness of in-home cable attached to the wall surface in conjunction with the performance of the installation method or accessories. The test method includes temperature cycle and damp heat.

I.2 Test sample

The sample should be attached to a plate by using the installation method and/or installation accessories that will be used, the length of the sample under test should be 500 mm. The plate should be made of materials that represent a wall, and this might be a composite wood or cement wall with an appropriate surface treatment. A load of 3 N should be applied to the sample. The sample configuration is shown in Figure I.1. The sample-wall assembly should be pre-treated at 20 ± 5 °C for 24 hours.

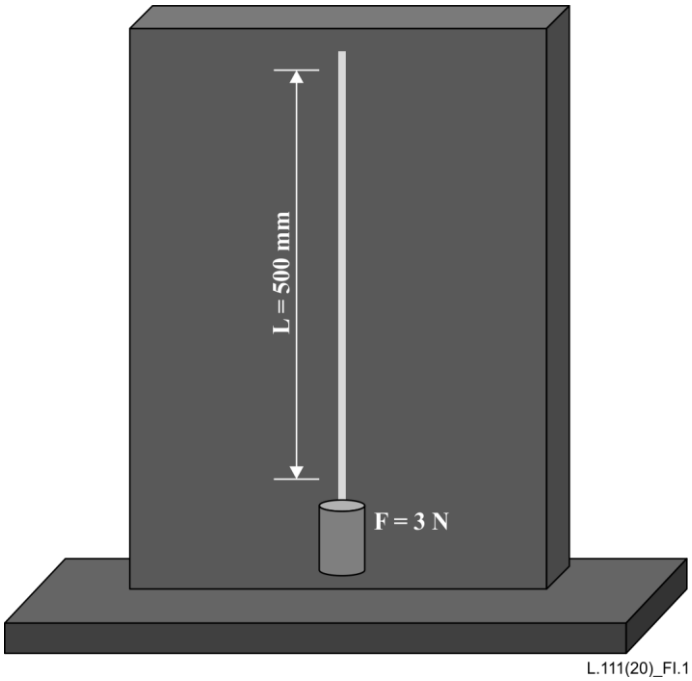

Figure I.1 – Test sample configuration

I.3 Test condition and criteria

The test conditions are listed in Table I.1. There are three test samples. No samples should fall off the wall.

Table I.1 – Test conditions

Test	Conditions
Temperature cycle [IEC 60794-1-22] method F1	Temperature: see clause 6.3.1 Holding time: No less than 8 hours 2 cycles
Damp heat [b-IEC 60793-1-50]	Temperature: 40 ℃±2 ℃ Relative humidity: 95% Time: 96 h

Appendix II

Chinese experience on test method for flame retardant of in-home cable attached to the wall surface

(This appendix does not form an integral part of this Recommendation.)

II.1 Introduction

This test method is used for flame retardant evaluation of in-home cables when attached to the wall surface.

II.2 Apparatus

See [b-IEC 60332-1-1].

II.3 Procedures

II.3.1 Sample configuration

The cable length is 600 ± 25 mm. The cable is attached to the middle of a plate. The plate should be made by materials that represent the wall, it might be a composite wood or cement wall with a latex paint surface treatment. The length of the plate is 600 mm and the width is 30 mm. The schematic diagram of the sample is shown in Figure II.1.

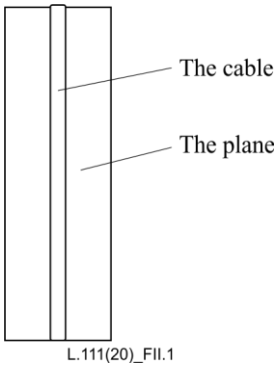

Figure II.1 – The schematic diagram of the sample (not the scale)

II.3.2 Pre-treatment

The sample-wall assembly should be pre-treated at a temperature of 23 ± 5 °C and the relative humidity of (50 ± 20)% for at least 16 hours.

II.3.3 Installation

The sample-wall assembly is fixed on two horizontal supports and it is placed vertically in the middle of the metal cover as described in [b-IEC 60332-1-1]. The distance between the lower edge of the upper support and the upper edge of the lower support should be (550 ± 5) mm. In addition, the sample should be fixed at a height, where the distance between the bottom of the sample cable end and the bottom of the metal cover should be about 50 mm as in Figure 1 of [b-IEC 60332-1-2].

The vertical axis of the sample should be in the middle of the metal cover.

II.3.4 Fire requirement

It should meet the requirements in [b-IEC 60332-1-2].

II.4 Test results evaluation

It could be in accordance with Annex A of [b-IEC 60332-1-2].

Appendix III

Chinese experience on in-home cable specifications and applications

(This appendix does not form an integral part of this Recommendation.)

This appendix mainly introduces the in-home cable specifications and applications used in China FTTH deployment.

III.1 Schematic diagram of typical structure of in-home cable

The typical structure of in-home cable is illustrated in Figure III.1.

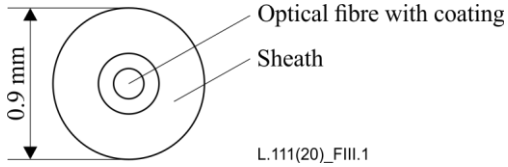

Figure III.1 – In-home cable

The typical structure of two bow-type drop cables with in-home cable inside used in China FTTH application are shown in Figure III.2.

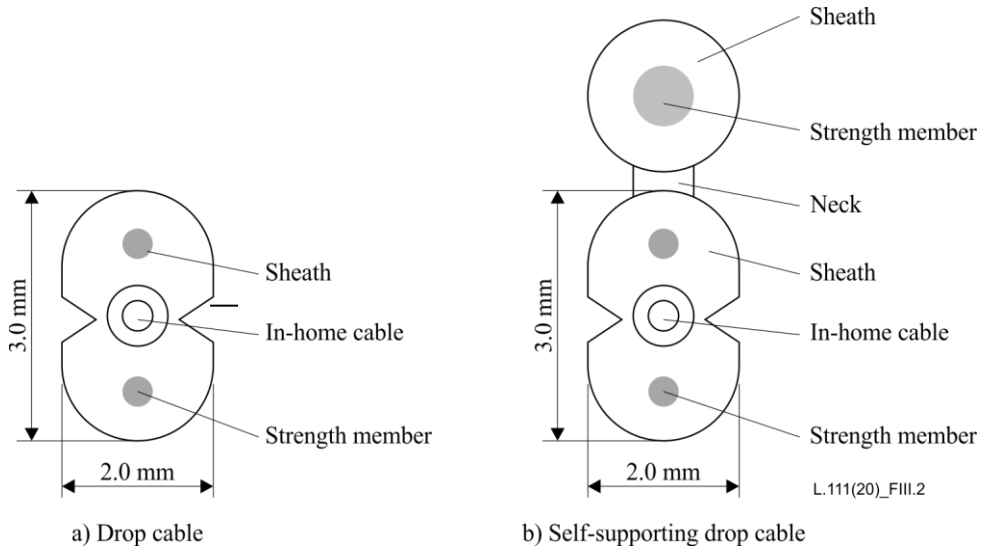

Figure III.2 – Bow-type drop cables with in-home cable inside

III.2 Fibre classification

These two types are recommended for in-home optical fibre cable.

– ITU-T G.657.A2: Bending loss insensitive single-mode fibre;

– ITU-T G.657.B3: Bending loss insensitive single-mode fibre B3.

III.3 Specifications of in-home cable

The technical data sheet of cables is given in Table III.1.

Table III.1 – Specification of bow-type drop cable and in-home cable

	Size	Weight	Colour	Allowable short term tensile force (N)	Allowable crush force		Minimum bending radius		Attenuation	
					Long term /(N/100 mm)	Short term /(N/100 mm)	Dynamic	Static	1310 nm	1550 nm
In-home cable	0.9 mm (±0.05 mm)	1 kg/ km	Clear	10	300	1000	15 mm	7.5 mm	≤0.4 dB/km	≤0.25 dB/km
Drop cable with in-home cable inside	2.0 mm*3.0m m (±0.10 mm)	10 kg/ km	Black/white or cream-colored	200	1000	2200	20 mm	10 mm		
Storage temperature	−5 ℃ ~ +50 ℃									
Operating temperature	−10 ℃ ~ +50 ℃									

III.4 Accessories

For in-home cable installation, glue can be used to fix the cable to the wall surface. Figure III.3 are types of glue accessory to attach the in-home cable. The first (a) is cold gel, the second is a glue stick with the tool used to melt the glue stick.

a) Cold gel b) Glue stick c) Glue tool

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Figure III.3 – Types of glue accessory

In order to protect the fibre bending, special accessories for fixing cable at a corner are used. Figure III.4 shows typical accessories.

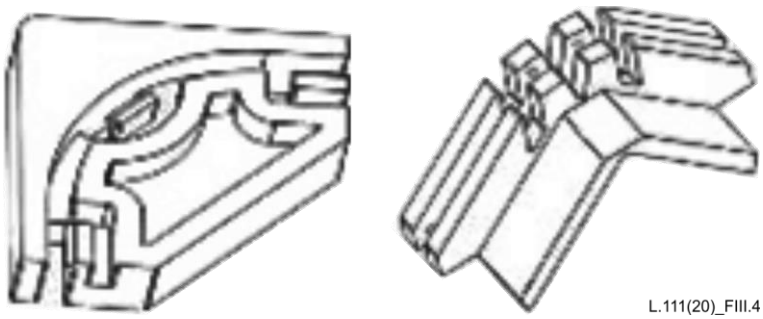

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Figure III.4 – Types of accessories for a corner

III.5 Example of in-home applications

III.5.1 Solution 1- Traditional drop cable and in-home cable

The FTTH solution to traditional drop cable and in-home cable is shown in Figure III.5. The traditional drop cable and in-home cable need to be connected via splicing.

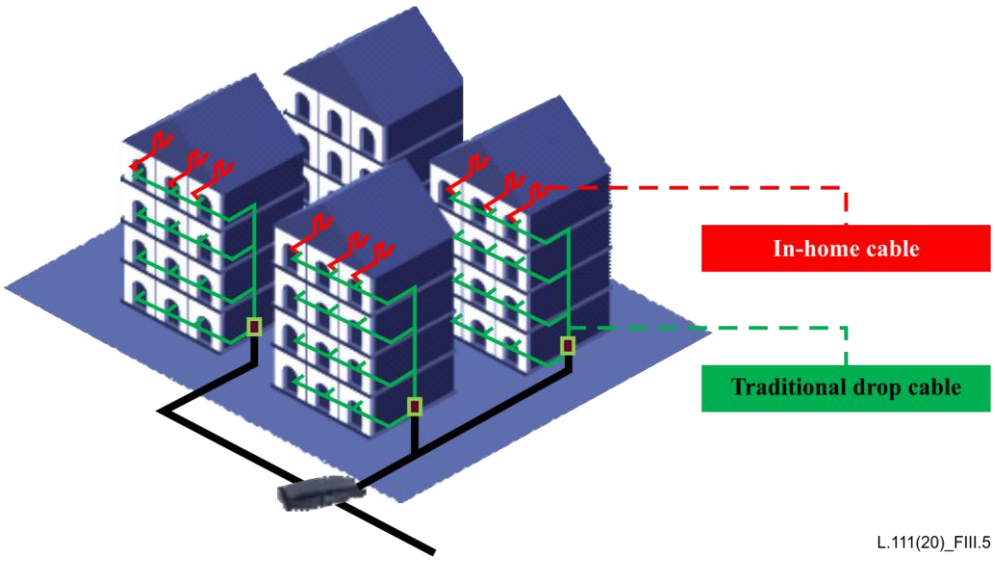


Figure III.5 – FTTH solution for traditional drop cable and in-home cable

1) Step 1: Introduce the traditional drop cable to home

Introduce the drop cable from the fibre distribution box in the corridor to the home information box through the reserved pathways, see Figure III.6.

Figure III.6 – Introducing the drop cable to home

2) Step 2: Splice the in-home cable with drop cable which is introduced to home information box, see Figure III.7.

Figure III.7 – Splicing the in-home cable with the drop cable

3) Step 3: Lay the in-home cable along the door and corner as shown in Figure III.8.

Figure III.8 – Installation of the in-home cable (indicated by orange line)

III.5.2 Solution 2- Drop cable with in-home cable inside

The FTTH solution to the drop cable with in-home cable inside (continuous cable with no splice) is shown in Figure III.9.

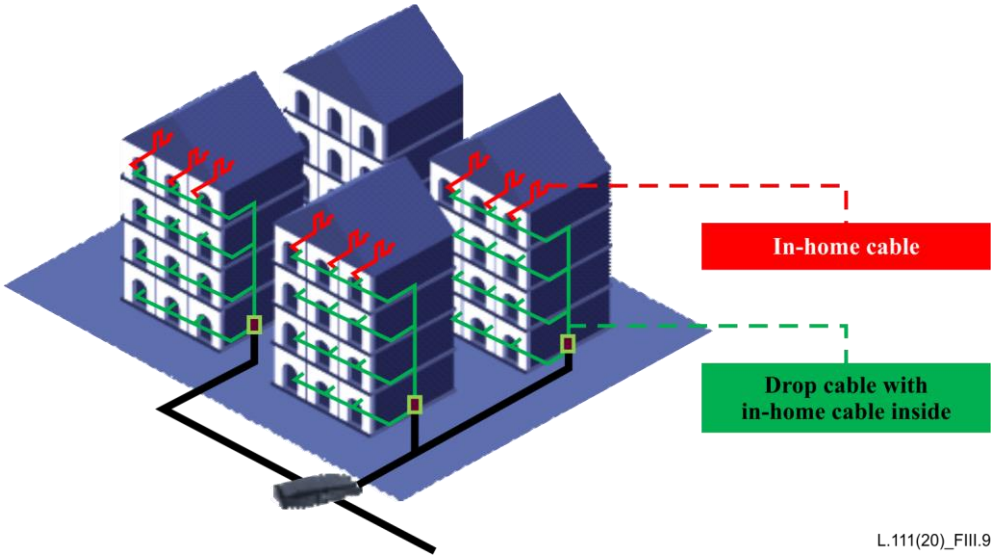


Figure III.9 – FTTH solution for drop cable with in-home cable inside

1) Step1: Introduce the bow-type drop cable from the corridor junction box into the indoor information box by reserving pipeline, reserve the indoor laying length (20 m for example), see Figure III.10.

Figure III.10 – Introducing the bow-type drop cable with in-home cable inside to home

2) Step 2: Peel off the reinforcing members and sheath on both sides of the bow-type drop cable, and keep the in-home cable in the middle, see Figure III.11.

Figure III.11 – Separate the in-home cable from the bow-type drop cable

3) Step3: Reserve the in-home cable after peeling off the reinforcement. The cable adhesive is evenly covered on the in-home cable using a cable applicator, and is laid along the wall corner and skirting.

Figure III.12 – Installation of the in-home cable with glue

Appendix IV

Japanese experience on in-home cable installation for minimum visibility

(This appendix does not form an integral part of this Recommendation.)

IV.1 Introduction

One of the major problems with FTTx service activation is the lack of ducts for fibre installation. In such cases, exposed cable installations are adopted. However, there are some cases where cable installation with traditional indoor or drop cables does not meet customers' requirements due to the appearance and/or the impact on walls. The in-home cable is deployed in such cases only when customers understand that in-home cable is less robust than traditional cables.

This appendix introduces in-home cable installation in conjunction with accessories used in Japan.

IV.1 Cable construction

In-home cable is composed of a single optical fibre that complies with [ITU-T G.657] category B3 and a 0.9 mm tight-buffered transparent layer, while traditional indoor and drop cables are composed of a rectangular-shaped coloured sheath and tension members as shown in Figure IV.1. The appearance of an in-home cable, a drop cable and an indoor cable are shown in Figure IV.2.

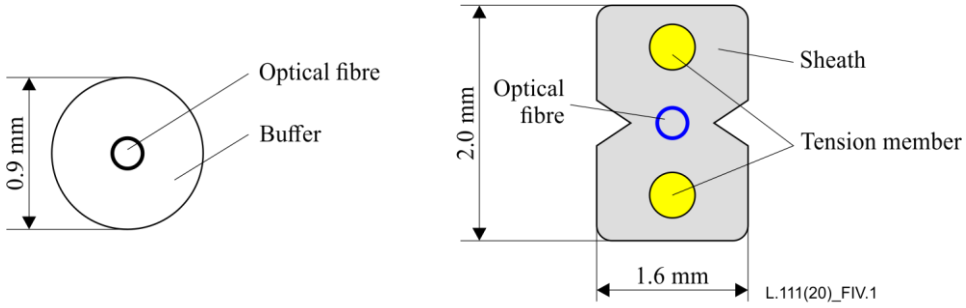


Figure IV.1 – Cable construction; (a) in-home cable and (b) indoor and drop cable

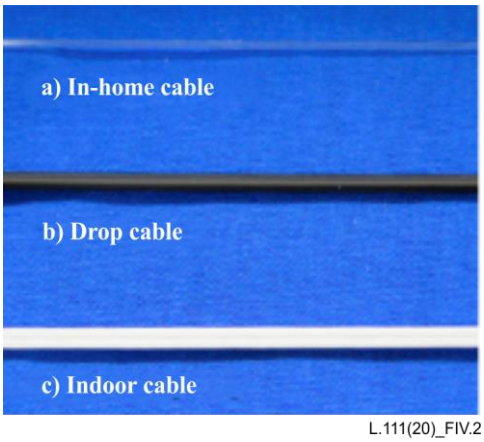


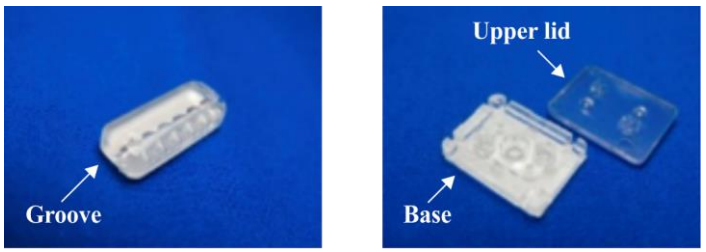
Figure IV.2 – Cable appearance; (a) in-home cable, (b) drop cable and (c) indoor cable

IV.2 Installation accessories

IV.2.1 Overview

Figures IV.3 and IV.4 show accessories for in-home cable installation on customers' premises. All the accessories are transparent for environmental harmonization. They can be fixed to the wall with

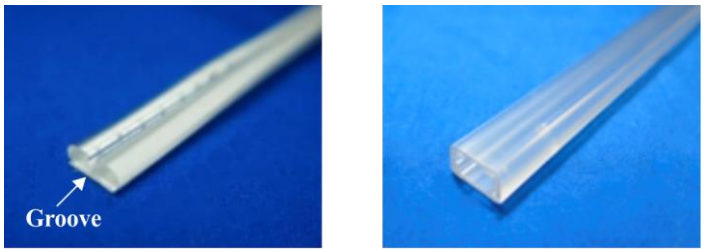
adhesive tape. The multiple staple-type accessories shown in Figure IV.3 (b) can also be fixed to various types of walls with screws or pins as appropriate (for example, see Figure IV.6). The in-home cable is fixed in place with a push-in groove using a simple tool. All the accessories are designed to avoid any adhesion between the in-home cable and the wall surface to reduce any impact on the walls.



a) Simplex b) Multiple types

L.111(20)_FIV.3

Figure IV.3 – Staple-type accessories for in-home cable installation: (a) simplex and (b) multiple types



a) Simplex b) Multiple types

L.111(20)_FIV.4

Figure IV.4 – Protector-type accessories for in-home cable installation: (a) simplex and (b) multiple types

IV.2.2 Test methods for installation accessories

1) Fixing force of in-home cable

Sample: in-home cable mounted with accessory

Number of samples: 5

Tensile force applied to in-home cable: 3 N, 1 min

No samples became demounted from the accessory.

2) Adhesive force of accessories

Sample: Accessory affixed to stainless plate

Number of samples: 5

Temperature: 23 ± 2 ℃, 40 ± 2 ℃, −10 ± 2 ℃

Shear force applied to the sample: 5 N, 1 min

No samples detached from the stainless plate.

3) Heat shock

Sample: Accessory affixed to stainless plate

Number of samples: 5

Temperature cycle: −30 ℃ to 70 ℃, 3-6 cycle/24 hour

Number of cycles: 200

Shear force (5 N, 1 min) is applied to the sample after the test. No samples detached from the stainless plate.

IV.3 Installation examples

The in-home cable can be installed with minimum visibility in the same areas in customers' premises where traditional indoor and drop cables are deployed as shown in Figures IV.5 and IV.6. It can also be used to introduce a fibre into a room through the small gap around the door (see Figure IV.7).

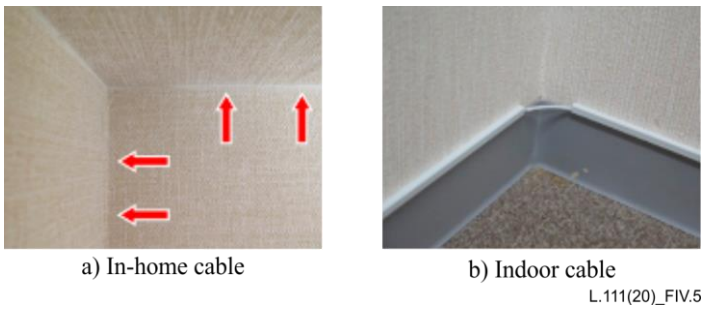


Figure IV.5 – Examples of installation in the corner of a room; (a) in-home cable and (b) indoor cable

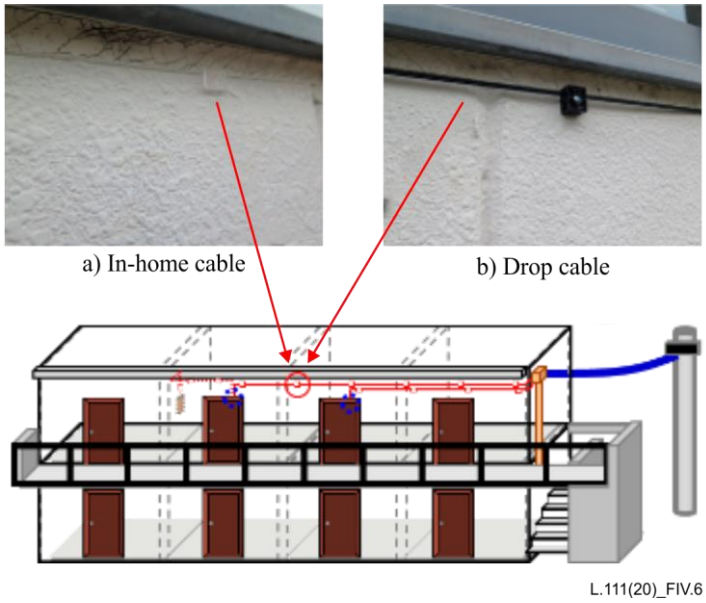


Figure IV.6 – Examples of installation outside under the eaves; (a) in-home cable and (b) drop cable

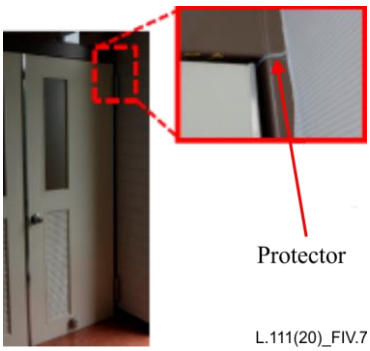


Figure IV.7 – Examples of installation where in-home cable is introduced into a room through the gap around a door

Appendix V

Indian experience on in-home cable with minimum visibility

(This appendix does not form an integral part of this Recommendation.)

V.1 Introduction

This appendix gives an example of an aesthetically pleasant optical fibre cable and its characteristics for in-home application. The optical fibre being used is bending loss insensitive having an excellent flexibility required for routing through various turns/curves ensuring fast and easy installation. The optical fibre cable is suitably protected with a low smoke zero halogen (LSZH) / flame retardant (FR) sheath which is suitable for fibre to the home application purposes. This in-home cable for minimum visibility is installed when an aesthetically pleasant appearance of the installed cable is preferred over the robustness of traditional indoor drop cables.

This appendix gives examples of optical fibre cable to be installed for in-home applications. These types of cables are mainly used as wiring cable in the user access section of fibre to the home (FTTH) and other optical access (FTTx) networks. These can be matched with connectors for pre-assembling or field assembling. The fibre system provides installers with a fast and easy technique for deploying fibre seamlessly around baseboard, windows and trim work, holding firmly in place and being nearly invisible to the observer.

V.2 Optical fibre cable construction

Bend insensitive single mode optical fibre meeting requirements of [ITU-T G.657] category A2/B3 is tight buffered to achieve an outer diameter of 900 µm with a transparent (or minimum visibility), durable, FR and/or LSZH sheath, which protects the fibre from any external damage. The sheath material should be compatible with fibre coating and should not add any stresses or introduce losses in the optical fibre and should allow easy stripping/removal with a suitable stripping tool.

The 900 µm mini-cable having minimum visibility is further coated with hard, resilient, durable, UV stabilized, flame retardant, LSZH engineered plastic sheath as shown in Figure V.1 to convert it to a dual sheath drop cable. Table V.1 shows characteristics of the cable.

The dual sheath drop cable is to be used as outdoor-indoor cable in the common areas of the building/ premises outside the living unit. The outer sheath to be manually stripped at the point of entry into the living unit and the 900 µm single sheath mini-cable is to be installed inside the home / living unit. Figure V.2 shows a cross-sectional view of the structure for in-home cable.

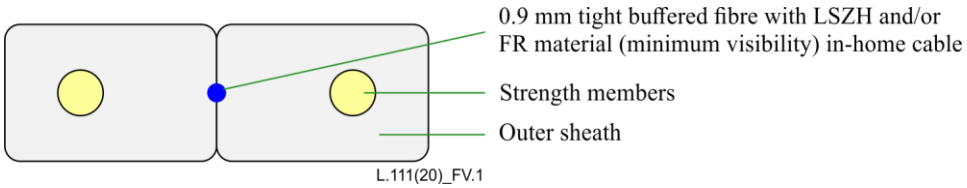


Figure V.1 – Cable construction of outdoor-indoor drop cable having in-home cable

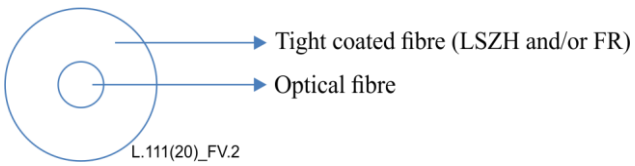


Figure V.2 – Structure for in-home cable (cross-sectional view)

Table V.1 – In-home cable characteristics

SN	Characteristics	Description
1.	Number of fibre	1
2.	Type of fibre	Bend-insensitive single mode fibre as per [ITU-T G.657] category A2/B3
3.	Colour of fibre	Uncoloured
4.	Cable diameter (Tight coated)	0.9 ± 0.05 mm
5.	Tight coated material	LSZH and/or FR

V.3 Mechanical and Environmental tests on in-home cable

This clause explains the mechanical tests applicable for the minimum visibility cable.

V.3.1 Cable bend test

The fibre and the component parts of the cable should not suffer permanent damage when the cable is repeatedly wrapped and unwrapped four complete turns of ten complete cycles, around a mandrel of 15D in diameter, where D is the overall diameter of cable according to the [IEC 60794-1-21] method E11. The cable outer jacket should not show any cracks visible to the naked eye, when examined whist still wrapped on the mandrel. The change in attenuation before and after the test should be < 0.20 dB at 1550 nm.

V.3.2 Cable tensile strength test

The cable should have sufficient strength to withstand a tensile load of 10N. The tensile strength is performed according to [IEC 60794-1-21] method E1. Fibre strain at 10N tensile load should not exceed 0.60% and should not cause permanent damage to constituent parts of the cable.

V.3.3 Crush Test

The cable should not suffer permanent damage when subjected to a compressive load of 50N applied between two plates of dimensions 100 mm × 100 mm. The load should be applied for 60 seconds according to [IEC 60794-1-21] method E3. The change in attenuation before and after the test should be maximum 0.20 dB at 1550 nm.

V.3.4 Impact test

The in-home cable should not show any cracks or breaks when the cable is subjected to 10 impacts of 1N from a height of 100 cm with impacting surface radius of 100 mm according to [IEC 60794-1-21] method E4. The change in attenuation before and after the test should be maximum 0.20 dB at 1550 nm.

V.3.5 Torsion test

The cable should not suffer any damage when a 0.3 metre length of cable is subjected to ten torsions of ±180° with 2N load according to [IEC 60794-1-21] method E7. The twist mark should not be taken as damage. The change in attenuation before and after the test should be maximum 0.20 dB at 1550 nm.

V.3.6 Kink test

The test is carried out according to [IEC 60794-1-21] method E10. The bending radius should be 10D where D is the overall diameter of the cable. When a sample length of ten times the minimum bending radius of the cable is subjected to kinking, it should not result in breakage of any fibre and kinks shall disappear after normalizing the cable. The change in attenuation before and after the test should be maximum 0.20 dB at 1550 nm.

V.3.7 Repeated bending test

The cable should not show any cracks or breaks when subjected to repeated bending 30 times, on 20D bending radius where D is the overall diameter of the cable, with a load of 25N according to [IEC 60794-21] method E6. The change in attenuation before and after the test should be maximum 0.20 dB at 1550 nm.

V.3.8 Temperature cycle test

Temperature cycling test should be carried out on one drum length of the cable to ensure stability of attenuation of the cable when subjected to temperature changes which may occur during storage, transportation and usage. The test is carried out according to [IEC 60794-1-22] method F1. The permissible temperature change for storage and operation should be from −20 ºC to +70 ºC.

After attaining temperature stability in the chamber, the cable should be subjected to temperature cycling for 12 hours at each temperature as indicated below:

- T_{A2} temperature: −20 ºC
- T_{A1} temperature: −10 ºC
- T_{B1} temperature: +60 ºC
- T_{B2} temperature: +70 ºC

The attenuation is to be measured at the end of each temperature at 1550 nm. The change in attenuation for entire range of temperature should be maximum 0.05 dB.

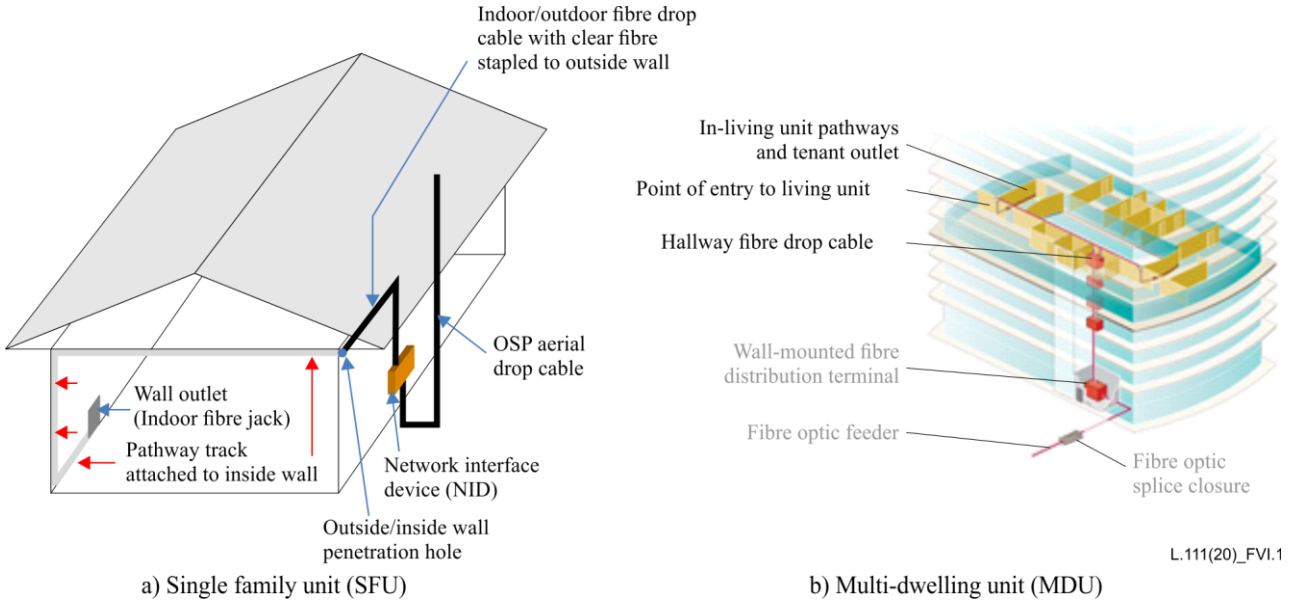
Appendix VI

United States experience on in-home fibre installation for minimum visibility

(This appendix does not form an integral part of this Recommendation.)

VI.1 Introduction

This appendix describes two US experiences that can be used for single family units (SFUs) / multi-dwelling units (MDUs) in-home optical fibre installations. These are referred to as method A and method B. Examples of an indoor/outdoor drop cable with 900-µm tight buffered (TB) ITU-T G.657.B3 fibre routed from an exterior splice case to a network interface device (NID) is provided. A drop cable routed aerially or buried, placed externally and stapled, then transitioned to 900-µm TB fibre using adhesive within the individual living unit (ILU), adapts and routes over most any surface, minimizes disruptions to décor, and provides a continuous path from curb to ONT. Drop cable is easily installed for single-family unit (SFU), and well suited for multi-dwelling unit (MDU) applications. Figure VI.1 shows SFU and MDU application spaces.



a) Single family unit (SFU) b) Multi-dwelling unit (MDU)

Figure VI.1 – SFU and MDU application spaces

VI.2 Solution components – SFU

The drop cable solution first provides for quick and easy installation of cable from the splice case to the NID. Secondly, it provides an ability to continue from the NID uninterrupted, if desired, for ILU deployment using a 900-µm tight buffered fibre. Figure VI.1 indicates applications for SFU, but the continuation of the drop within the ILU could be configured for MDU applications if routed from a floor terminal or fibre distribution hub (FDH).

The two components of this solution are:

– Drop cables

– A fibre pathway for 900-µm tight buffered fibre

VI.2.1 Solution component 1 – Indoor/outdoor fibre drop cable

Designed as a drop solution from the outdoors to the indoors, the fibre drop cable meets −40 °C to 70 °C (−40 °F to 158 °F) for outdoor conditions and is UV and fungus resistant. The ruggedized cable can be stapled with T25 staples and has 440N (100-lb) pull strength. Riser rated OFNR, OFCR, or (FT4) per [b-NEC 770], the cable can enter basements or attics before transitioning to

ILU with 900-µm tight buffered fibre. The key characteristics are shown in Table VI.1 and examples of the drop cables are shown in Figures VI.2 and VI.3.

Table VI.1 – Indoor/outdoor fibre drop cable key characteristics

Method A	Method B
Is riser-rated cable OFNR, OFCR, or (FT4) per [b-NEC 770] Can be stapled using a standard T25 staples due to self-bend limiting cable design Can be placed in tight coil and tie wrapped for storage without concern for bend radius management Has a cable jacket that can be removed for easy access 900-µm tight buffered fibre exceeds ITU-T G.657.B3 with 2.5mm bend radius Has an optional tone wire for locating Has pre-terminated or field-installed connectors	Is an optical fibre nonconductive riser-rated cable per [b-NEC 770] Can be stapled using a standard T25 staples Has a cable jacket that can be peeled for easy access to the clear fibre Is ITU-T G.657.B3 compliant 900-µm clear fibre Is all dielectric construction The ends can be pre-terminated or terminated with a field-installable connector

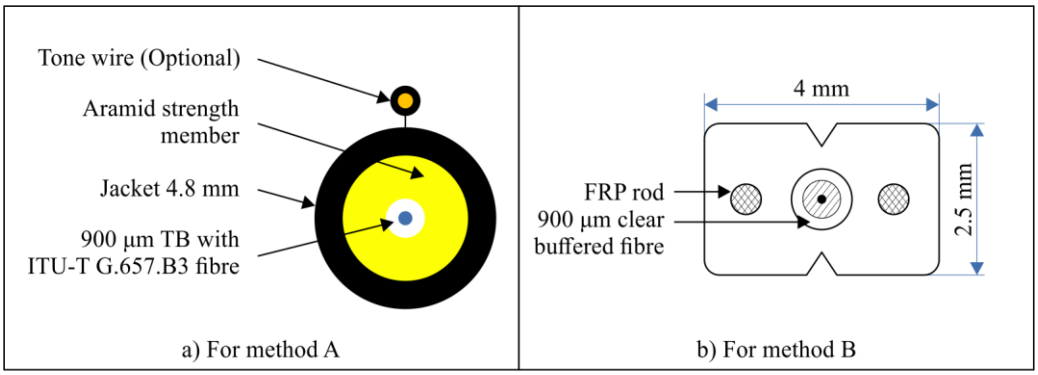


Figure VI.2 – Cross section of the drop cables

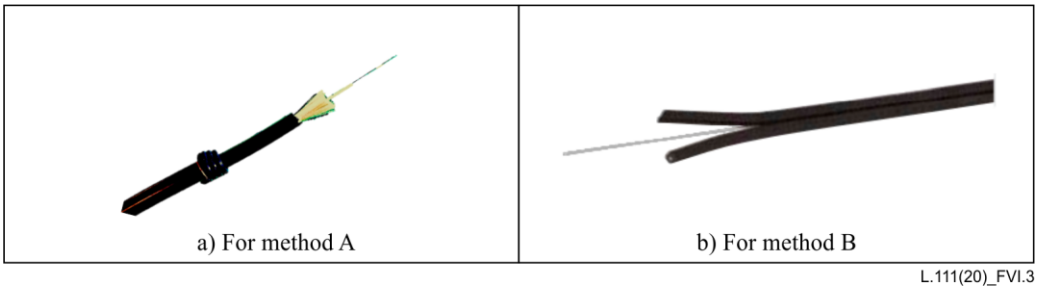


Figure VI.3 – Drop cables

VI.2.2 Solution component 3 – Fibre pathway

Method A – The adhesives used to directly attach the 900-µm fibre can also be used for home and office installations. The adhesive does not require pre-conditioning to the installation environment and dries clear to nearly invisible once installed. The adhesive is applied using a simple applicator designed to provide the minimal amount of adhesive required for installation.

Method B – The use of a fibre pathway for the 900-µm fibre can be used for home and office installations. A fibre pathway track can be clear and have features that diffuse reflected light,

resulting in near invisibility. The clear translucent adhesive-backed pathway can be delivered on a spool for easy installation.

The key characteristics are shown in Table VI.2 and examples of the pathway types are shown in Figure VI.4. Installation examples are shown in Figure VI.5.

Table VI.2 – Fibre pathway key characteristics

Method A	Method B
Uses an adhesive suitable for most surfaces to attach 900-µm fibre (Figure VI.4 (a)) Is easily routed around multiple corners 900-µm tight buffered fibre exceeds ITU-T G.657.B3 with 2.5-mm bend radius Minimizes the need for specialized tools (Figure VI.6 (a)) Provides simple installation (Figure VI.5 (a))	Uses a clear 900-µm fibre installed in a contoured track (Figure VI.4 (b)) Has minimal protrusion Uses an adhesive backing for the track The contoured track diffuses light to reduce visibility Provides simple installation (Figure VI.5 (b) Minimizes the need for specialized tools (Figure VI.6 (b))

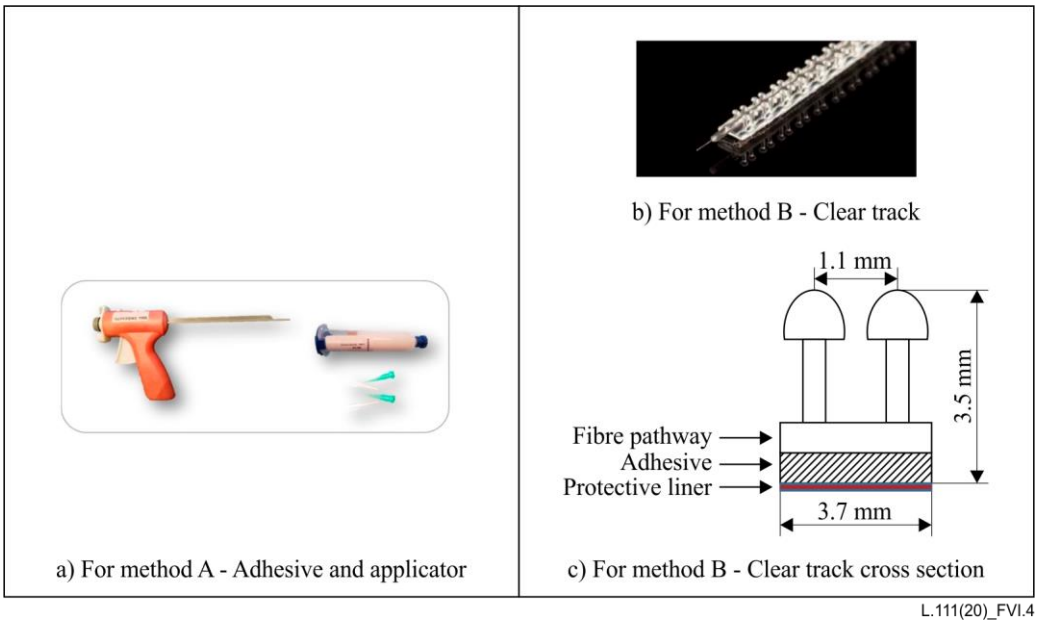


Figure VI.4 – Methods for pathway installation

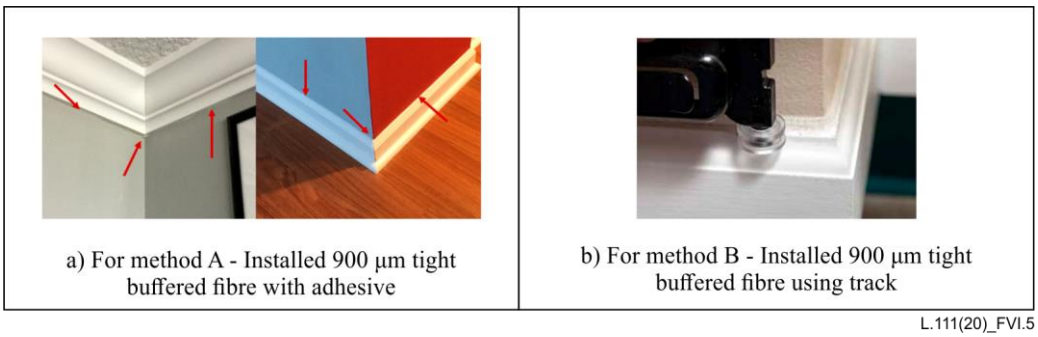


Figure VI.5 – Installation examples

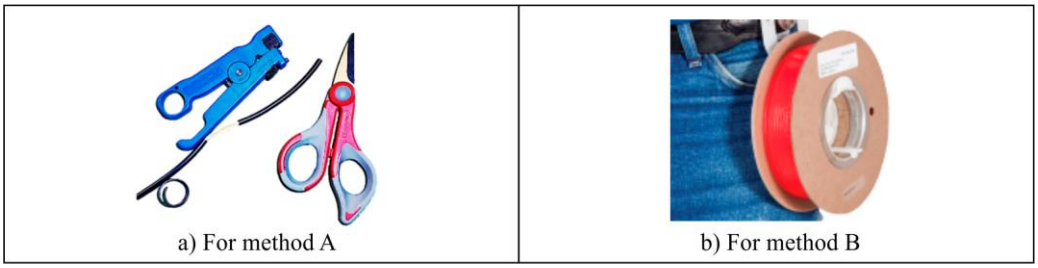


Figure VI.6 – Installation tools

VI.3 Solution components - MDU

MDU installations are used to route fibre from point of entry (POE) of the indoor living unit (ILU) to the telco closet and then to the hallway just outside the living unit or office location. (The building backbone solution is not in scope for this appendix.) Both method A and method B consist of three components:

– The ILU pathways and tenant outlet

– The POE terminal

– Hallway fibre cable

VI.3.1 Solution component 1 – ILU pathways and tenant outlet

A multi-fibre MDU solution should provide quick and easy installation of optical fibre from the FST to the POE. The pathways and tenant outlets help provide easy installation and flexibility.

The key characteristics are shown in Table VI.3. Figure VI.7 shows Method A and Method B for drop cables.

Table VI.3 – ILU pathways and tenant outlet key characteristics

Method A	Method B
Small footprint allows for placement in most any location Fibre is easily routed around multiple corners 600-µm TB fibre exceeds ITU-T G.657.B3 with 2.5 mm bend radius Uses an adhesive suitable for most all surfaces Common technicians' tools used for installation Provides simple installation Components including the TB are paintable 600-µm tight buffered fibre module for wall outlet (Figure VI.8 (a))	Diffuse-reflection track that provides building owners and tenants with an inconspicuous fibre solution (Figure VI.4 (b and c)) Clear adhesive backing allows for simple installation without the use of staples or liquid adhesives Multi-surface application to many surfaces including latex and oil paints and wallpaper Has been listed to the requirements of UL 2024: Cable Routing Assemblies and Communications Raceways and [b-CSA C22.2 No. 262] Optical Fibre and Communications Cable Raceway Systems – FT4. Low profile wall plates that mount using standard adhesive backing strips (Figure VI.8 (b))

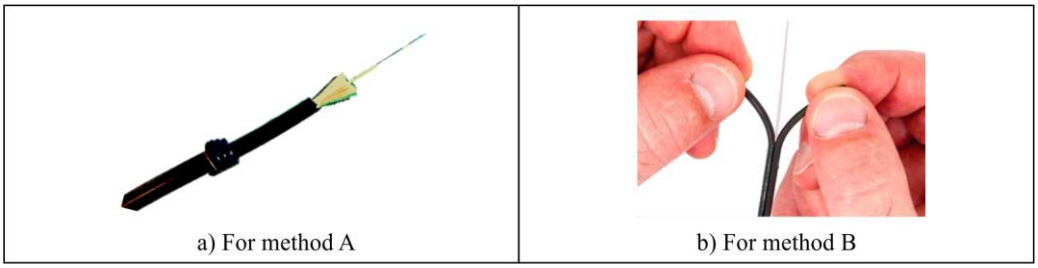


Figure VI.7 – Drop cables

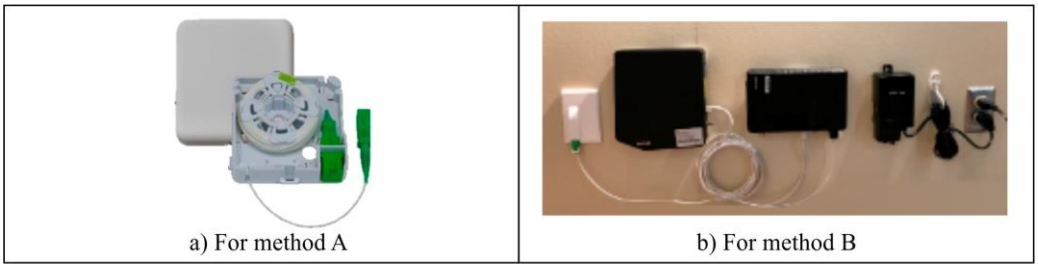


Figure VI.8 – Wall outlets

VI.3.2 Solution component 2 – The point of entry (POE) terminal

The POE module is the demarcation point from the hallway to the ILU. The compact nature of the module limits the visual aspect and can be painted to match the décor. The POE has space for slack loops of the multi-fibre cord which is used to access individual fibre for connection to the tight-buffered cable. The key characteristics are shown in Table VI.4 and examples of the POEs are shown in Figure VI.9.

Table VI.4 – Point of entry (POE) terminal key characteristics

Method A	Method B
Minimal size limits disruption to décor Easily installed with two screws Provides slack storage for the multi-fibre cord Splice holder and adapter allow for connections to ILU fibre POE is paintable	Used to connect to hallway distribution cables from a point-of-entry location near an apartment door to a wall outlet in the living unit positioned near an ONT Has a small design to limit fibre waste and large boxes designed to store excess cable slack Can be terminated to help reduce expensive and time-consuming fusion splicing

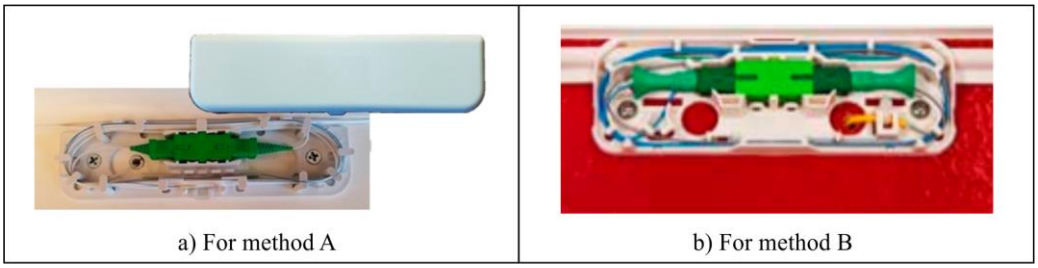


Figure VI.9 – Point of entry modules

VI.3.2 Solution component 3 – Hallway fibre cable

Designed as an MDU solution by minimizing the size12-fibre micro-module, cables can be easily laid and captured within the adhesive application (Method A) or a track solution (Method B)

The key characteristics are shown in Table VI.5 and examples of the hallway cables are shown in Figure VI.9.

Table VI.5 – Hallway fibre cable key characteristics

Method A	Method B
Easily routed around multiple corners 250-µm fibre exceeds ITU-T G.657.B3 with 2.5-mm bend radius Uses an adhesive suitable for most all surfaces Riser rated cable OFNR, OFCR, or (FT4) per [b-NEC 770] Can be pre-terminated at FST end or field installed with splices or connectors	White 1.8-mm micro-module jacket 12 ultra-bend-insensitive single-mode fibres with 250-µm coating with colour code Proof tested to 100 kpsi Meets ITU-T G.657.B3, G.652.D Can be pre-terminated at FST end or field installed with splices or connectors Installed in track

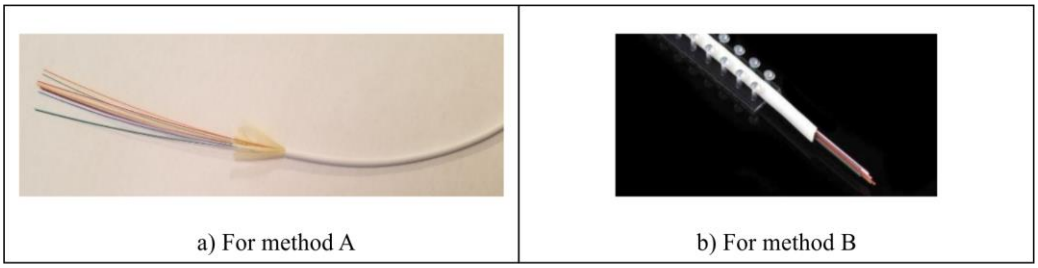


Figure VI.10 – Hallway cables

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[b-NEC 770] NFPA 70, Article 770 - *Optical Fibre Cables.*

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