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Federal Department of the Environment, Transport, Energy and Communications DETEC

Federal Office of Communications

Technical Guidelines

concerning

FTTH In-House Installations, Physical Media of Layer 1

Edition 3: 05.03.2012

Contents

1 General

1.1 Scope

The present document defines a technical guideline for the physical media of layer 1 of the in-house installation part of fibre to the home networks. It was written by a telecommunications industry working group including operators, suppliers, associations and regulator. The goal of the technical guideline is to ensure that the in-house installation can be shared by two or more fibre networks serving the same location. This has the benefit that the in-house installation in any given building need only be done once. Commercial questions are out of scope of this technical guideline.

The in-house installation extends from a building entrance facility typically in the basement of a building to an optical telecommunications outlet (socket) in the subscriber's premises. The technical guideline describes a reference model, specifies physical infrastructure elements and describes processes. Neither access networks nor home networks are specified in this technical guideline although they are relevant for their influence on the in-house installation. This technical guideline is based as far as possible on recognised international technical guidelines.

While the technical guideline describes some important aspects of the in-house installation it does not represent a complete solution. Each network operator is responsible for planning and implementing its FTTH network using appropriate engineering procedures.

The technology of fibre optic networks is undergoing constant development. The working group observes this development and revises the technical guideline as necessary to take new developments into account. In the second edition of the document the title was changed to 'FTTH In-House Installations, Physical Media of Layer 1' to more accurately reflect the scope of the guideline.

The technical guideline is a voluntary one and there is no legal obligation for any party to observe it. The working group recommends however that any party constructing a fibre to the home in-house installation observe the technical guideline.

This technical guideline is available also in German, French and Italian. The reference is the English version.

1.2 Participants

The following organisations contributed to the work:

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Broadband Networks AG
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Cablex AG
Dätwyler Schweiz AG
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Federal Office of Communications
Federal Office of Metrology
Feller AG
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1.4 References

[1] EN 50173-1 Information technology. Generic cabling systems. General requirements

[2] ITU G.652 Characteristics of a single-mode optical fibre and cable

[3] ITU G.657 Characteristics of a Bending Loss Insensitive Single Mode Optical Fibre and Cable for the Access Network

[4] IEC 60793-2-50 Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres

[5] IEC 60304 Standard colours for insulation for low-frequency cables and wires

[6] IEC 60794-5 Optical fibre cables - Part 5: Sectional specification - Microduct cabling for installation by blowing

[7] IEC 60794-3-11 Optical fibre cables - Part 3-11: Outdoor cables - Detailed specification for duct and directly buried single-mode optical fibre telecommunication cables

[8] IEC 60794-2-20 Optical fibre cables - Part 2-20: Indoor cables - Family specification for multi-fibre optical distribution cables

[9] IEC 61756-1 Fibre optic interconnecting devices and passive components - Interface standard for fibre management systems - Part 1: General and guidance

[10] IEC 61754-20 Fibre optic connector interfaces - Part 20: Type LC connector family

[11] IEC 61755-3-2 Fibre optic connector optical interfaces - Part 3-2: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia ferrules for 8 degrees angled-PC single mode fibres

[12] IEC 61755-3-6 Fibre optic connector optical interfaces - Part 3-6: Optical interface - 2,5 mm and 1,25 mm diameter cylindrical 8 degrees angled-PC composite ferrule using Cu-Ni-alloy as fibre surrounding material, single mode fibre

[13] IEC 61755-3-8 Fibre optic interconnecting devices and passive components - Fibre optic connector optical interfaces- Part 3-8: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical 8 degrees angled-APC composite ferrule using titanium as fibre surrounding material, single mode fibre

[14] IEC 61755-1 Fibre optic connector optical interfaces - Part 1: Optical interfaces for single mode non-dispersion shifted fibres - General and guidance

[15] IEC 61753-021-2 Fibre optic interconnecting devices and passive components performance standard - Part 021-2: Grade C/3 single-mode fibre optic connectors for category C - Controlled environment

[16] IEC 61280-4-2 Fibre optic communication subsystem basic test procedures - Part 4-2: Fibre optic cable plant - Single-mode fibre optic cable plant attenuation

[17] EN 50173-4 Information technology. Generic cabling systems. Homes

[18] EN 50083 series (1-10) Cable networks for television signals, sound signals and interactive services.

[19] IEC 60825 series Safety of laser products

[20] SUVA Sicherheitsanforderungen an Lichtwellenleiter-Kommunikationssysteme (LWLKS)

[21] NIV 734.27 Niederspannungs- Installationsverordnung

[22] IEC 60332 series Tests on electric and optical fibre cables under fire conditions

[23] IEC 60754 series Tests on gases evolved during combustion of materials and cables

[24] IEC 61034 series Measurement of smoke density of cables burning under defined conditions

[25] Richtlinie zur Wohnungsnummerierung, BFS, Februar 2008

[26] Multimedia-Installationen – bauliche Voraussetzungen für Ein- und Mehrfamilienhäuser, Swiss Electrotechnical Committee (CES)

[27] ITU X.200 Information technology – Open Systems Interconnection – Basic Reference Model: The basic model

[28] IEC 61753-131-3 Ed. 1.0: Fibre optic interconnecting devices and passive components - Performance standard - Part 131-3: Single-mode mechanical fibre splice for category U – Uncontrolled environment

[29] EN 50411-3-2 Fibre organisers and closures to be used in optical fibre communication systems - Product specifications - Part 3-2: Singlemode mechanical fibre splice

[30] IEC 61073-1 Fibre optic interconnecting devices and passive components - Mechanical splices and fusion splice protectors for optical fibres and cables - Part 1: Generic specification

[31] IEC 61754-28 [1] Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 28: Type LF3 connector family

All texts of laws with SR references are published in the systematic collection of federal law and can be consulted on the www.bk.admin.ch website. They can also be obtained from the Federal Office for Construction and Logistics (BBL), CH-3003 Berne.

The technical and administrative regulations as well as the numbering plans can be consulted on the www.bakom.admin.ch website. They can also be obtained from the Federal Office of Communications OFCOM, 44, Postfach, CH-2501 Biel-Bienne.

The ITU-T Recommendations can be obtained from the ITU, Place des Nations, 1211 Geneva 20 http://www.itu.int/ITU-T/

[1] At final draft stage

The ETSI standards can be obtained from the European Telecommunications Standardisation Institute, 650 route des Lucioles, 06921 Sophia Antipolis, France, www.etsi.org

The ISO standards can be obtained from the central secretariat of the International Organisation for Standardisation, 1, rue de Varembé, 1211 Geneva, www.iso.ch

The IEC standards can be obtained from the IEC Central Office, 3, rue de Varembé, CH-1211 Geneva 20, www.iec.ch

The Swiss standards (SN) can be obtained from Swiss Association for Standardisation, Bürglistrasse 29, 8400 Winterthur, (www.snv.ch)

The W3C Recommendations are available at www.w3c.org

The IAB's RFCs are available at www.ietf.org

The referenced standards are the considered to be the valid editions on 5 March 2012.

1.5 Definitions and abbreviations

1.5.1 General definitions

For the purposes of this industry standard the following definitions and abbreviations apply. The definitions and abbreviations are based on the European Standard for the EN 50173 series, e.g. [1].

administration
methodology defining the documentation requirements of a cabling system and its containment, the labelling of functional elements and the process by which moves, additions and changes are recorded

building entrance facility
facility that provides all necessary mechanical and electrical services, that complies with all relevant regulations, for the entry of telecommunications cables into a building and which may allow for transition from external to internal cable

cabling
system of telecommunications cables, cords and connecting hardware that supports the operation of information technology equipment

connection
mated device or combination of devices including terminations used to connect cables or cable elements to other cables, cable elements or application specific equipment

cord
cable unit or element with a minimum of one termination

distributor
term used for the functions of a collection of components (for example, patch panels, patch cords) used to connect cables

equipment cord
cord connecting equipment to a distributor

equipment interface
point at which application-specific equipment can be connected to the generic cabling or network access cabling

home distributor
the distributor within a home where cables terminate

indoor cable
cable to be used for indoor cabling according to IEC 60794-2 series [8] and temperature range -20°C to +60°C

interconnect
method of connecting a cabling subsystem to equipment (or another cabling subsystem) without the use of a patch cord or jumper

layer 1
layer 1 of the ISO OSI model, equivalent to ‘physical layer’ [27]

optical fibre cable (or optical cable)
cable comprising one or more optical fibre cable elements

optical fibre duplex adapter
mechanical device designed to align and join two duplex connectors

optical fibre duplex connector
mechanical termination device designed to transfer optical power between two pairs of optical fibres

outdoor cable
cable to be used for outdoor cabling according to IEC 60794-3 [7] series and temperature range -30°C to +70°C

physical media
part of layer 1 comprising cabling system, adapters, connector details and identification

small form factor connector
optical fibre connector designed to accommodate two or more optical fibres with at least the same mounting density as balanced cabling interfaces in accordance with EN 60603-7 series

splice
joining of conductors or fibres, generally from separate cables

telecommunications
branch of technology concerned with the transmission, emission and reception of signs, signals, writing, images and sounds; that is, information of any nature by cable, radio, optical or other electromagnetic systems

telecommunications outlet
fixed connecting device where the ICT home cable terminates. The telecommunications outlet provides an interface to the terminal equipment cabling for ICT applications

terminal equipment
equipment (e.g. telephone handset) that provides user access to an application at an application outlet

terminal equipment cabling
cords and other devices connecting the telecommunications outlet or broadcast outlet to the terminal equipment

test interface
point at which test equipment can be connected to the generic cabling

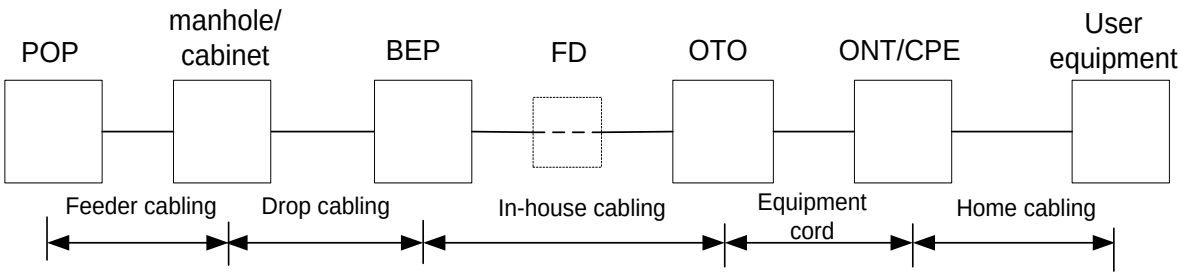
transmission equipment
active and passive equipment used to distribute applications from distributors to other distributors and to outlets

1.5.2 Abbreviations

APC	Angled Physical Contact
BEP	Building Entry Point
CAT	Category
CATV	Cable Television
CPE	Customer Premises Equipment
DSL	Digital Subscriber Line
FD	Floor Distributor
FITH	Fibre in the Home
FTTH	Fibre to the Home
HF	High Frequency

ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IL	Insertion Loss
IP	Ingress Protection
ITU	International Telecommunication Union
LAN	Local Area Network
ONT	Optical Network Termination
OTDR	Optical Time Domain Reflectometer
OTO	Optical Telecommunications Outlet
OTO-ID	OTO Identification Code
OTU	Optical Termination Unit
PC	Physical Contact
POP	Point of Presence
RL	Return Loss
TBD	To Be Decided
TEL	Telephone
TO	Telecommunications Outlet
TP	Twisted Pair

2 Reference model



Key

BEP	Building Entry Point
CPE	Customer Premises Equipment
FD	Floor Distributor
ONT	Optical Network Termination
OTO	Optical Telecommunications Outlet
POP	Point of Presence

Figure 1 FTTH in-house installation reference model

This technical guideline describes aspects of the drop cabling, building entry point, in-house cabling and optical telecommunications outlet.

2.1 General considerations about buildings

The reference model is applicable to both new and existing buildings including special cases such as apartment splitting or merging. General considerations are given in section 6.6. More details can be found in [26].

2.2 Building entry point (BEP)

The BEP allows the connection of the outdoor (feeder and / or drop) to the indoor (in-house) cable. The type of connection may be a fusion splice or other optical connection.

Note: In individual residential houses the functionality of the BEP may not be required in which case the drop cable terminates directly at the OTO.

2.3 Floor distributor (FD)

The floor distributor is an optional element which allows the transition from the vertical to the horizontal indoor cable.

2.4 In-house cabling

The in-house cabling links the BEP to the OTO. The main components are an optical indoor cable or other, blowing-based, installation of fibre elements. A key element of this technical guideline is that four fibres are installed between the BEP and each OTO.

2.5 Optical telecommunications outlet (OTO)

The OTO is a fixed connecting device where the fibre optic indoor cable terminates. The optical telecommunications outlet provides an optical interface to the equipment cord of the ONT/CPE.

2.6 Optical network termination (ONT)

The ONT terminates the FTTH optical network at the customer premise. It includes an electro-optical converter. The ONT and CPE may be integrated.

2.7 Customer premises equipment (CPE)

The CPE is any active device, e.g. set-top-box, that provides the end-user with FTTH services (high-speed data, TV, telephony, etc.). The ONT and CPE may be integrated.

2.8 Home cabling

The home cabling supports the distribution of a wide range of applications TV, telephone, Internet access etc. within the premises. Application-specific hardware is not part of the home cabling.

2.9 User equipment

The user equipment TV, Phone, personal computer, etc. allows the user to access the FTTH services.

3 General fibre and cable considerations

3.1 Fibre characteristics

The fibre characteristics are given in different international standards. Most commonly, fibre codes from ITU and IEC are referenced. Both codes are used in this document.

The type of the fibre is single mode fibre.

At the BEP, fibres from the drop cabling (outdoor cable) and the fibres from the in-house cabling (indoor cable) have to be connected. The specifications of these fibres are described in the different standard fibre categories. They have to fulfil certain requirements which are described in the references given in Table 1 below.

Table 1 Fibre characteristics

Fibre type	ITU Code	IEC Code
Outdoor cables	G.652D	IEC 60793-2-50 B1.3
Outdoor cables	G.657A*	IEC 60793-2-50 B6_a
Indoor cables	G.657A*	IEC 60793-2-50 B6_a

* G.657A includes both G.657A1 and A2.

Low bend fibres G.657B2 und B3 are not recommended because of compatibility issues.

Drop and in-house cabling can be realized by using blowing techniques in microducts.

3.2 Bending radius requirements

Bending radius in the BEP and outdoor cable sections for standard single mode fibres G.652D or G.657A shall be 30 mm and above.

Bending radius in the OTO and indoor cable sections for G.657A fibres shall be 15 mm and above.

Mechanical reliability expectation for optical fibres related to mechanical stresses shall be at least 20 years.

Table 2 Bending radius requirements

Cable type	Fibre type		
	ITU Code	IEC Code	Bend radius [mm]
Outdoor cables	G.652D	IEC 60793-2-50 B1.3	≥ 30
Outdoor cables	G.657A	IEC 60793-2-50 B6_a	≥ 30*
Indoor cables	G.657A	IEC 60793-2-50 B6_a	≥ 15

* For compatibility with G. 652 class D based outdoor cables, 30 mm minimum bending radius shall be maintained.

3.3 Splicing compatibility between indoor and outdoor cables

The different mode field diameter mean values, as well as their tolerances, have an effect on splice losses when fibres of different categories and families are spliced together.

Care must be taken to properly adjust splicing equipment and to correctly evaluate the splicing losses among different fibre families, which can show increases in comparison with conventional splice losses, when performing unidirectional OTDR measurements.

3.4 Cable type

Optical loose tube fibre cables according to the IEC 60794 series or microduct cabling for installation by blowing technique according to the IEC 60794-5 series [6] shall be used for installations at the BEP.

The compatibility of other cable constructions to the standard cables at the specified interfaces shall be considered.

3.4.1 Outdoor cable

Outdoor cables are covered by IEC 60794-3-11 [7].

The operating temperature range is between -30°C and +70°C.

3.4.2 Indoor cable

Indoor cables are covered by IEC 60794-2-20 [8] and shall provide 4 fibres between the BEP and each OTO.

The operating temperature range is between -20°C and +60°C.

3.5 Colour coding of fibres

Fibres within buffer tubes, as well as buffered fibres, are colour coded to differentiate the fibres within the cable. This colour coding enables installers to easily identify fibres at both ends of the fibre link and also indicates the appropriate position of each fibre in the cable. Colours shall correspond to standard colours in IEC 60304 [5].

For fibre counts above 12, additional groups of 12 fibres should be identified by combining the above sequence with an added identification (for example, ring marking, dashed mark or tracer).

Fibre colour and numbering for outdoor cabling shall be according to the following table:

Table 3 Colour coding for fibres in outdoor cables

Fibre No.	Colour	Fibre No.	Colour
1	red	13	red + marking
2	green	14	green + marking
3	yellow	15	yellow + marking
4	blue	16	blue + marking
5	white	17	white + marking
6	violet	18	violet + marking
7	orange	19	orange + marking
8	black	20	transparent + marking
9	grey	21	grey + marking
10	brown	22	brown + marking
11	pink	23	pink + marking
12	turquoise	24	turquoise + marking

Loose tube colours in outdoor cables shall be as follows:

Table 4 Loose tube colours in outdoor cables

Loose tube no.	Colour
1	red
2	green
3	non colour or white
4	non colour or white

Count direction is indicated by the green loose tube.

Fibre or tube colour and numbering for indoor cables shall be according to the following table:

Table 5 Indoor cable fibre or tube colours

Cable type	Fibre or buffered-fibre colour
4-fibre cable:	
Fibre No.1	red
Fibre No.2	green
Fibre No.3	yellow
Fibre No.4	blue

3.5.1 Microduct cabling for installation by blowing

The requirements for microduct optical fibre cables, microduct fibre units, microducts and protected microducts for installation by blowing for outdoor and/or indoor use are given below. It shall be possible to install or remove the microduct optical fibre cable from the microduct or protected microduct by blowing during the operational lifetime.

A microduct suitable for installation of microduct cables is a small, flexible, lightweight tube with an outer diameter typically less than 16 mm.

Microduct optical fibre cables, fibre units, microducts and protected microducts for installation by blowing are defined in the IEC 60794-5 series [6].

3.6 Cables containing flammable materials

The fire performance of indoor and outdoor cables should comply with the requirements of the IEC 60332 [22], IEC 60754 [23] and IEC 61034 series [24].

4 Specification at the building entry point (BEP)

The following specifications are related to point-to-point optical fibre systems and new installations only.

4.1 Installation requirements at the BEP

Optical fibre cables used in FITH are designed so that normal installation practices and equipment can be used wherever possible. They do, however, generally have a strain limit rather lower than metallic conductor cables and, in some circumstances, special care and arrangements may be needed to ensure successful installation.

It is important to pay particular attention to the cable manufacturer's recommendations and stated physical limitations and not exceed the given cable tensile load ratings for the outdoor and indoor cable as well as their different bend radius requirements. Damage to a cable caused by mechanical overloading during installation may not be immediately apparent but can lead to failure later in its service life.

Installation of an optical fibre cable and connecting elements at the BEP can be influenced significantly by careful planning and preparation of an installation specification. The installation specification should consider:

1) The type of building:
    a. Individual residential houses
    b. Apartment blocks
    c. Business premises
2) Cable entry hardware:
    a. Leading-in tubes
    b. BEP
3) Cable entry components:
    a. The cabling infrastructure
    b. Cable routes including a separate route for electrical wires to the fuse-board or smart meter
    c. Potential hazards and installation environment
    d. Provide a bill of materials and technical requirements for cables, trays, splices, boxes
    e. Details of any additional work, route preparation (including ductwork, tray-work and trunking)
    f. Clear indication of responsibilities and contractual interfaces, especially if there are any site or access limitations
    g. Post installation requirements for reinstatement, spares, ancillary services and regulatory issues

4.2 Fusion splice at the BEP

Fusion splicing shall be used at the BEP.

The requirements for fusion splices and splice protectors to be used at the BEP are summarized in the following table: Splice protector types shall be heat shrink or crimp. Dimensions are defined in IEC 61756-1 [9].

Table 6 Fusion splice at the BEP

Characteristics	Requirement
Max. attenuation of splices	0.15 dB
Return loss	> 60 dB
Operating temperature range	-25°C to 70°C

Note: Mechanical splices are not currently specified for use at the BEP because their dimensions do not match the fusion splice protectors. Should a suitable standardised solution for mechanical splices become available their use shall be reconsidered.

4.3 Connection box at the BEP

The fibre management systems are according to IEC 61756-1 [9].

Because of space reasons, in small buildings (typically 1-2 apartments) a multiple element management system may be used (1 splice tray).

For 3 and more apartments / building and for business buildings single circuit management systems shall be used (1 splice tray / apartment).

The connection box at the BEP is mounted on the wall inside or outside the building and has the following main functions:

- to fasten incoming outdoor and outgoing indoor cables
- to mount the required number of splice trays
- to allow management of single circuits (fibre circuit disturbance)
- to manage classical installation and installation by blowing
- to allow locking if needed
- to store unused fibres
- to provide means for fibre identification

The degree of protection for the BEP in-house installation shall be IP20 and for outdoor IP44.

Operating temperature range for indoor applications is between -10°C to +60°C and for outdoors -25°C and +70°C.

The following table gives the requirements for overlengths in the connection box and splice tray.

Table 7 Overlengths

Element	Requirement
Fibre or buffered-fibre overlength	1.5 m

4.3.1 Splice tray

The splice tray for single circuit management systems shall have capacity to store 4 splices. Strain relief shall be available.

The fibre and buffered fibre overlength is typically stored in the same tray as the splices. It shall permit the movement of the splice to the splicing equipment or tools and back to the splice holder.

The length should be such that it allows 3 re-splices. Often the fibres are stored in loops near the splice area. For optimised handling and to avoid violating the minimum bending radius, guiding elements are needed.

The splice tray provides internally a place for 4 splice holders. Different types are specified by:

- splice protection type;
- fixing method.

The tray has to fulfil the needs for fixing or stacking.

4.3.2 Placement of the BEP

The placement of the BEP will be defined according to the installation possibilities and landlord requirements. The following guidelines help find the optimal place:

- The BEP should be placed
  - close to existing vertical cabling, e.g. copper telephone wires, electrical power cables, CATV cables, bell wires,
  - in a telecommunications technical space (wall-box) if available (mainly in new buildings)
- The BEP should be easily accessible but at the same time not unduly exposed to risks such as vandalism, physical damage by people traffic or goods deliveries.
- The physical conditions should be favourable, avoiding for example excessive humidity, dust or vibrations.

5 Floor distributor

An optional distributor may be used to make connections between the horizontal cable leading to the OTO and vertical cabling subsystems in multi-dwelling units with multiple apartments on one floor.

The material specification for the floor distributor is not defined in this document.

6 Specification at the optical telecommunications outlet (OTO)

The optical telecommunications outlet shall be designed to manage 4 fibres with a minimum bending radius of 15 mm. The outlet shall provide space for:

- fibre overlengths,
- 4 splices,
- 4 LC/APC adapters or 4 LF3/APC adapters,
- 4 LC/APC optical connectors or 4 LF3/APC connectors.

The OTO can also be considered as an optical external network testing interface.

Means of identification shall be provided for:

- passive optical ports,
- fibres.

6.1 Fibre characteristics

Fibre characteristics at the OTO shall be as defined in IEC 60793-2-50 B6_a [4], (G.657 A)

6.2 Connection outlet

The design of the outlet shall fulfil the following requirements:

- to accommodate 4 splices and 4 splice protectors,
- to store the fibre overlengths,
- to avoid lower bend radii than 15 mm.

6.3 Connection type

The fibre connection at the OTO can be:

- pre-terminated cable assemblies
- spliced pigtails
- field-mountable connector

6.3.1 Optical connectors

The type of the optical connector is LC/APC or an LF3/APC connector.

The mechanical intermateability is defined in IEC 61754-20 [10] or IEC 61754-28 [31]. The dimensional and material requirements of the ferrule endface are defined in IEC 61755-3-2 (zirconia) [11], IEC 61755-3-6 (Cu-Ni-alloy) [12] and IEC 61755-3-8 (titanium) [13].

Optical connections at the OTO shall be Grade C for attenuation and Grade 1 for return loss as defined in IEC 61755-1 [14].

The mechanical and climatic requirements are defined in IEC 61753-021-2 [15] for category C (controlled environment) with a temperature range of -10°C to +60°C.

6.3.2 Splices

The requirements for splices at the OTO are summarized in the following table.

Table 8 Splice requirements at the OTO

Characteristic	Requirement
Max. attenuation	0.25 dB *
Return loss	> 60 dB
Operating temperature range	-10°C to 60°C

* The maximum value of the splice attenuation is 0.25 dB because at the OTO both splicing technologies (fusion and mechanical) may be used. The reader should compare this with the splice requirements at the BEP (0.15 dB, fusion splices only).

See also [28], [29] and [30].

When mechanical splices are used an angled type is recommended.

6.4 Placement of the OTO

The placement of the OTO will be defined according to the installation possibilities and landlord requirements. The following guidelines help find the optimal place:

- For business premises, the OTO will be installed in the room with the IT equipment.
- For residential premises, the OTO will be installed in a multimedia distribution box if available or otherwise in the living room.
- In individual residential houses a BEP connection box may not be used. In this case the placement guidelines of section 4.3.2 apply to the OTO.

Multimedia distribution boxes are typically available in newer buildings and can only be considered for the OTO installation under the following conditions:

- The box is the central point to distribute the home cabling to the room(s) with the user equipment.
- The box has a power socket, enough space and sufficient air circulation for at least one ONT/CPE.

6.5 OTO identification code

The operator, who first builds the FTTH in-house network, allocates an OTO identification code (OTO-ID). Any new operator who later shares the infrastructure is obliged to use the OTO-ID already allocated by the first operator. The OTO-ID shall be allocated according to the following conventions:

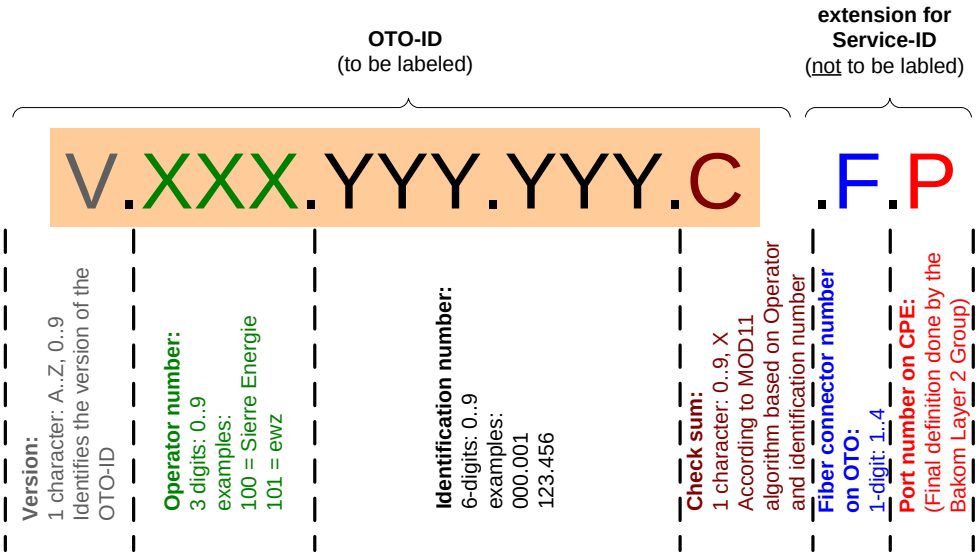


Figure 2 OTO identification code

The OTO-ID consists of the following sections:

- **Version**
  The version character allows identification of the version of the OTO identification code convention. This may be needed once the OTO identification code convention needs to be changed or extended.
  BAKOM releases a new version character whenever it is requested by the industry.
  The first version character will be **B**, to clearly distinguish from already existing OTO-IDs.
- **Operator number**
  These three digits identify the operator, who initially built the FTTH in-house network and labelled the OTO with the OTO-ID (in his operator range).
  BAKOM assigns operator numbers and publishes the list.
  The first operator number will be **100**, to avoid possible difficulties with leading zeros.
- **Identification number**
  These six digits are a unique identification number for each OTO per operator. The operator is free to simply increment the number, build subsections or use any other numbering assignments within his range. Operators who build more than 999'999 OTO will receive multiple operator numbers.
- **Check sum**
  The check sum is based on the MOD11 algorithm and allows identification of single typing errors (e.g. 123 instead of 129) or two swapped digits (e.g. 123 instead of 132). The result of MOD11 is 0..9 and "X" which represents the result of 10 (equal to "roman numeral").
  The procedure to calculate the check sum is as follows: (based on the OTO-ID example B.101.286.475.8)
  1. Take the operator and identification number of the OTO-ID.
  → example: 101.286.475
  2. Multiply an incrementing number with each individual digit and build the sum.
  → example: 1*1 + 2*0 + 3*1 + 4*2 + 5*8 + 6*6 + 7*4 + 8*7 + 9*5 = 217
  3. Build the MOD 11 (remainder of a integer division by 11).
  → example: 217 MOD 11 = 8 (proof: 217 / 11 = 19.73... ; which is equal to 19 remainder 8)

- **Fibre connector number on OTO**
  This digit extends the OTO-ID with the fiber connector number on the OTO, where the equipment cord towards the CPE has to be plugged in. Because of four fibres and maximum four connectors, the fibre connector number can only be 1, 2, 3 or 4.
- **Port number on CPE**
  This digit(s) extends the OTO-ID with the port number on the CPE, where the home cabling towards the user equipment has to be plugged in.
  The final definition of the port number will be done by the BAKOM Layer 2 working group.

6.6 Apartment identification code

This section describes a convention for numbering the individual apartments in an apartment block. The apartment identification is based on the Guidelines for Apartment Numbering by the Swiss Federal Statistical Office [25]. The guidelines cover buildings with more than 3 apartments per floor.

In order to avoid interpretation mistakes and to simplify handling in IT tools this concept has been improved by:

- Introduction of a leading zero to single digit numbers
- Separation of the floor number and the apartment number by a dot

Example:

05.03

05: floor number

03: apartment number

6.6.1 Floor definition

Ground floor:

main entry, provided with street number or

main entry where the mailboxes and/or bell buttons are placed.

For a main entry situated between two floors the following rule applies:

lower floor = basement

higher floor = ground floor

if there are the same number or more steps downward as upward.

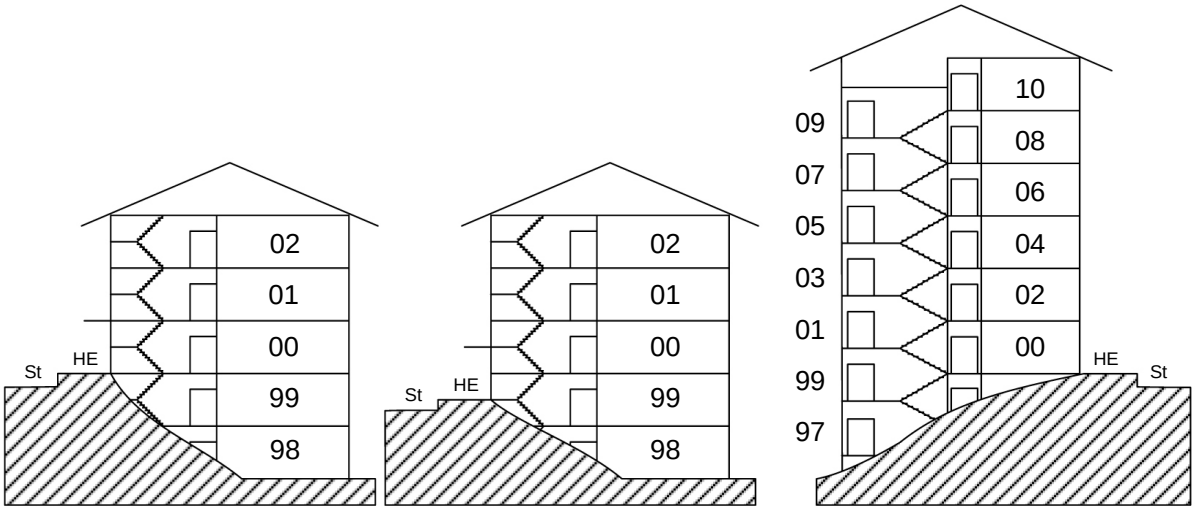
6.6.2 Floor numbering

Consecutive numbers with a leading zero added to single digit numbers, i.e. 00.89

Ground floor = 00

Basement: no negative numbers rather the following descending sequence is used: 99.90.
Example: first basement = 99, second basement = 98, etc.

Figure 3 illustrates the floor numbering scheme.



Key

St	Street
HE	House Entrance

Figure 3 Floor numbering scheme

6.6.3 Apartment numbering

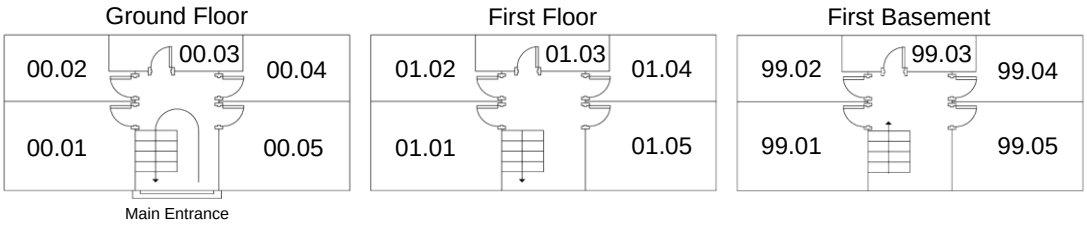
Two digit number with leading zero for single digit numbers: 01 - 99

Viewed from the main entrance the numbering starts at the first apartment on the left hand side and proceeds clockwise.

In contrast to the original numbering system [25] apartments on the ground floor also have a two digit number with leading zero if required.

See the following examples.

Example 1



Example 2

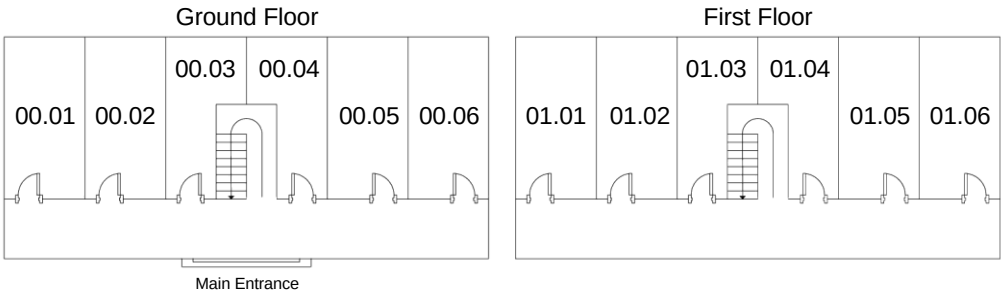


Figure 4 Examples of apartment numbering

In special situations the apartment numbering can be realized on an individual basis according to some logical numbering sequence.

6.6.4 Special cases

For apartments distributed over multiple floors with multiple entries the lowest apartment door is definitive for the numbering.

For apartments on the same floor with multiple entries the main entrance to the apartment is definitive for the numbering.

6.6.5 Apartment splitting

Any unaffected apartments keep their old number.

The new or split apartments have to be renumbered and receive consecutive numbers starting at the first free number for the floor.

Figure 5 shows an example.

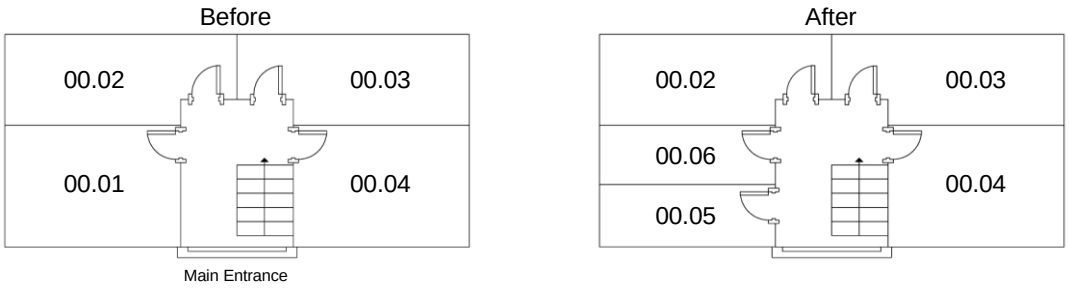


Figure 5 Example of apartment splitting

6.6.6 Apartment merging

The higher apartment number is discarded (see the following example).

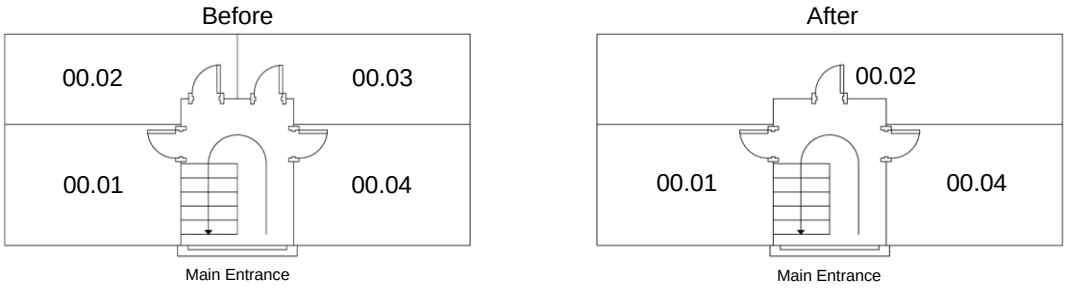


Figure 6 Example of apartment merging

6.6.7 Building extension

In the case of an extension to an existing building new apartments are subject to continued numbering according to the rules set out in this chapter.

6.6.8 Status of apartment identification in Switzerland

The city, community and power utilities have their own standardized apartment identification systems that have been successfully used for several decades. Local authorities, power, gas, water supply and teleheating utilities as well as most real estate owners are generally using such standards.

The extensive use, the high quality and the long term experience for these standards assures the efficiency of the current apartment identification for most Swiss municipalities and utilities. In order to facilitate the FTTH roll out, it may make sense for local / regional utilities use their own standards.

However, an exchange of information between existing local identification and the new swiss identification standard based on a conversion table should be provided.

7 Quality of the in-house cabling (BEP-OTO)

The in-house cabling (BEP-OTO) has the following components:

- Indoor cable
- Splices and splice protectors
- Optical connectors or connectorized pigtails

The reference values for insertion loss and return loss are described in Table 9.

Generally, the attenuation of the indoor cables can be neglected for correct in-house cabling (low bending loss, no stress on fibres, cables, splice protectors, etc.) because the indoor cable length is short (approx. 50 m). Therefore, a proper in-house installation (BEP-OTO) shall have maximum 0.9 dB attenuation (see Table 9).

The values given in this document are based on current FTTH deployment. Floor distributors and BEP using connectors are not taken into account.

8 Testing the in-house cabling (BEP-OTO)

The property owner or network operator shall decide about the need of the testing procedure and the proper test method. However, the installer is responsible for installing the in-house cabling (BEP-OTO) according to the quality described in chapter 7.

The testing of optical fibre cabling shall be performed as defined in IEC 61280-4-2 [16] at 1550 nm.

The measurements can be carried out as follows:

1. Reference test method: bidirectional OTDR measurement between POP and OTO
2. Alternative test method: unidirectional OTDR measurement from the OTO

Correct splice and insertion loss values of optical connectors can be evaluated only by bidirectional OTDR measurements. However, in practical situations the alternative test method (2) can be used to evaluate the optical link. This method should give the installer an indication about losses with an acceptable level of confidence. This simplified test method is based on assumptions that shall be agreed between installer and network operator.

The installer shall provide the network operator with two main deliverables regarding the link quality confirming that:

1. the insertion (IL) and return loss (RL) values of splices, connectors and fibres are correct
2. the optical link OTO-BEP provides the required optical performances (no break in the cable, acceptable bend losses, etc.)

The launch and tail measurement fibre for OTDR measurements shall be G.657A or G.652D fibre with a minimum length of 300 m. The use of a launch fibre of the same type as the fibre in the drop cable gives lower uncertainty for unidirectional OTDR measurements.

If light is already present on the optical fibre, the testing may be performed at 1310 nm using a 1550 nm filter or at 1625 nm using an OTDR with dedicated ‘in-service’ module.

8.1 Reference test method: bidirectional OTDR measurement between POP and OTO

This measurement requires simultaneous access to POP and OTO for each fibre link and gives a **correct evaluation** of the following events:

- of splices, optical connectors, fibres and bends
- return loss of splices and optical connectors, as well as local fibre defects

The reference values of the mentioned losses are summarized in Table 9.

Table 9 Bidirectional measurement: insertion and return loss requirements

Parameter	**BEP**	**OTO (see remarks below)**		**Total**
Measurement: OTDR bidirectional	Splice [dB/event]	Splice	Optical connector	
IL (maximum value of each splice and connector)	0.15 dB	0.25 dB	0.5 dB	0.9 dB

Parameter	BEP	OTO (see remarks below)		Total
IL (maximum value OTO (splice plus connector))	n/a	0.75 dB		
RL (minimum value)	60 dB	60 dB	60 dB (mated)	

Remarks:

1) Because the distance between the splice and the optical connector at the OTO is short (typically 0.5m), these will be seen on the most OTDRs (depending on the resolution) as one event that shows one insertion loss and one return loss value.

2) In order to evaluate correctly the insertion loss and return loss of splice and connector at the OTO (one event on OTDR display):

a) perform bidirectional OTDR measurements. On the OTDR display this will be seen as one event at the OTO (splice AND connector).

b) The correct value of the insertion loss of the event (splice and connector at OTO) is obtained by averaging the insertion loss values measured in each direction. This averaged value shall be within the limits given below:

⇒ IL max: 0.75 dB (0.5 dB connector + 0.25 dB splice)

⇒ RL min: 60 dB

8.2 Unidirectional OTDR measurement from the OTO

In most situations it is not possible to have access to the POP to perform bidirectional OTDR measurements. In these situations alternative, simplified test methods, unidirectional OTDR, can be used that give an acceptable indication to the installer regarding the link quality between OTO and BEP.

An assessment value for the attenuation between OTO and BEP of a proper in-house installation shall be agreed between installer and property owner or network operator. A default value of less than or equal to 1.4 dB (OTDR trace markers shall be positioned before the OTO and after BEP) should be considered.

It is important to note that the unidirectional OTDR measurements do not present the real values, see chapters 7 and 8.1. The simplified test method does not negate the obligation of the installer to provide the network operator with the performance presented in chapter 7.

It should be mentioned that many fusion splicing devices give a good indication of the mean values of the splices. An uncertainty of about +/-0.04 dB / splice should be considered.

The use of a launch fibre of the same type as the fibre in the drop cable gives lower uncertainty for unidirectional OTDR measurements.

The following diagrams are examples of OTDR measurements showing both acceptable and unacceptable performance. In each case the measurement is made between the trace markers ‘A’ and ‘B’.

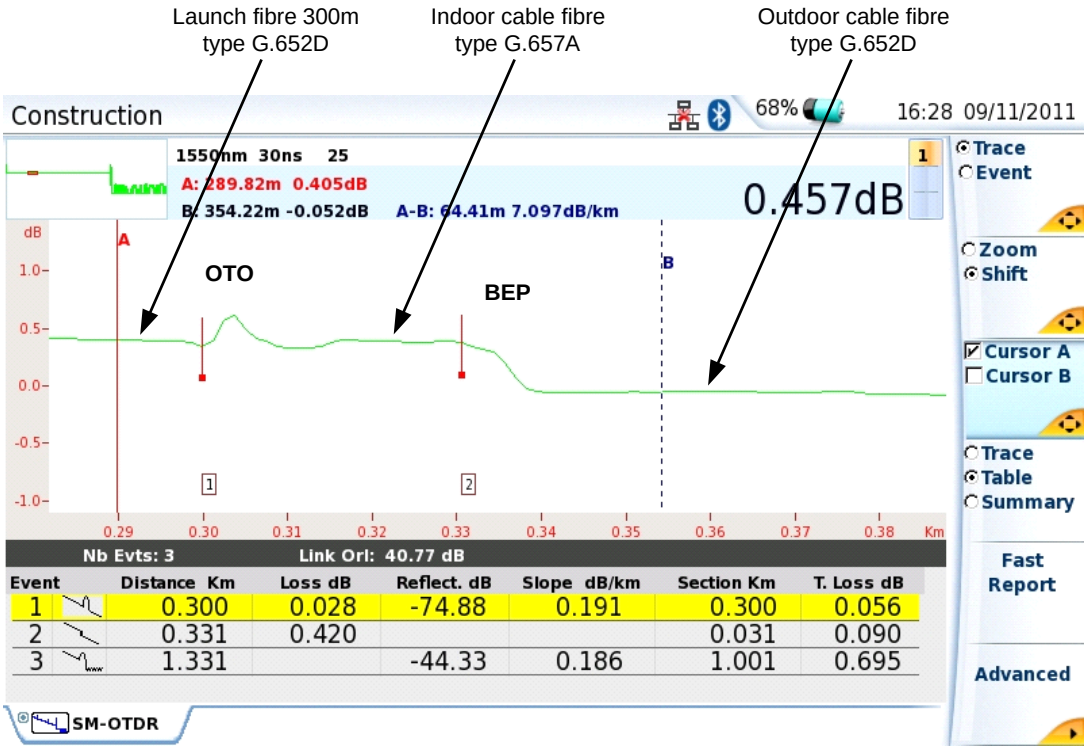


Figure 7 OTDR trace showing a link with acceptable loss

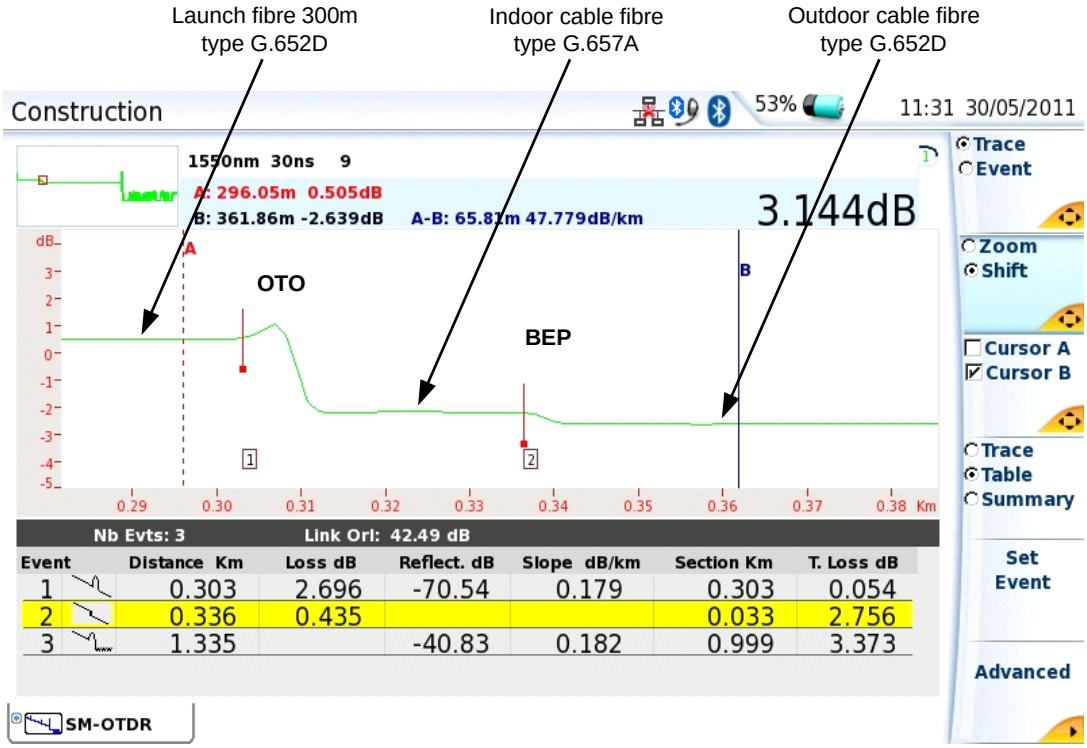


Figure 8 OTDR trace showing a link with unacceptable loss

9 Safety requirements

9.1 General requirements

Work shall be performed by certified technicians only. The laser safety requirements are according to the IEC 60825 series [19] and SUVA [20].

The electrical safety requirements are according to NIV 734.27 [21].

Each network operator is responsible for correctly interpreting and implementing the safety requirements described in the referenced documents.

9.2 Laser safety

According to the IEC 60825 series the type of the customer premises is “unrestricted”.

As long as FTTH implementations respect hazard level 1 (IEC 60825 series [19]) at the customer premises, as well as laser class 1 or 1M (IEC 60825 series [19]) of the laser sources, no special requirements regarding marking or laser safety are necessary at the customer premises (from the optical cable entry point into the building through to the optical-electrical converter, including BEP and OTO) has to be considered.

For other FTTH implementations special attention must be provided to laser safety if the hazard level is higher than 1 and therefore specific protection measures shall be implemented between POP and ONT according to the specified standards. According to the standards referenced above, hazard levels 3B and 3R are not permitted at the customer premises.

10 Annex 1 Home cabling

10.1 General recommendations

The home cabling should be structured conform to EN 50173-4 [17] and allow operation of Ethernet/LAN, CATV/HF-Broadcast and telephony at each multimedia connection point.

The cabling from the central distribution point (multimedia distribution box) should be deployed with a ‘star’ architecture and in the basic version consists either of high quality twisted-pair cables or a combination of twisted-pairs and a 75 Ohm coaxial cable.

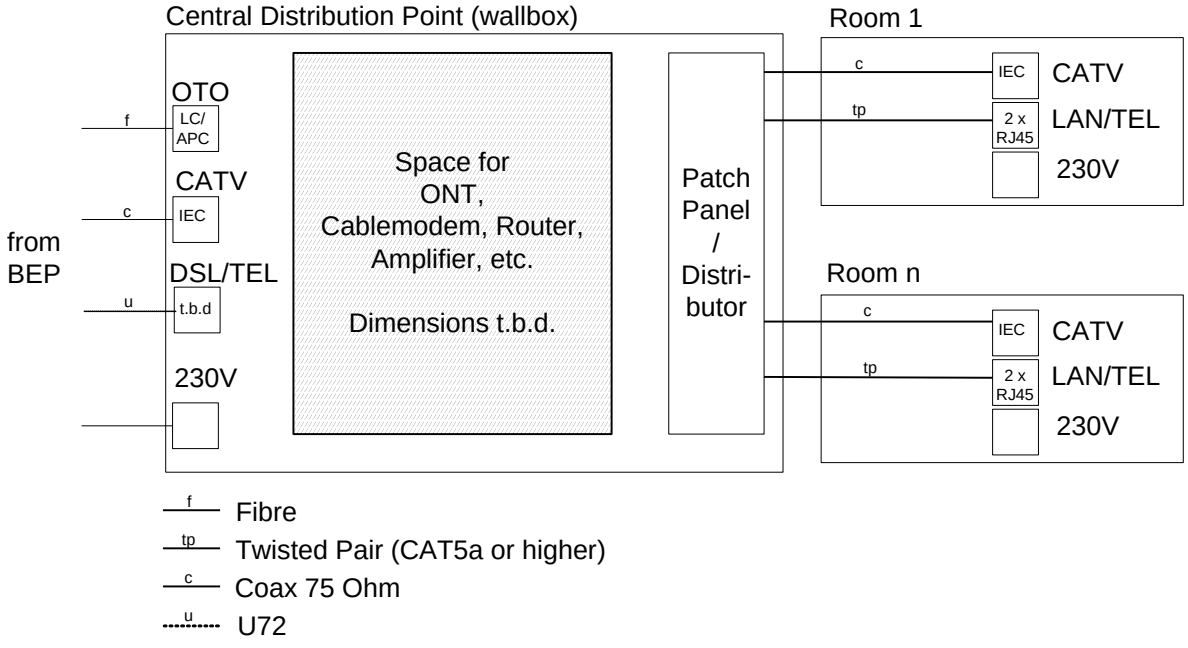
In principle, at least one multimedia access point per room should be provided. If the communications infrastructure is not completed for all rooms in the initial building phase at least the conduits and mounting boxes for the sockets should be installed to simplify the subsequent installation of the remaining communications infrastructure.

The high-frequency broadcast part of the structured cabling should be bi-directional and fulfil the electrical requirements according to EN 50083-x, e.g. [18].

The home cabling in the customer premises (OTO - ONT/CPE - user equipment) is described in the Multimedia Installation handbook [26] edited by the SEV (Swiss Electrotechnical Committee).

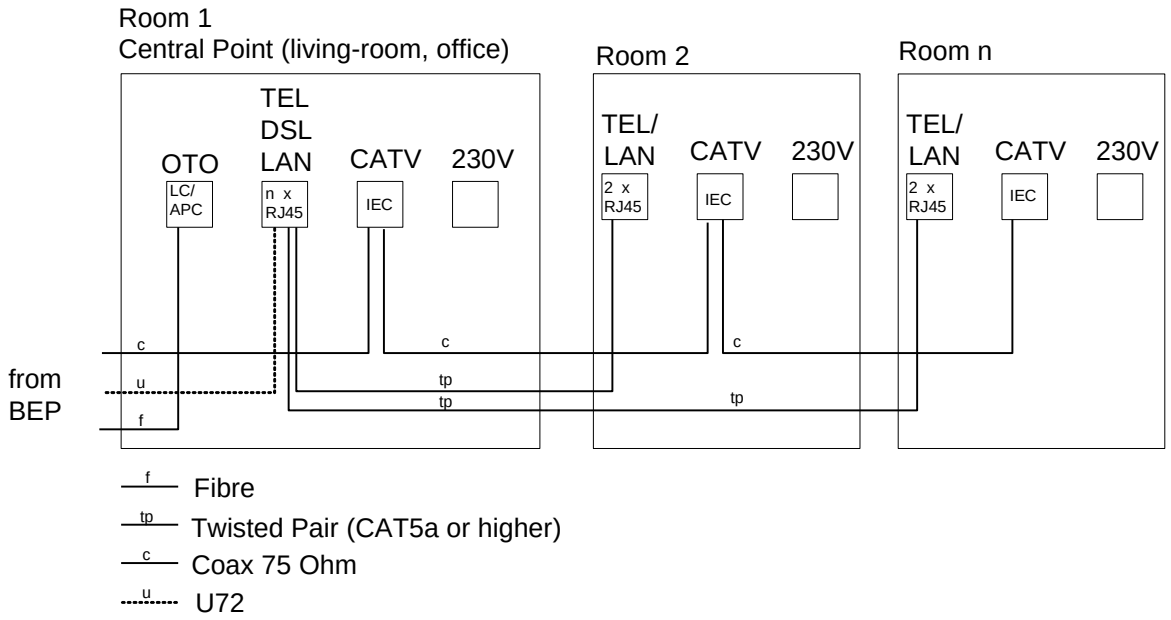
10.2 Example with central home distribution rack or ‘wall embedded box’

This generic structure should be applied in single family houses or apartments with more than 3 rooms.



10.3 Example without central distribution rack or ‘wall embedded box’

This simple structure can be applied in smaller apartments up to 2/3 rooms.



11 Annex 2 FTTH in-house installation in new buildings

New buildings should be provided with an FTTH installation to cover present and future needs.

The following table summarises the most important aspects that should be considered regarding the fibre part of the in-house installation and references commonly needed details. The references correspond to this BAKOM technical guideline and to the CES handbook [26].

Each situation shall be evaluated separately.

Process	Reference for details	Observations
Physical entry into the building and to the BEP	- BAKOM Ch. 4.1, 4.3.2 - CES Ch. 7	General guidance is given in the BAKOM guideline, details in the CES handbook.
Type of building - individual residential house - apartment building - business premises	- BAKOM Ch. 4.1 - CES Ch. 9	Detailed planning criteria for each type of building are described in the CES handbook.
Dimensioning the indoor ductwork	- CES Ch.9	Where possible a duct to the electrical distribution box should be provided for smart metering or other future purposes.
Transmission media (fibre, copper, coax, etc.)	- BAKOM Ch. 10 - CES Ch. 7, 9	The CES handbook details the deployment of all transmission media while the BAKOM guideline is focused on fibre.
Home cabling	- BAKOM Ch. 10 - CES Ch. 9	It is advisable to provide enough space for future applications.
BEP placement in new buildings	- BAKOM Ch. 4.3.2 - CES Ch. 7.2	Recommended to be placed in a technical room, copper and fibre in the same place
OTO placement	- BAKOM Ch. 6.4 - CES Ch.9	It is recommended to use a multimedia distribution box.
Principle of deployment	- CES	According to the agreement with the provider
Time of FTTH in-house deployment	-	According to the agreement with the provider