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TECHNICAL SPECIFICATION

Versatile Link Plus
Terminated Cords and Cables Specifications

ABSTRACT:

This document specifies the terminated cable assemblies to be used in the passive plant of the VL+ system.

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HISTORY OF CHANGES

REV. NO.	DATE	PAGES	DESCRIPTIONS OF THE CHANGES
0.1	2018-10-28	All	First draft for discussion
0.2	2018-12-20	All	Reviewed by Francois Vasey.
0.3	2019-02-11	All	Implementation of F. Vasey comments.
1.0	2019-03-04	All	First version.
1.1	2019-07-29	5, 6, 7, 9, 10	Additional comment regarding the minimum bending radius of fibres and cables.

SPECIFICATION TREE

The hierarchy of Versatile Link Plus specifications is shown below. The position of the present specification document is highlighted in bold. Line items in italic will not result in specification documents but are shown to ease understanding of the structure.

	EDMS Document Number
Part 1. System	1719328
Part 2. Components	
Part 2.1 Front-End Transceiver Module	1719329
Part 2.1.1 Laser diode (VCSEL) Die	1762631
Part 2.1.2 Photodiode Die	1762632
Part 2.1.3 Laser Driver	1719330
Part 2.1.4 Transimpedance Amplifier	1719333
Part 2.2 Back-End Transmitter/Receiver	1762899
Part 2.3 Passive Optical Components	1762900
Part 2.3.1 Optical fibres	2045619
Part 2.3.2 Optical cords and cables	2045620
Part 2.3.3 Terminated cords and cables	**2045621**

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1. INTRODUCTION

The Versatile Link Plus (VL+) project provides a multi-gigabit per second optical physical layer for the data readout and control of High Luminosity LHC (HL-LHC) experiments. A flexible bidirectional system architecture is proposed for which components are specified in this document set.

This document specifies the terminated cable assemblies to be used in the passive cabling plant of the VL+ system: naked fan-out, multi-fibre patch cords, fan-out patch cords, shuffle patch cords and trunk cables.

2. COMPONENT DESIGN SPECIFICATIONS

2.1 NAKED FAN-OUT

The naked fan-out consists of a bundle of naked fibres with one multi-fibre connector on a side, and multiple multi-fibre connectors on the other side. This is illustrated in Figure 1.

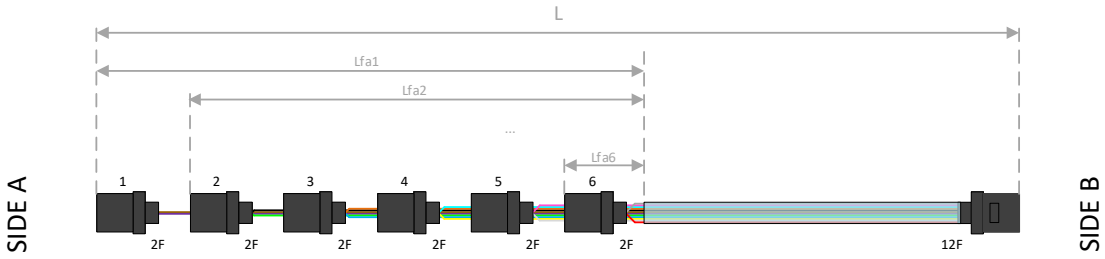

Figure 1 — Example of naked fan-out with seven connectors and two fibres per connector on SIDE A.

The naked fan-out can contain up to 24 optical fibres.

An optical fibre protection/loose tube can be used in some particular cases. This protection shall be flame retardant, low smoke and halogen free (LSZH).

Optical fibre connectors fitted to the fibres shall be able to support a tensile force of few Newton (to be defined).

A minimum bending radius of 15 mm shall be considered in order to prevent the fibre from damaging or degrading its performance.

The length tolerance requested for naked fan-out is specified in Table 1. Total naked fan-out length always includes the connectors.

Table 1 — Naked fan-out length tolerance.

Multi-fibres patch cord length [m]	Length tolerance	Special length tolerance
any L	-0 / +2 cm	-0 / +1 cm

The connectors shall be low loss MT ferrules. The MT ferrule specifications are given in chapter 3.

2.2 MULTI-FIBRE PATCH CORD

The multi-fibre patch cord consists of a multi-fibre cord with multi-fibre connectors at each end. This is illustrated in Figure 2.

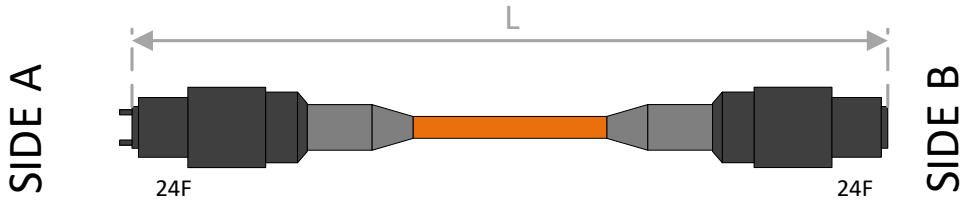

Figure 2 — Example of multi-fibre patch cord with up to 24 fibres.

The multi-fibre cords can contain 12 or 24 optical fibres and are described in another document (EDMS 2045620).

An optical fibre protection/loose tube can be used in some particular cases. This protection shall be flame retardant, low smoke and halogen free (LSZH).

Optical fibre connectors fitted to the cord cable shall be able to support a tensile force of 44 N.

A minimum bending radius of ten times the outer jacket dimensions (to be defined) shall be considered in order to prevent the cable from damaging or degrading its performance.

The length tolerance requested for multi-fibre patch cords is specified in Table 2. Total multi-fibres patch cord length always includes the connectors.

Table 2 — Multi-fibres patch cord length tolerance.

Multi-fibres patch cord length [m]	Length tolerance	Special length tolerance
any L	-0 / +5 cm	-0 / +2 cm

The connectors shall be low loss MPO/MTP connectors with 24 fibres. The connector performance and assembly specifications are given in chapter 3.

The MPO/MTP connectors on SIDE A shall be of male gender up to 24 fibres and the MPO/MTP connector on SIDE B of female gender with 24 fibres. The MPO/MTP male connector with alignment pins is specified as MPOM and the MPO/MTP female connector as MPOF.

2.3 FAN-OUT PATCH CORD

The fan-out patch cord consists of a multi-fibre cord with one multi-fibre connector, a fan-out kit and multiple multi-fibre cords with multi-fibre connectors on the fan-out side. This is illustrated in Figure 3.

The fan-out patch cord can have more than two branches on SIDE A, in which case the unused fibres will be cut inside the connector boot.

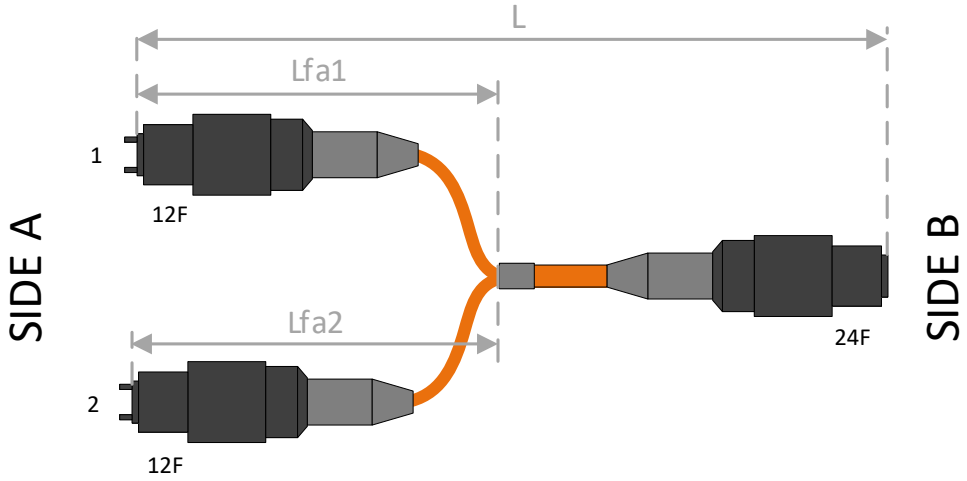

Figure 3 — Example of fan-out patch cord with 24 fibres and 2 single cords of 12 fibres.

The multi-fibre cords can contain 12 or 24 optical fibres and are described in another document (EDMS 2045620).

An optical fibre protection/loose tube can be used in some particular cases. This protection shall be flame retardant, low smoke and halogen free (LSZH).

The fan-out kit shall have a diameter of less than 5 mm and shall be non-magnetic. Fibres shall be of one single length between the connectors at its extremities (no splices).

Optical fibre connectors fitted to the cord cable shall be able to support a tensile force of 44 N.

A minimum bending radius of ten times the outer jacket dimensions (to be defined) shall be considered in order to prevent the cable from damaging or degrading its performance.

The length tolerance requested for fan-out patch cords is specified in Table 3. Total fan-out patch cord length always includes the connectors.

Table 3 — Fan-out patch cord length tolerance.

Fan-out patch cord length [m]	Length tolerance	Special length tolerance
any L	-0 / +5 cm	-0 / +2 cm

The connectors shall be low loss MPO/MTP connectors with either 12 or 24 fibres.

The MPO/MTP connectors on SIDE A shall be of male gender with 12 fibres and the MPO/MTP connector on SIDE B of female gender with 24 fibres. The MPO/MTP male connector with alignment pins is specified as MPOM and the MPO/MTP female connector as MPOF.

2.4 SHUFFLE PATCH CORD

The shuffle patch cord consists of multiple multi-fibres cords with multi-fibres connectors, a shuffle box and multiple multi-fibres cords with multi-fibres connectors on the other side. This is illustrated in Figure 4.

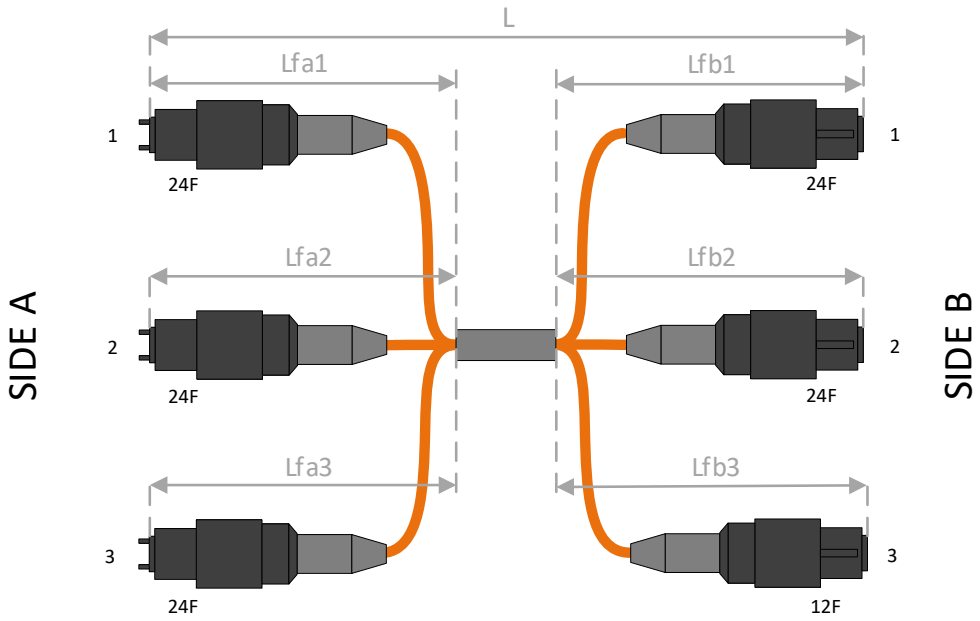

Figure 4 — Example of shuffle patch cord with three multi-fibres cords of 24 fibres on one side and two multi-fibres cords of 24 fibres plus one multi-fibre cord of 12 fibres on the other side.

The multi-fibre cords can contain 12 or 24 optical fibres and are described in another document (EDMS 2045620).

An optical fibre protection/loose tube can be used in some particular cases. This protection shall be flame retardant, low smoke and halogen free (LSZH).

The shuffle box shall have a dimension of maximum 50 x 90 x 10 mm and shall be non-magnetic. Fibres shall be distributed among the different multi-fibres cord within this box. Fibres shall be of one single length between the connectors at its extremities (no splices).

Optical fibre connectors fitted to the cord cable shall be able to support a tensile force of 44 N.

A minimum bending radius of ten times the outer jacket dimensions (to be defined) shall be considered in order to prevent the cable from damaging or degrading its performance.

The length tolerance requested for shuffle patch cord is specified in Table 4. Total shuffle patch cord length always includes the connectors.

Table 4 — Fan-out patch cord length tolerance.

Shuffle patch cord length [m]	Length tolerance	Special length tolerance
any Lf	-0 / +5 cm	-0 / +2 cm

The connectors shall be low loss MPO/MTP connectors with either 12 or 24 fibres.

The MPO/MTP connectors on SIDE A shall be of male gender and the MPO/MTP connector on SIDE B of female gender. The MPO/MTP male connector with alignment pins is specified as MPOM and the MPO/MTP female connector as MPOF.

2.5 TRUNK CABLE

The trunk cable is a multi-fibre cable terminated with multi-fibre connectors. The trunk cable can be of the breakout type (without fan-out kits) or of the fan-out type (with fan-out kits). Each multi-fibre cord inside the cable hosts 12 or 24 fibres and shall be terminated with multi-fibre connectors at both ends. This is illustrated in Figure 5.

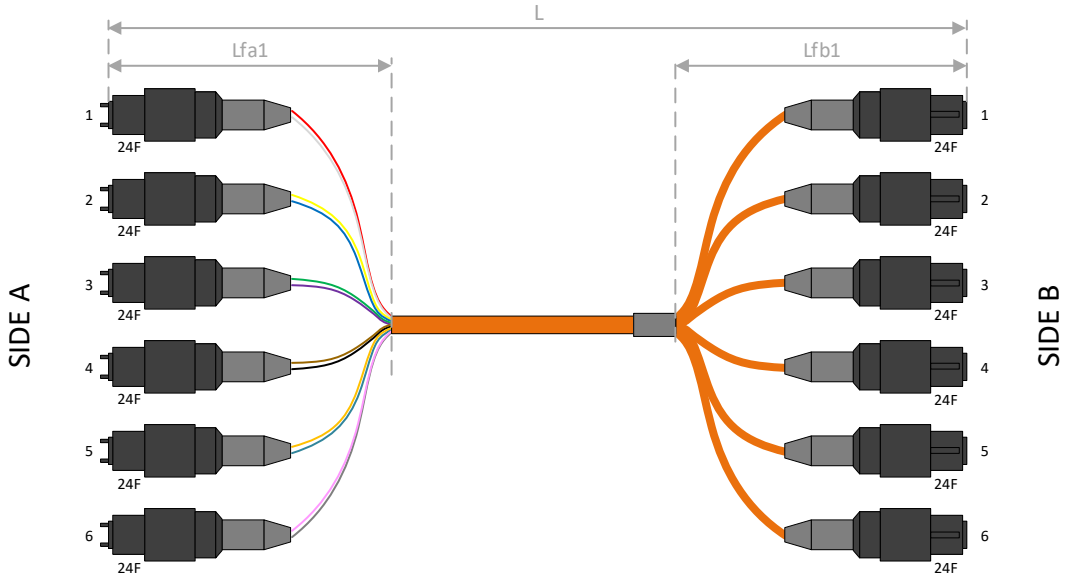

Figure 5 — Example of trunk cable with 6 single branches of 24 fibres. Side A is of breakout type while side B is of fan-out type.

The multi-fibre cable can contain up to 144 optical fibres and is described in another document (EDMS 2045620).

The optical fibre protection/loose tube that can be used shall be flame retardant, low smoke and halogen free (LSZH).

The fan-out kit shall have a diameter of less than 12 mm and shall be non-magnetic. Fibres shall be of one single length between the connectors at its extremities (no splices).

The breakout type construction shall be designed in order to prevent any risk of damage for the fibres at the point of transition, without the need of using fan-out kits.

Optical fibre connectors fitted to the cord cable shall be able to support a tensile force of 44 N.

A minimum bending radius of ten times the outer jacket dimensions (to be defined) shall be considered in order to prevent the cable from damaging or degrading its performance.

The length tolerance requested for trunk cables is specified in Table 5 and Table 6. The total trunk cable length always includes the connectors.

Table 5 — Breakout cable length tolerance for trunk cables.

Breakout cable length [m]	Length tolerance	Special length tolerance
L ≤ 25	-0 / +10 cm	-0 / +5 cm
25 < L < 150	-0 / +1%	-0 / +5 cm

Table 6 — Fan-out length tolerance for trunk cables.

Fan-out length [m]	Fan-out length tolerance	Special fan-out length tolerance
any Lf (typically Lf ≤ 2 m)	-0 / +5 cm	-0 / +2 cm

The trunk cable may have a staggered configuration of the single multi-fibre cords. Figure 6 shows an example specification of a trunk cable with six single cords. The grading, or offset, is the distance between each group of single cords (measured from the edge of the connector ferrule).

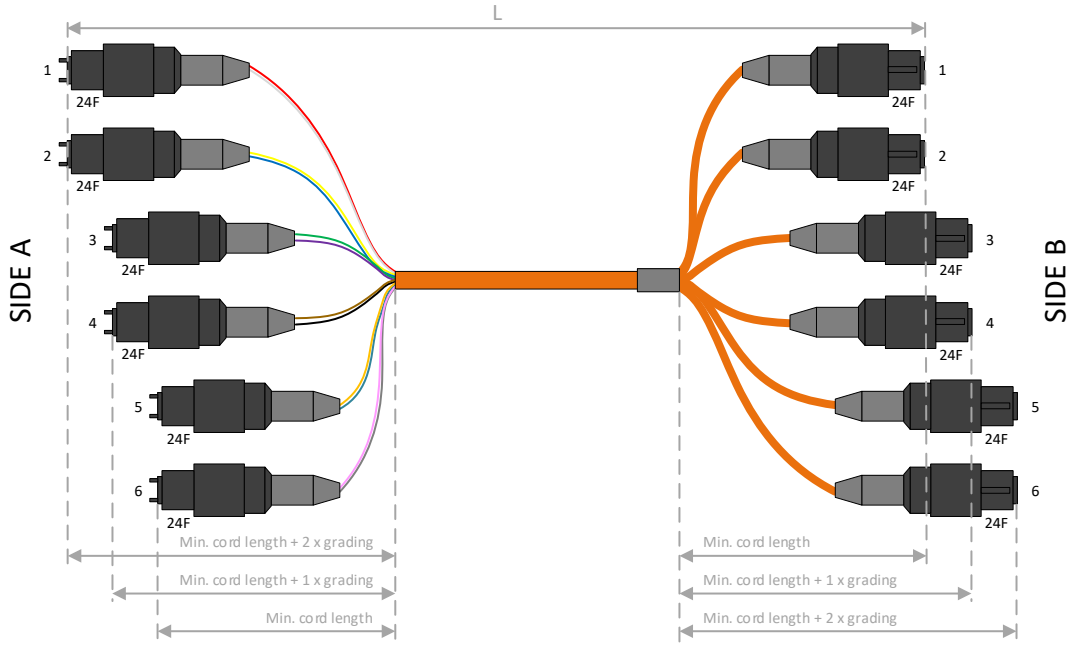

Figure 6 — Example of trunk cable with 6 single cords, staggered in groups of 2.

Typical dimensions of the fan-out part are defined in Table 7.

Table 7 — Typical dimensions of the fan-out part of trunk cables.

Minimal cord length (Lf)	Grading
1.5 m	0.05 m

The connectors shall be low loss MPO/MTP connectors with either 12 or 24 fibres.

The ends of the trunk cable shall be properly protected and packaged with material, suitable for the forthcoming installation. Pulling sleeves shall be always included in the

packing. Trunk cables of all types shall be equipped with pulling sleeves on both extremities.

3. CONNECTOR PERFORMANCE AND ASSEMBLY

3.1 CONNECTOR PERFORMANCE

The connectors shall be low loss MT ferrules or MPO/MTP connectors with either 12 or 24 fibres.

Insertion and Return loss values for optical multi-fibre connectors are specified in Table 8. Optical performance specification is defined for each single-fibre of an optical multi-fibre connector interface (maximal value) and for the average value of all fibres of one interface (typical value).

Table 8 – Optical specifications for 12 and 24 fibres MPO connector.

Attribute	Units	Max.	Typ.
Insertion Loss	dB	≤ 0.35	≤ 0.10
Return Loss	dB	≥ 20	

The connector performance shall be tested against reference connectors according to IEC 61300-3-4 Insertion Method B and IEC 61300-3-6 Method 2. The optical performance shall be within the specified threshold for multi-mode fibre at 850 nm. Multi-mode launch conditions shall be according to IEC 61280-4-1. The connector end-faces shall be cleaned according to the manufacturer's instructions and visually examined before performance testing.

The optical connectors, adapters and their mechanical compatibility are defined in IEC standards 61754 series. The dimensional and material requirements of the ferrule end-face are defined in IEC 61755-3 series.

The material used should be flame retardant and halogen-free. Ideally, the materials used will be non-magnetic and the mass and profile of the connector should be minimized. If magnetic materials are within the connectors the mass and magnetic susceptibility (μr) must be specified.

3.2 CONNECTOR ASSEMBLY

Two different types of connector assembly methods (type A, type B) may be used for multi-fibre connectors.

The configuration of type A is shown in Figure 7 for multi-fibres connectors of 12 fibres.

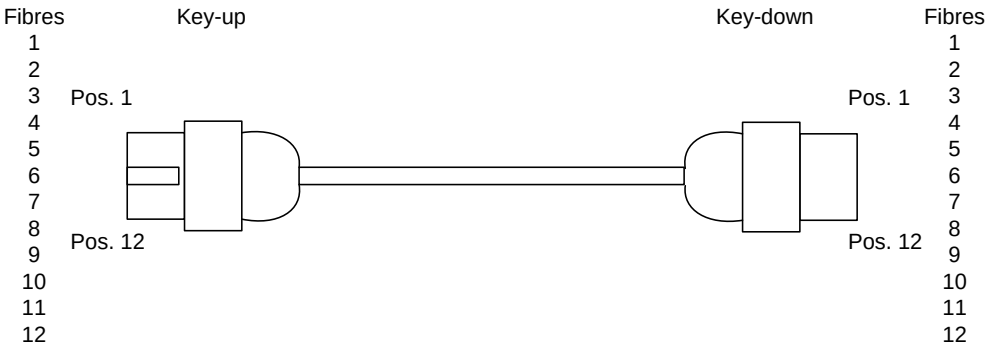

Figure 7 — Multi-fibre connector assembly method type A.

The configuration of type B is shown in Figure 8.

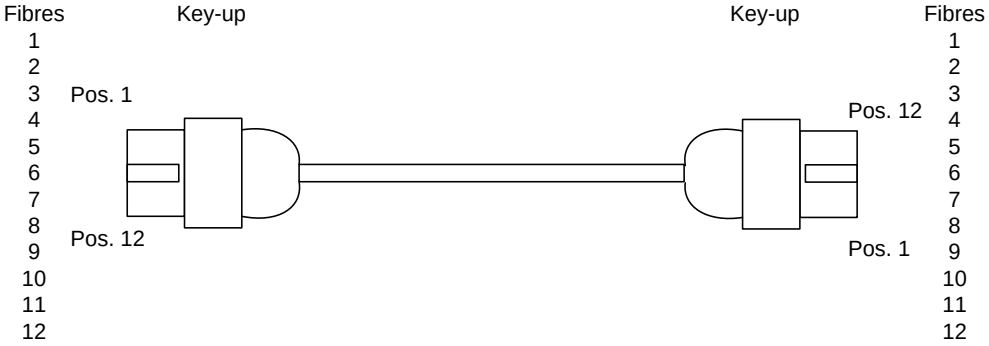

Figure 8 — Multi-fibre connector assembly method type B.

For multi-fibre connectors with 24 fibres, the 24 fibres are arranged in two rows of 12 fibres each. The definition of the rows "top" and "bottom" is shown in Figure 9. Row "top" is the row next to the key of the multi-fibre connector. In case of MT ferrule, the key side is the side of the epoxy window.

For configuration of type A, the 12 fibres of row "top" at one extremity shall be connected to the row "bottom" at the other extremity, and vice versa.

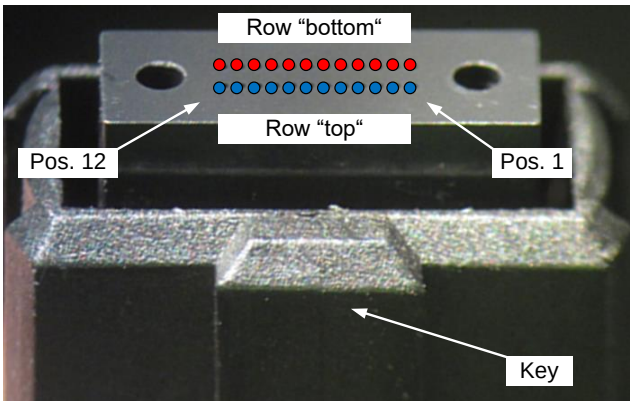

Figure 9 — Multi-fibre connector with 24 fibres arranged in 2 rows, row “bottom” (red) and row “top” (blue).

3.3 CONNECTION TABLE

The connection table gives information on the position of the fibres in a connector and the links with the other connectors.

One connection table is made per connector on SIDE B. In case the component have more than one connector on SIDE B, multiple connection tables shall be made.

The connectors are identified by the combination of a letter, representing the side of the assembly, and a number, corresponding to the connector number.

The first column of the table represents the described connector. The table contains as many lines as the described connector contains optical fibres, and as many columns as the number of connector on SIDE A. The number given at the intersection of a line and a column indicate the position of the fibres associated to the line in the connector associated to the column.

Figure 10 gives an example of a connection table for a naked fan-out with six MT ferrule on SIDE A. The described components is shown on Figure 1.

CONNECTION						
SIDE B	SIDE A1	SIDE A2	SIDE A3	SIDE A4	SIDE A5	SIDE A6
1						6
2					6	
3				6		
4			6			
5		6				
6	6					
7	7					
8		7				
9			7			
10				7		
11					7	
12						7

Figure 10 – Example of a connection table for a naked fan-out with six MT ferrules on SIDE A. The described components is shown on Figure 1.

4. INTERCONNECTION SPECIFICATIONS

4.1 MT FERRULE TO MT FERRULE ADAPTER

An MT Spring Clamp allows the connection of two MT Ferrules at the VTRx+ patch panel.

Figure 11 gives an overview of the two MT Ferrules connection.

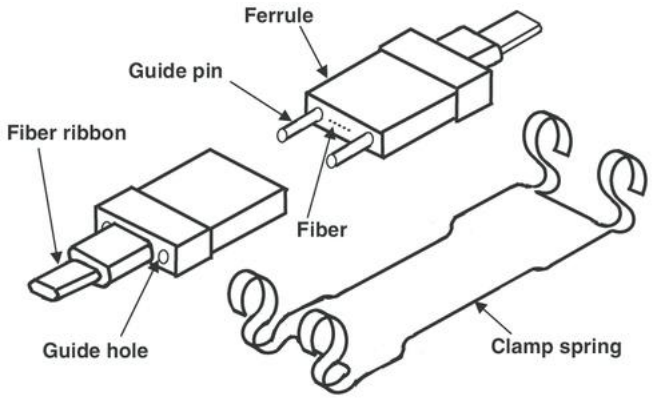

Figure 11 – Connection of two MT Ferrules using a MT Spring Clamp.

Figure 12 gives the characteristic dimension of the MT Spring Clamp.

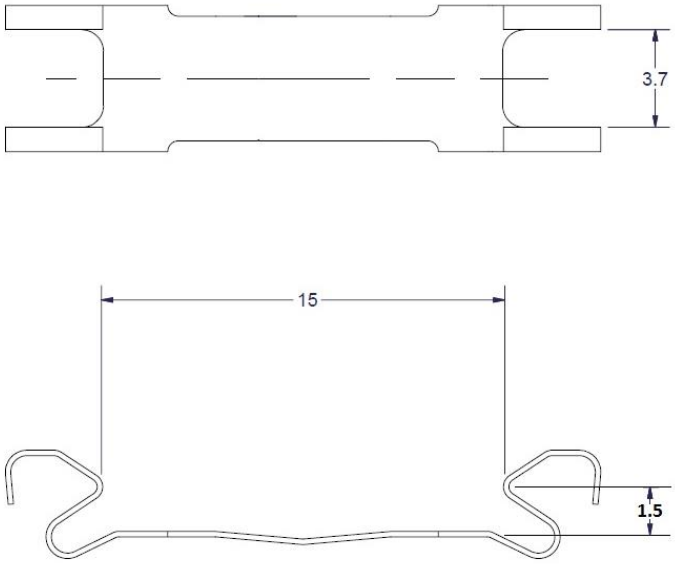

Figure 12 – Characteristic dimensions of the MT Spring Clamp.

The optical connectors, adapters and their mechanical compatibility are defined in IEC standards 61754-7 series.

The MT Spring Clamp has to be made of non-magnetic material (e.g. Beryllium Copper).

4.2 MT FERRULE TO MPO/MTP ADAPTER

An MT Ferrule to a MPO/MTP adapter allows the connection of an MT Ferrule with a MPO/MTP connector at the PP0 patch panel.

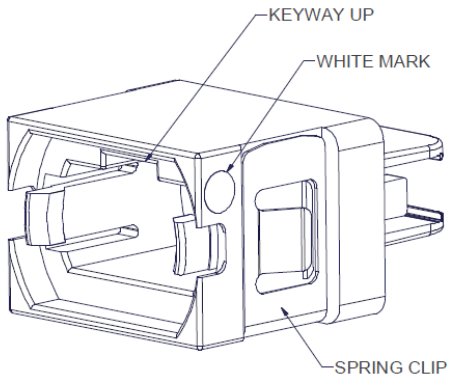

Figure 13 – MT Ferrule to MPO/MTP adapter.

The optical connectors, adapters and their mechanical compatibility are defined in IEC standards 61754-7 series.

The MT Ferrule to MPO/MTP adapter has to be made of non-magnetic materials.

Stackable adapters would be an advantage.

4.3 MPO/MTP ADAPTER

An MPO/MTP adapter allows the connection of two MPO/MTP connectors at the PP1, PPRack and PPShelf patch panels.

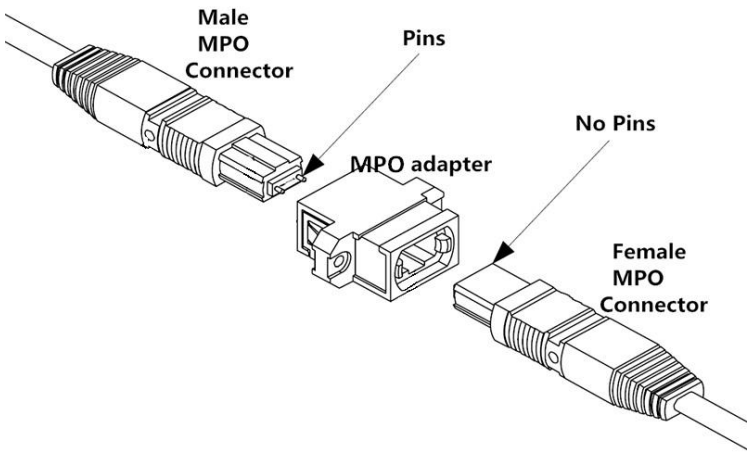

Figure 14 – Connection of two MPO/MTP connectors using an MPO/MTP adapter.

The optical connectors, adapters and their mechanical compatibility are defined in IEC standards 61754-7 series.

Adapters are either key-up/key-down (type A) or key-up/key-up (type B). In case high density is required, stackable adapters could be used.

The MPO/MTP adapter has to be made of non-magnetic materials.

5. ENVIRONMENTAL SPECIFICATIONS

In function of the installation place, the terminated cords and cables are subject to different environmental conditions. The material used for assembling the terminated cords and cables shall be chosen in function of these conditions.

5.1 STANDARD ENVIRONMENT

The specifications of the standard environment are given in Table 9.

Table 9 – Environmental Specifications for the multi-fibres patch cord.

#	Attribute	Min.	Typ.	Max.	Unit.
	Total Ionising Dose			10	kGy
	Total Neutron Fluence			1×10^{14}	cm^{-2}
	Total Hadron Fluence			1×10^{14}	cm^{-2}
	Operating Temperature	0		+60	°C
	Magnetic Field			4	T

5.2 HARSH ENVIRONMENT

The specifications of the harsh environment are given in in Table 10.

Table 10 – Environmental Specifications for the multi-fibres patch cord.

#	Attribute	Min.	Typ.	Max.	Unit.
	Total Ionising Dose			1	MGy
	Total Neutron Fluence			1×10^{15}	cm^{-2}
	Total Hadron Fluence			1×10^{15}	cm^{-2}
	Operating Temperature	-35		+25	°C
	Magnetic Field			4	T

The assemblies produced for this environment will be called "radiation resistant".