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LHC

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LHC-X1ZDC-EN-0001

Date: 2021-06-03

TECHNICAL NOTE

Installation of ZDC Signal Air-Core Cables

ABSTRACT:

This technical note is intended to specify the details of the installation of ZDC air-core cables. It contains information about materials, as well as the path and technical solution chosen.

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DOCUMENT SENT FOR INFORMATION TO:

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HISTORY OF CHANGES

REV. NO.	DATE	PAGES	DESCRIPTIONS OF THE CHANGES
0.1	2021-04-21	17	Draft sent into approval loop.
0.2	2021-05-26	19	Implemented comments after the first approval loop. Document sent into approval.
0.3	2021-06-03	19	Final version (changes: Figure 6, list of people for approval, specified the chosen J hook)

TABLE OF CONTENTS

1. INTRODUCTION

1.1 ZDC REQUEST

The ZDC detector group needs the installation of 8 air-core coaxial signal cables to be routed from ZDC detector installed in the TANs located in sector 1-2 and in sector 8-1 in the LHC tunnel (at about 140 m from IP1) to USA15 service cavern. The eight cables will arrive to the ZDC rack Y.30-11.A1, located at level 1 of bldg. 3125 (USA15).

Four cables will serve ZDC side A, located in the in sector 8-1 TAN, while the other four cables will serve ZDC side C, located in sector 1-2 TAN.

The ZDC detector group requested the installation of these cables to ATLAS Technical Coordination (TC). Due to the kind of cables (stiff and delicate) TC decided to ask for the installation to BE-EA-AS, which has already installed similar cables for ATLAS Forward Physics (AFP) in the past and has good experience as well as the needed resources in terms of tools and personnel.

1.2 REASONS FOR THE REQUEST

The reason to replace the current signal cables with these air-core cables is to mitigate the attenuation in the long cables, which leads to the distortion of the fast intrinsic signals from the ZDC Cherenkov signal.

The only other option was moving the readout system in the tunnel itself, closer to the detector, which was discussed and determined to be too risky and therefore discarded.

While in Run 2, the signal had a rise time of 5 ns and fall time of about 25 ns, meaning typical signals are not contained in one Bunch Crossing (BC), in Run 3 is expected 97% containment within 1 BC and thus safe operation in 50 ns running.

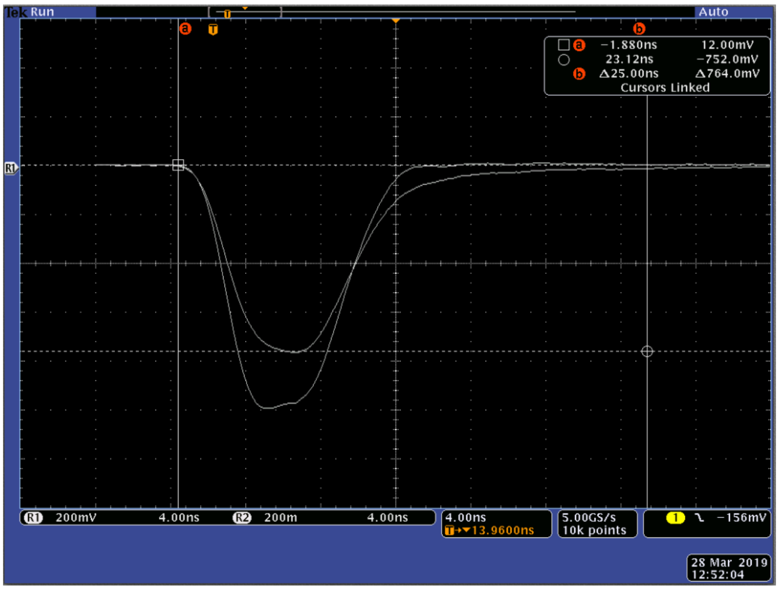


Figure 1 — Signal plot Run 2 vs. Run 3

1.3 CABLES

1.3.1 Air-core cables

The 7/8" HELIFLEX Air-Dielectric Coaxial cable used for this cabling activity has a flame retardant and halogen free jacket in accordance with CERN rules. Its outer diameter is 28mm. The detailed description of the cable can be found in the data sheet in Annex 1.

1.3.2 CC50 cables

The Coaxial cable 50 Ohm Type C-50-6-1 is used as termination of the air-core cable on both ends. In the CERN catalogue it has a SCEM code: 04.61.11.252.3. Its outer diameter is 10.5mm. The detailed description of the cable can be found in the data sheet in Annex 2.

1.4 CONNECTORS

At both ends of each air-core cable a type 7-16 DIN male connector is mounted. The detailed description of the connector can be found in the data sheet in Annex 3.

On both ends of each CC50 cable a coaxial BNC male connector is mounted. In the CERN catalogue it has a SCEM code: 09.46.11.735.0

To join the air-core cable to the CC50 cable, a female/female adapter is used. This joint is shown in Figure 2.

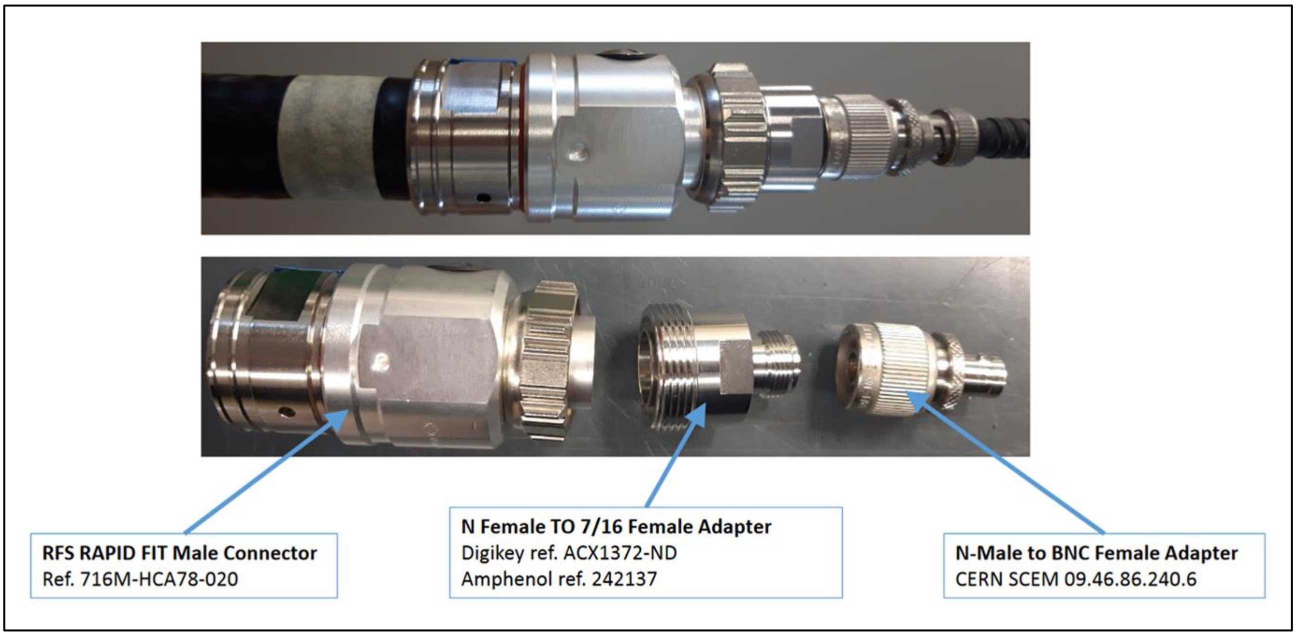


Figure 2 — Air-core to CC50 connection detail

2. CABLING PROJECT

2.1 MATERIAL PROCUREMENT

The ZDC detector group procured nine drums of 300m and all needed connectors. The Drums are safely stored at CERN in bldg. 609. Eight drums will be used for the 8 cables, while a ninth one is kept as spare.

Also, the necessary CC50 extensions will be procured by ZDC detector group.

All necessary items needed for the installation itself (supports, additional cable trays, etc.) will be procured by BE-EA-AS.

2.2 CABLING STUDY

The cabling study was done by ATLAS TC in collaboration with BE-EA. This study includes the 3D model and the cabling document stored in EDMS [1].

The cables path goes from the LHC tunnel to USA15, passing via the survey galleries, the UX15 cavern and the TE16 technical gallery. It is described in more details in chapter 3.

This routing has been agreed between ATLAS TC, BE-EA-AS and ZDC detector group, involving also EN-ACE-INT group for the tunnel portion of the path, EN-EL and BE-GM for the path into the survey galleries.

2.3 PRELIMINARY TESTS

Reflectometry tests have been performed by the ZDC detector group. The results of these tests have shown that it is possible to join two pieces of cables using the above-mentioned connectors. In fact, joining by connectors has been found to create no noticeable artifacts or distortions (a very small reflection has been observed).

2.4 CONSTRAINTS

2.4.1 CABLES

Air-core cables are very stiff, and the bending radii are very large. Despite their stiffness, they are extremely delicate, and they can easily be damaged if handled carelessly or if bended too many times.

2.4.2 LOGISTICS

Air-core cables cannot be routed starting from a mid-point, but they must be pulled necessarily from one end. Due to the size of each drum, the starting point must be the tunnel side.

Each cable weights more than 200kg. Therefore, its handling requires a large amount of people along the path.

Cable trays along the way are partially (if not completely) full. Hence, additional trays or different hanging solutions are required.

2.4.3 TECHNICAL ISSUES

To avoid deteriorating of signal, the splicing points between air-core cables and CC50 cables must be as close as possible to the ending point. The length of CC50 cables should be limit to a maximum of 10m.

During LS3, the part of air-core cables running into the tunnel must be removed to allow the execution of HL-LHC.

Furthermore, during LS3 the TAN will be replaced by the TAXN installed closer toward ATLAS I.P. by about 14m, hence at a distance of 127m from I.P. Therefore, despite each air-core cable will be pulled in one single piece, all cables must be cut into two parts before LS3, to allow the removal and replacement of the tunnel part.

The new routing for the tunnel to be implemented in LS3 will be studied as soon as the configuration for the related portion of the tunnel is defined and frozen (expected in the fourth quarter of 2021).

2.4.4 SAFETY ASPECTS

During the entire duration of the works (installation, testing, etc.) the powering permits of LHC sectors 1-2 and 8-1 must be suspended.

Therefore, the BE-OP-LHC responsible, the BE DSO and the ATLAS LEXGLIMOS must be informed before the work start to ensure that the beam permit status is modified accordingly.

Once the cables are routed and the installation activity is over, the two doors YCPZ01=UPS16 (sector 1-2) and YCPZ01=UPS14 (sector 8-1) must be re-sealed. The sealing shall be inspected and evaluated by the ATLAS LEXGLIMOS and the BE DSO.

Only after the written approval of the sealing the two powering permits can be re-signed to allow again the powering phase in the concerned LHC sectors.

2.5 SCHEDULE

The installation of these air-core cables is foreseen in summer 2021 and currently planned as described below:

- Weeks 26 and 27 side A (sector 8-1)
- Weeks 28 and 29 side C (sector 1-2)

In case of problems or delays, the second option is to postpone the activity after the pilot beam (fall 2021). In this case the plan is to perform the installation as described below:

- Weeks 44 and 45 side A (sector 8-1)
- Weeks 46 and 47 side C (sector 1-2)

However, the exact schedule is constrained by the LHC schedule.

3. ROUTING DETAILS

3.1 GLOBAL ROUTING SCHEME

From the ZDC detectors, the cables are routed along the tunnel and enter the survey galleries (UPS14 and UPS16). Then passing into UX15 and into the technical gallery (TE16), they arrive in USA15 up to Y.30-11.A1.

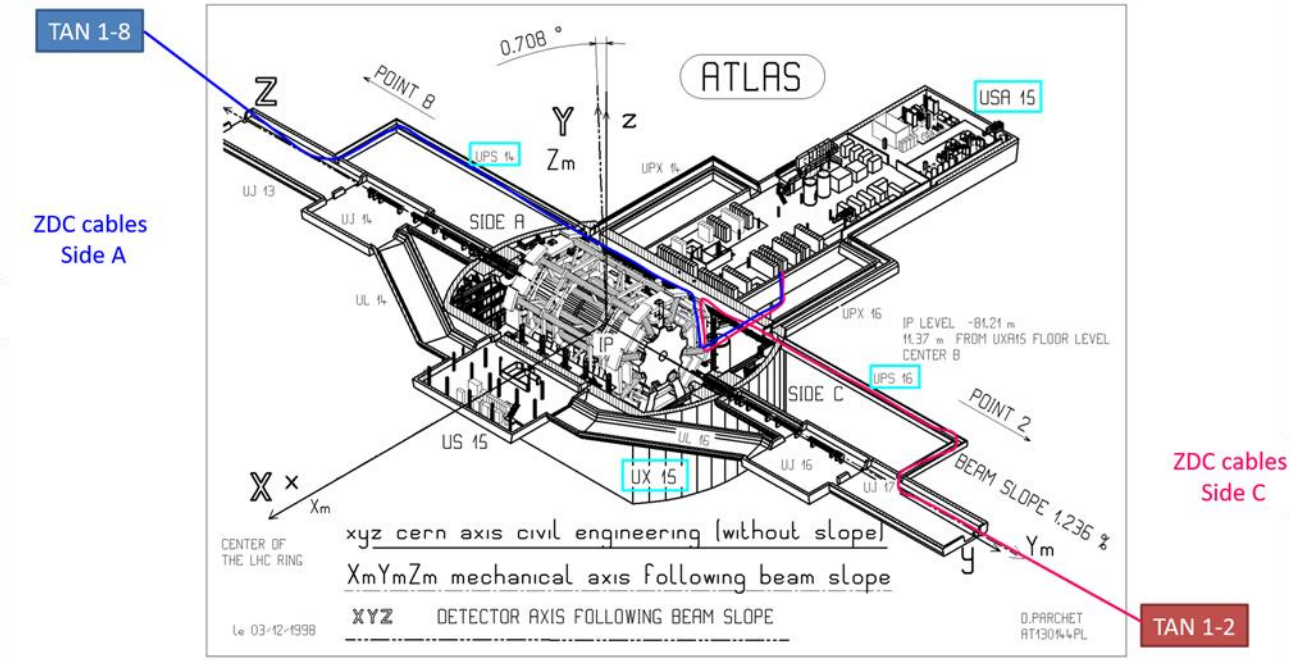


Figure 3 — Routing scheme

3.2 ROUTING OF ZDC SIDE A CABLES LHC- UX15

The ZDC side A detector is located in the sector 8-1 TAN (see figure 3 in blue).

3.2.1 PHASE 1 ROUTING

From the ZDC, four CC50 cables are routed up along the back wall to reach the “splicing point” located below the longitudinal tray in a position that still have to be fully defined. The four air-core cables depart from this splicing point (see Figure 4).

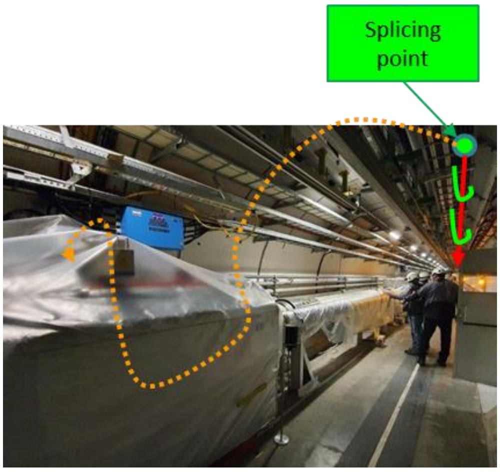


Figure 4 — Splicing point side A in tunnel 8-1

A rough estimation of the dimensions of the volume occupied by the cables splicing assuming that all male connectors will be in the same location is either 200mm x 50mm x 80mm, or 100mm x 100mm x 80mm, depending on the final routing (four cables in a row, or two cables in two rows).

The exact location of the splicing point is still to be defined.

The air-core cables are routed below the horizontal tray on the top of the tunnel using “J supports” attached to that tray.

The plan is to use CAT48 J hooks. The detailed description of the J hooks can be found in the data sheet in Annex 4.

Once they arrive to the UJ13 (larger part of the tunnel), they are routed using the same method below the perpendicular tray that crosses the tunnel and into the tray which follows the wall up to the red door of UPS14 (survey gallery).

Into the survey gallery, the cables are routed in the vertical cable tray close to the floor along the outer corner (with respect to the curve of the gallery).

Just before entering in UX15 the cables will go up along the wall and inside UX15 they enter the J hooks attached to the longitudinal tray running over the Level 4 platform.

The installation of the J hooks in this part of UX15 cavern requires the displacement of the newly installed led lights.

Going towards side C the cables arrive around Z0 and are routed into a new vertical tray, that will be installed on the wall beside the existing one, which is full.

3.2.2 PHASE 2 ROUTING

In LS3 the tunnel portion of the cables will be temporarily removed and the existing trays will be removed/modified.

The current idea for the re-installation of the cables is the following:

The cables are routed from the splicing point into the drain channel below the QRL (cryogenic line behind the beam line), using J hooks attached to the curved wall (see Figure 5).

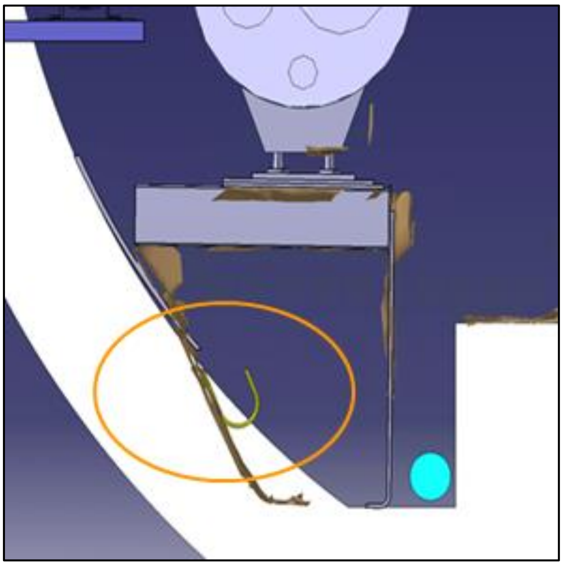


Figure 5 — Routing along the tunnel

Once they arrive to the UJ13, they are routed up along the back wall to reach the J hooks attached to the lower cable tray up to the red door of UPS14.

The rest of the path in LS3 will not be modified.

3.3 ROUTING OF ZDC SIDE C CABLES LHC – UX15

The ZDC side C is located in the Sector 1-2 TAN (see Figure 3).

3.3.1 PHASE 1 ROUTING

From the ZDC, four CC50 cables are routed along the back wall to reach the "splicing point" located below the longitudinal tray in a position that still have to be fully defined. The four air-core cables depart from this splicing point (see Figure 6).

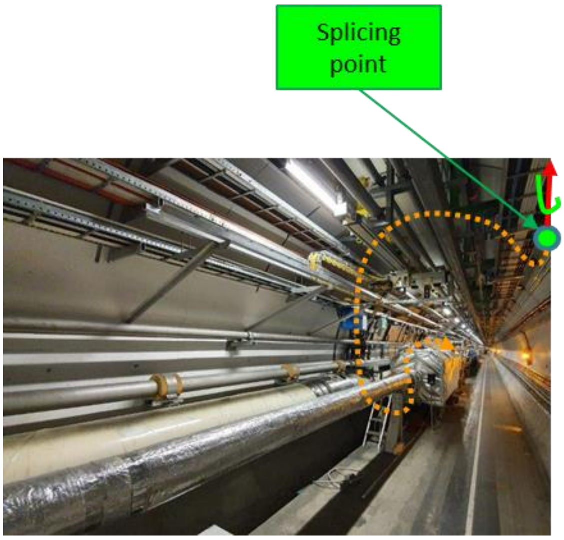


Figure 6 — Splicing point side C in tunnel 1-2

As for side A, the air-core cables are routed below the horizontal tray on the top of the tunnel using "J supports" attached to that tray.

Once they arrive to the UJ17 (larger part of the tunnel), they are routed using the same method below the perpendicular tray that crosses the tunnel and into the tray which follows the wall up to the red door of UPS16 (survey gallery).

Into the survey gallery, the cables are routed in the vertical cable tray close to the floor along the outer corner (with respect to the curve of the gallery).

Just before entering in UX15 the cables will go up along the wall and inside UX15 they enter the J hooks attached to the longitudinal tray running over the Level 4 platform.

The installation of the J hooks in this part of UX15 cavern requires the displacement of the newly installed led lights.

Going towards side A the cables arrive around Z0 and are routed into the same new vertical tray used for Side A cables.

3.3.2 PHASE 2 ROUTING

As for side A, in LS3 the tunnel portion of the cables will be temporarily removed and the existing trays will be removed/modified.

The current idea for the re-installation of the cables is the following:

The cables are routed from the splicing point into the drain channel below the QRL, using J hooks attached to the curved wall.

Once they arrive to the UJ17, they are routed up along the back wall to reach the J hooks attached to the lower cable tray up to the red door of UPS16.

The rest of the path in LS3 will not be modified.

3.4 COMMON ROUTING OF ZDC SIDE A AND SIDE C CABLES UX15- USA15

All eight cables go down along the wall in the new cable tray arriving to the top of the technical gallery TE16.

They enter in TE16 on the left side (side A). A dedicated new cable tray (to be installed) will run attached to the ceiling of the gallery so that the air-core cable will keep free the access to the existing trays below.

At the end of the gallery the cables go up along the wall in a dedicated new cable tray (to be installed).

Once arrived in USA15 level 1, the cables are routed below the false floor in a dedicated new cable tray (to be installed) and reach the side wall.

When the cables reach the side wall of USA15, they run along the wall up to the splicing point (see Figure 7).

From the splicing point to the rack Y.30-11.A1 (see Figure 7), the CC50 cables are routed below the false floor and enter into the rack from below.

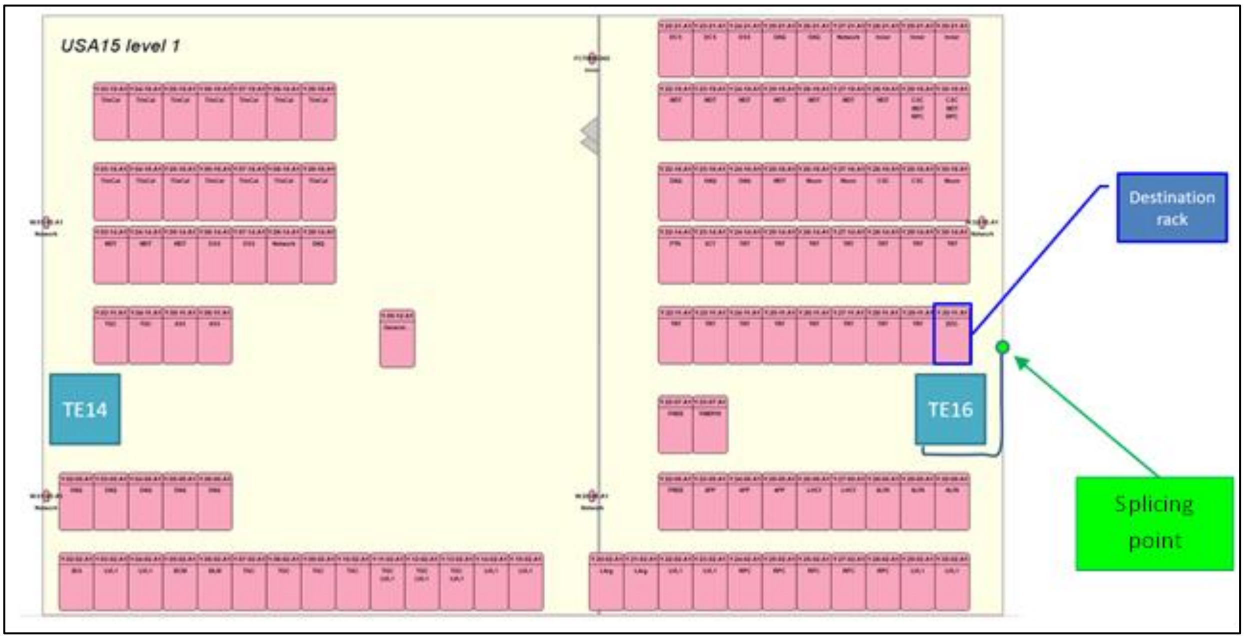


Figure 7 — Splicing point and destination rack in USA15

4. REFERENCES

[1] Cabling study (AT1-UZ-IN-0001).

[2] The initial proposal for this installation process was scheduled to be presented at TREX meeting on September 30th 2020, but due to delays it was then rescheduled for the TREX meeting on October 14th 2020.

[3] After several changes, the installation process was presented again during TREX meeting on March 4th 2021.

[4] Results of preliminary tests can be found here.

[5] Schedule and tunnel installation update can be found here.

ANNEX 1- AIR-CORE CABLE: 7/8" HELIFLEX AIR-DIELECTRIC COAXIAL CABLE DATA SHEET

Product Data Sheet **HCA78-50JFN**

RFS

7/8" HELIFLEX® Air-Dielectric Coaxial Cable, flame retardant/ halogen free jacket

Product Description

HELIFLEX® 7/8" low loss air dielectric cable

Application: UHF, VHF

7/8" HELIFLEX® Air Dielectric Coaxial Cable

Features/Benefits

- **Low Attenuation**
  The low attenuation of HELIFLEX® coaxial cable results in highly efficient signal transfer in your RF system.
- **Complete Shielding**
  The solid outer conductor of HELIFLEX® coaxial cable creates a continuous RFI/EMI shield that minimizes system interference.
- **Low VSWR**
  Special low VSWR versions of HELIFLEX® coaxial cables contribute to low system noise.
- **Outstanding Intermodulation Performance**
  HELIFLEX® coaxial cable's solid inner and outer conductors virtually eliminate intermods. Intermodulation performance is also confirmed with state-of-the-art equipment at the RFS factory.
- **High Power Rating**
  Due to their low attenuation, outstanding heat transfer properties and temperature stabilized dielectric materials, HELIFLEX® cable provides safe long term operating life at high transmit power levels.
- **Wide Range of Application**
  Typical areas of application are: feedlines for broadcast and terrestrial microwave antennas, wireless cellular, PCS and ESMR base stations, cabling of antenna arrays, and radio equipment interconnects.

Frequency [MHz]	Attenuation [dB/100m]	Attenuation [dB/100ft]	Power [kW]
0.5	0.0813	0.0248	73.0
1.0	0.115	0.0351	73.0
1.5	0.141	0.0430	70.9
2.0	0.163	0.0497	61.4
10	0.366	0.112	27.3
20	0.520	0.158	19.2
30	0.638	0.194	15.7
50	0.827	0.252	12.1
88	1.10	0.337	9.11
100	1.18	0.359	8.49
108	1.23	0.374	8.15
150	1.45	0.443	6.92
174	1.57	0.478	6.39
200	1.69	0.514	5.94
300	2.08	0.634	4.84
400	2.42	0.738	4.17
450	2.57	0.785	3.93
500	2.72	0.830	3.71
512	2.76	0.840	3.66
600	3.0	0.914	3.37
700	3.25	0.992	3.12
800	3.49	1.07	2.91
824	3.55	1.08	2.86
894	3.71	1.13	2.74
900	3.72	1.13	2.74
925	3.78	1.15	2.69
960	3.85	1.17	2.65
1000	3.94	1.20	2.59
1250	4.45	1.36	2.30
1500	4.91	1.50	2.10
1700	5.26	1.60	1.97
1800	5.43	1.65	1.91
2000	5.75	1.75	1.81
2200	6.07	1.85	1.72
2300	6.22	1.90	1.68
3000	7.22	2.20	1.47

Attenuation at 20°C (68°F) cable temperature
Mean power rating at 40°C (104°F) ambient temperature

Technical Features

Structure

Inner conductor:	Copper Tube	[mm (in)]	9 (0.35)
Dielectric:	Helical Polyethylene Spacer	[mm (in)]	20.2 (0.79)
Outer conductor:	Corrugated Copper	[mm (in)]	25.5 (1)
Jacket:	Polyethylene, PE, Metalhydroxite Filling	[mm (in)]	28 (1.103)

Mechanical Properties

Weight, approximately	[kg/m (lb/ft)]	0.68 (0.46)
Minimum bending radius, single bending	[mm (in)]	100 (4)
Minimum bending radius, repeated bending	[mm (in)]	250 (10)
Bending moment	[Nm (lb-ft)]	27 (20)
Max. tensile force	[N (lb)]	1600 (360)
Recommended / maximum clamp spacing	[m (ft)]	0.5 / 0.9 (1.8 / 3)

Electrical Properties

Characteristic impedance	[Ω]	50 +/- 0.5
Relative propagation velocity	[%]	93
Capacitance	[pF/m (pF/ft)]	71 (21.6)
Inductance	[µH/m (µH/ft)]	0.178 (0.054)
Max. operating frequency	[GHz]	3
Jacket spark test RMS	[V]	8000
Peak power rating	[kW]	73
RF Peak voltage rating	[V]	2700
DC-resistance inner conductor	[Ω/km (Ω/1000ft)]	1.1 (0.34)
DC-resistance outer conductor	[Ω/km (Ω/1000ft)]	0.88 (0.27)

Recommended Temperature Range

Storage temperature	[°C (°F)]	-70 to 85 (-94 to 185)
Installation temperature	[°C (°F)]	-40 to 60 (-40 to 140)
Operation temperature	[°C (°F)]	-50 to 85 (-58 to 185)

Other Characteristics

Fire Performance: Flame Retardant, LS0H

VSWR Performance: Standard — Typical 20.8dB (1.2 VSWR) or better within the operation bands of most global frequency ranges. Premium also available. Contact factory for options in your specific frequency band.

Other Options: Phase stabilized and phase matched cables and assemblies are available upon request.

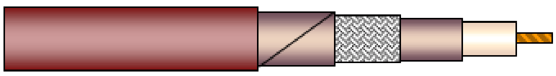
ANNEX 2 - CC50: COAXIAL CABLE 50 OHM TYPE C-50-6-1 DATA SHEET

Draka

A brand of the Prysmian Group

02Y(St)C(St)H 2.25L/6.1AF(C-50-6-1)
02Y(St)C(St)H 2.25L/6.1AF (CC50)

Coaxial according to CERN specification 461 REV. 6



Application

The radio-frequency cables described in this chapter are used in transmitter and receiver installations in radio communications as well as in the entire field of commercial radio-frequency technology and electronics.

Standards

DIN 47264, EN50117-1, IEC 61196-1

Flame resistance

acc. to IEC 60332-1

Construction

Inner conductor	stranded copper wires, bare 7 x 0.75, diameter 2.25 ± 0.01 mm
Insulation	Foam-PE, diameter 6.10 ± 0.05
Outer conductor	Al-PET-Al-foil + copper braid, tinned, 92% optical coverage + Al-PET-Al-foil
Sheath	FRNC, diameter 10.1 ± 0.2
Colour	brown, RAL 8017
Printing CS2867600	DRAKA COMTEQ – manufacturing year C-50-6-1 meter marking and batch number
Printing CS2867601	DRAKA COMTEQ – manufacturing year CC50 meter marking and batch number

Mechanical properties

Minimum bending radius	without load	5 x outer diameter
	with load	10 x outer diameter
Temperature	during operation	-30° C to + 70° C
	during installation	-15° C to + 55° C
Corrosivity		IEC 60754-2

Draka

A brand of the Prysmian Group

02Y(St)C(St)H 2.25L/6.1AF(C-50-6-1)
02Y(St)C(St)H 2.25L/6.1AF (CC50)

Electrical properties

at 20°C

DC resistance	Inner conductor	5.6 Ω/km
	Outer conductor	2.0 Ω/km
Mutual capacitance		84 pF/m
Velocity ratio		78 %
Characteristic impedance	200 MHz	50 Ω ± 2 Ω
Operating voltage		1.2 kV_{rms}
Test voltage	Inner/Outer conductor	3.0 kV_{rms}
Partial discharge test		1.3 kV_{rms}
Insulation resistance		≥ 10 GΩ*km

Electrical data

at 20°C

Frequency (MHz)	**Attenuation (dB/100m)**	**Max. power rating (Watts)** (ambient temperature 40°C and max. inner conductor temperature 100°C)	**Return loss (dB)** several peaks are allowed	
	nominal	maximum		
1	0.6		**Frequency (MHz)**	
10	1.7			
100	5.0			
200	8.0			
800	18.0			

All further requirements acc. to CERN Spec. 461 REV. 6

Technical data

Product code	Desig-nation	Type	Brand name	Outer diameter mm	Weight kg/km	Standard delivery length m	Drum size *OWD	Gross weight kg	Copper content	Tensile force N
1002794	02Y(St)C(St)H	2.25L/6.1 AF-FRNC	C-50-6-1	10.1	130	1000	800/330/448	170	66.0	405
1002820	02Y(St)C(St)H	2.25L/6.1 AF-FRNC	CC50	10.1	130	1000	800/330/448	170	66.0	405

*OWD (one way drum)

Draka

A brand of the Prysmian Group

02Y(St)C(St)H 2.25L/6.1AF(C-50-6-1)
02Y(St)C(St)H 2.25L/6.1AF (CC50)

Product Code Table

Product Description	Product Code	PG Reference Code	PG Part Number
CC50 (C-50-7-1; 2.25L/6.1AF-FRNC)		60014574	**60014574**

ANNEX 3 - CONNECTOR FOR AIR-CORE CABLES: TYPE 7-16 DIN MALE CONNECTOR DATA SHEET

PRODUCT DATASHEET

716M-HCA78-020

RADIO FREQUENCY SYSTEMS
The Clear Choice®

7-16 DIN Male Connector for 7/8" Coaxial Cable, RAPID FIT™ Sealing compound

Radio Frequency Systems line of high performance coaxial cable connectors are designed specifically to provide the highest quality connector-cable interface while simplifying and speeding up the attachment of connectors to HELIFLEX® coaxial cables. RFS connectors are fully tested for mechanical and electrical compliance specifications. They are available in all popular cable sizes in a variety of mating interfaces. The 7-16 connector is the most rugged RF connection meeting all requirements even under severe environmental conditions.

Connector 7-16 plug CAF

FEATURES / BENEFITS

- Excellent gas tightness, Overpressure for increased voltage handling is maintained throughout the system
- Robust Mechanical Design, Superior and consistent performance guarantees outstanding system characteristics.
- Extremely low reflection factor, Outstanding low reflection factor improves overall system performance and margin and reduces mismatch losses
- Totally Waterproof according to IP 68, Assures safe, long term operation in the harshest of environments. System tightness doesn't have to rely on overpressure from dehydration equipment.

Technical Features

GENERAL SPECIFICATIONS		
Transmission Line Type		Coaxial Cable
Cable Size		7/8"
Cable Type		Air Dielectric
Model Series		HCA78-50 Series
Connector Interface		7-16 DIN
Connector Type		RAPID FIT™
Sealing Method		Sealing compound *)
Gender		Male
MECHANICAL SPECIFICATIONS		
Plating Outer/Inner		Silver/Silver
Length	mm (in)	74 (2.91)
Outer Diameter	mm (in)	39.5 (1.55)
Weight	kg (lb)	0.4 (0.88)
Inner Contact Attachment		Spring Finger
Outer Contact Attachment		Threaded
ACCESSORIES		
Wrench size front	mm (in)	36 (1-7/16)
Wrench size rear	mm (in)	32 (1-1/4)
TESTING AND ENVIRONMENTAL		
Sealing Volume	cm³ (ounces)	5 (0.17)

External Document Links	Notes
Installation Instruction	*) The sealing compound must be ordered separately.

716M-HCA78-020 REV: C REV DATE: 07.Jun.2016 www.rfsworld.com

All information contained in the present datasheet is subject to confirmation at time of ordering

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ANNEX 4 - J HOOKS: CAT48 AND CAT64 J HOOKS THE DATA SHEET

Cat HP J-Hook

Cat HP J-Hook





Cat HP J-Hooks are the heart of the Cat HP System. The J-Hooks have a wide base design and smooth beveled edges to provide a large bending radius for current and future high-performance data cables and fibre optics. Cat HP J-Hooks are available in a wide range of sizes to offer a solution that meets industry standards for Cat 6A and easily accommodates Cat 7, large-diameter fibre optic, innerduct and coax cable. Individual Cat HP J-Hooks can be fastened directly to the building structure or can be used to expand existing Cat HP J-Hook cable supports. The J-Hooks are designed to provide a strong and stable pathway support installation.

- Provides optimal support for high-performance data cable, up to and including Cat 5e, Cat 6, Cat 6A, Cat 7 and fibre optic
- Rounded edges on J-Hooks provide proper bend radius support for high performance data cables
- Multiple color options aid in the identification and organization of the pathway application
- Provides superior fill capacity and load rating over most other non-continuous cable support alternatives
- Tested according to DIN 4102-12
- Complies with EN 50174-2
- Meets ISO®/IEC℠ 14763-2, TIA 568-C and TIA 569-C
- Painted J-Hooks are low-smoke and halogen-free

Material: Steel

Part Number	Article Number	Diameter ø	Area	Cable Capacity, Cat 5e	Cable Capacity, Cat 6	Cable Capacity, Cat 6A	Static Load F
Finish: Pre-galvanized							
CAT16HP	181061	25.0 mm	690 mm²	20	15	10	270 N
CAT21HP	181188	33.3 mm	1,174 mm²	50	40	25	270 N
CAT32HP	181062	50.0 mm	2,561 mm²	90	60	35	270 N
CAT48HP	181063	75.0 mm	5,974 mm²	200	150	60 lb	cULus®
CAT64HP	181064	100.0 mm	9,987 mm²	330	220	140	270 N