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## 1. Introduction

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RF energy is simultaneously transmitted down radiating cables and radiated from all points along them into the surrounding space. Slots cut into the outer conductor of the coaxial cable allow controlled levels of electromagnetic energy to be radiated both out of and into the cable. Radiating cables are used wherever normal radio communication is difficult or impossible, in particular in communication systems where a discrete antenna would not provide adequate coverage, such as in tunnels, underground railways, mines, buildings, etc.

A radiating cable functions both as a transmission line and as an antenna. The amount of radiation is quantified by the *coupling loss*. In the tables below, the coupling loss is defined as the difference between the power transmitted into the cable and the power received by a  $\lambda/2$ -dipole antenna located at a distance of 2 m from the cable. (This definition is taken from IEC-96).

## 2. Features and applications

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EUPEN radiating cables and cable accessories are specifically designed for the needs of modern radio communication systems :

- Ideal for advanced GSM, PCN/PCS, DECT and paging systems as well as conventional 2-way radio installations.
- Engineered for fast, problem-free installation and ease of handling.  
The connectors use a solderless, self-flaring design, and a waterproof O-Ring sealing.
- Outstanding mechanical and electrical performance specifications equal or exceed anything comparable.

EUPEN can supply a large range of cables to meet installations conditions where a high level of reliability as well as long service life are essential features.

Together the cables and the connectors from EUPEN are an unbeatable match that optimises the entire system performance.

- Low attenuation
- Excellent field strength with low coupling loss
- Broadband characteristics
- Increased amplifier spacing due to very low longitudinal attenuation
- Intensitivity to ageing effects
- Good transverse stability
- Simple connector installation
- Quick cable installation
- Resistance to corrosion
- Halogen-free and fire resistant jacketing

Innovative designs, a careful choice of raw materials together with consistent manufacturing and quality assurance techniques, ensure the electrical and mechanical superiority of Eupen cables.

Underground communication systems using EUPEN radiating cables operate world-wide: in the Metros of Brussels, Paris, Seoul and Budapest, in road tunnels in Austria, Belgium, Italy, the Netherlands, Australia and many other challenging locations.

## 3. Halogen-free and fire resistant features

### 3.1. Test on flammability



A distinction is made between the flammability of single cables and of cable in bundles.

#### a) Test on flammability of single cables

Test in accordance with : VDE 0472 Part 804-B  
BS 4066 Part 1  
IEC 332-1

A sample of 600 mm is attached vertically in a metal chamber, the front of which is left open. A propane gas burner with a flame length of 175 mm is positioned to give a 45° angle between the flame (100 mm above the lowest end of the sample) and the sample.

In the case of BS 4066, the duration of the test is obtained by the following formula:

$$t = 60 + m/25 \text{ (seconds);}$$

m = mass of sample in g

This test is regarded as having been passed if the sample has not burnt, or if the flames self-extinguish, and if the damage to the cable does not extend round its entire circumference.

#### b) Test on flammability of cable bundles

Test in accordance with : VDE 0472 Part 804-C  
BS 4066 Part 3 (NMV 1,5)  
IEC 332-3 Cat. C

The test samples are attached on a steel ladder. The number of samples is determined by their outer diameter.

The steel ladder is mounted at the rear of a test chamber of width 1 m, depth 2 m and height 4 m. The test chamber is ventilated via an aperture at the base of the chamber. The air flow rate should be approximately 5 m³/min.

A propane gas burner is directed at the samples from a distance of 75 mm.

The test duration is 20 min, and the test is regarded as passed if the flames self-extinguish and when no part of the samples is damaged, above a height 2.5 m (3.0 m for VDE) above the burner.

### 3.2. Test on smoke density

Test in accordance with : VDE 0472 Part 816  
BS 6724 Appendix F  
IEC 1034-1 and 2

#### Test Equipment

The test chamber consists of a 3 metre cube.

The measurement system consists of a light source (a standardised 100 W halogen lamp) and a Selenium or Silicon photo-electric cell, both installed at a height of 2.15 m.

A rectangular tray filled with 1 litre of alcohol provides the source of flame.

A ventilator ensures an even distribution of smoke. Flame turbulence is avoided by a metal screen which protects the tray.



#### Test Samples

The length of the test samples is 1 m.

The number of test samples depends on the outer diameter as given in the table below.

#### Test Procedure

The samples are fixed horizontally above the tray containing the alcohol. The ventilator is started and the alcohol is lit. The light intensity (and therefore light transmission) is recorded by a plotter which is connected to the photo-electric cell.

#### Evaluation

The test is regarded as passed if the levels of light transmission given in the table below are exceeded throughout the test.

Outer Diameter in mm	Number of samples	Light Transmission
> 40	1	> 70%
> 20 and ≤ 40	2	> 60 %
> 10 and ≤ 20	3	> 60 %

## 3.3. Test on corrosive gas emissions



*Test in accordance with : VDE 0472 Part 813  
BS 6425  
IEC 754-2*

This test indirectly allows corrosive gas emissions from the insulating or jacketing compounds to be measured. Small quantities of halogens can be detected by measurement of pH-value and conductivity.

### Test Procedure

In a furnace of 500-600 mm length, at least 1 g of insulating or jacketing compound is heated to a temperature of 935 °C.

Air circulation is arranged to convey the combustion gases into a bottle filled with distilled water.

### Evaluation

The test is regarded as passed when after 30 minutes the measured pH-values are not lower than 4.3 and when the electrical conductivity does not exceed 10 µs/mm.

### 3.4. Test on insulation integrity

*Test in accordance with : VDE 0472 Part 814  
IEC 331*

This test determines the insulation integrity under fire conditions. Cables tested according to this standard are marked **FE 180**.

#### Samples

A 1.2 m long cable sample has the outer jacket and any other covering removed at both ends. The conductors are prepared for electrical connection.

The prepared sample is fixed horizontally approximately 75 mm above the burner.

The samples are connected (via a 3 A fuse for each conductor) to a voltage source and tested at their rated voltage. All screens and other metal jackets are connected together and earthed. The conductors at the far end from the voltage source are bent apart in order to prevent them making electrical contact.

#### Burner

A tube type gas burner of a 610 mm length gives flames with a temperature of at least 750 °C over a length of 600 mm.

#### Test Procedure

The burner is lit and adjusted to a temperature of at least 750 °C using a thermocouple. The sample is connected to an electrical supply and introduced into the flames. The sample is tested for a period of 180 minutes.

#### Evaluation

The test is regarded as passed if none of the 3 A fuses blow during the test period.



## 4. Cable construction

The **inner conductor** is made of solid copper, copper-clad aluminium wire, smooth copper tube or corrugated copper tube, according to the conductor size.

The **dielectric** is a cellular polyethylene foam, manufactured by a unique process using an ozone-friendly gas. The low density of the foam guarantees low longitudinal attenuation.

The foam dielectric is bonded to the inner conductor by a pre-coating layer. This layer ensures good adhesion of the inner conductor to the dielectric. It also permits easy, clean removal of the dielectric during connector installation.

For the **outer conductor**, a copper tape is used, longitudinally overlapped and bonded to the outer jacket to improve bend radius and water-tightness.

As an alternative a welded, annularly-corrugated outer conductor is also available.

The standard cable construction uses weather-resistant black polyethylene as the **outer jacket**.

Cables are also available with a flame-retardant and halogen-free outer jacket, for applications requiring flame-retardancy.

This construction meets such international standards as IEC 332-3 (for flame propagation), IEC 1034 (smoke density) and IEC 754 (acidity of evolved gases).

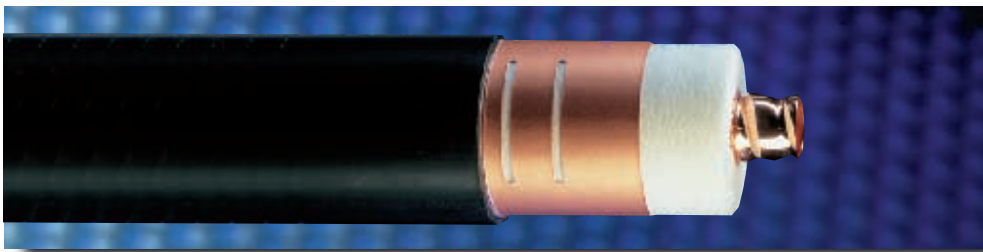
If a fire barrier tape (e.g., of mica) is added and placed between dielectric and outer conductor the cable meets also the requirements of IEC 331 test. The barrier tape has a low  $\tan \delta$  and does not affect the transmission characteristics of the cable.



## 5. Construction, mechanical and electrical cable characteristics

### 5.1 . LSC - Leaky Sections Cables

**Leaky sections** are pre-punched into the outer conductor; the distance between sections is set to optimise low coupling loss and longitudinal attenuation over a wide bandwidth. With this unique construction the distance between repeaters can be increased, and the broadband coupling loss is not significantly degraded from that obtained using continuously-slotted coupled-mode cables or radiating-mode cables.

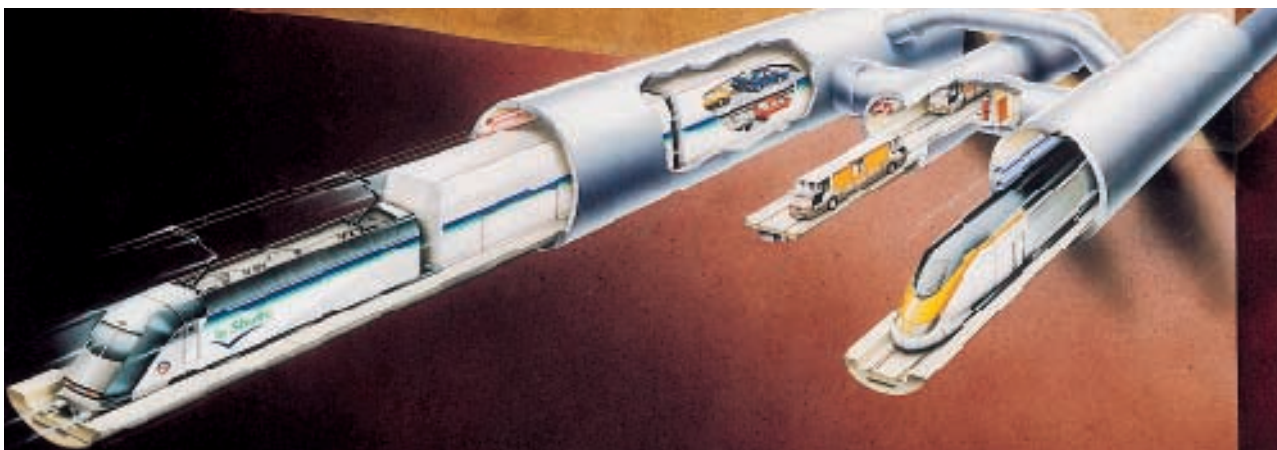


Cable Group	LSC 1/2"	LSC 3/4"	LSC 7/8"	LSC 1 5/8"
Cable Type	512RC8R	517RC8R	522RC8R	543RC8R
Order number	Halogen-free in accordance with IEC 754			
	7000	-	0834	1973
Cable Type	512RC8R-HLFR	517RC8R-HLFR	522RC8R-HLFR	543RC8R-HLFR
Order number	Halogen-free and Flame-retardant in accordance with IEC 754, 332-1, 332-3C & 1034			
	8521	8429	8212	9171
Cable Type	512MRC8R-HLFR	517MRC8R-HLFR	522MRC8R-HLFR	543MRC8R-HLFR
Order number	Halogen-free and Flame-resistant with circuit integrity in accordance with IEC 754, 332-1, 332-3C, 1034 & 331			
	8521M	8429M	8212M	9171M
Construction				
Inner conductor				
Material and construction	Copper clad aluminium wire	smooth copper-tube	smooth copper-tube	corrugated copper-tube
Diameter (mm)	4.8	6.8	9.1	17.5
Dielectric				
Material	gas-injected low density cellular PE			
Diameter (mm)	12.4	17.6	23.5	43.8
Outer conductor				
Construction	Punched, longitudinally-overlapped copper foil, bonded to the outer jacket			
Diameter (mm)	12.7	17.6	23.8	44.1
Outer jacket				
Thickness (mm)	1.3	1.7	1.5	2.2
Diameter (mm)	15.5	21	27.0	48.5
Theoretical weight (kg/km)	231	425	550	1255



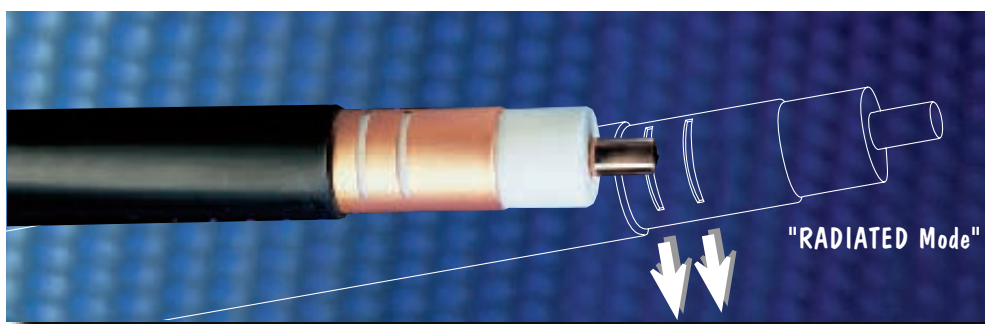
Cable Group	LSC 1 1/2"		LSC 3 1/4"		LSC 7 1/8"		LSC 1 5/8"		
Mechanical characteristics									
Minimum bending radius (mm)	250		300		400		600		
Maximum tensile strength (daN)	110		150		160		200		
Electrical characteristics									
DC resistance at 20°C									
- inner conductor (Ω/km)	1.48		1.2		0.93		0.78		
- outer conductor (Ω/km)	2.62		2.0		1.46		0.77		
Nominal capacitance (pF/m)	75								
Characteristic impedance (Ω)	50								
Velocity ratio (%)	88								
Nominal attenuation at 20°C									
30 MHz (dB/100m)	1.15		0.82		0.64		0.35		
50 MHz (dB/100m)	1.5		1.1		0.85		0.47		
100 MHz (dB/100m)	2.15		1.6		1.25		0.7		
150 MHz (dB/100m)	2.7		2.0		1.6		0.9		
200 MHz (dB/100m)	3.15		2.35		1.85		1.1		
300 MHz (dB/100m)	3.9		3.0		2.4		1.4		
450 MHz (dB/100m)	4.95		3.85		3.1		1.85		
900 MHz (dB/100m)	7.45		6.0		4.85		3.15		
1000 MHz (dB/100m)	7.95		6.4		5.25		3.5		
1800 MHz (dB/100m)	11.7		10.6		10.1		7.9		
Coupling loss (according to IEC 96, distance = 2m)		c50 <sup>a)</sup> c95 <sup>b)</sup>		c50 <sup>a)</sup> c95 <sup>b)</sup>		c50 <sup>a)</sup> c95 <sup>b)</sup>		c50 <sup>a)</sup> c95 <sup>b)</sup>	
150 MHz (dB)	67	78	65	77	63	73	70	80	
450 MHz (dB)	67	79	65	77	63	73	67	78	
900 MHz (dB)	67	79	65	78	63	73	65	76	
1800 MHz (dB)	69	84	65	78	63	73	65	75	

a) b) c 50 (c 95) is the coupling loss with 50% (95%) probability



## 5.2. RMC - Radiated Mode Cables

Radiated Mode cables are designed for DCS/PCS and GSM applications at frequencies of 800 MHz to 2400 MHz. The slots are arranged so that the direction of radiation is predominantly orthogonal to the cable axis. This results in optimised, reduced coupling loss variations over specific frequency bands. Under certain conditions radiated mode cables with low coupling loss variation can improve considerably the quality of CDMA and video transmissions.



Cable Group	RMC 7 / 8 "	RMC 1 1 / 4 "
Cable Type	522RC8RM	532RC8RM
Order number	Halogen-free in accordance with IEC 754	
	4070	4071B
Cable Type	522RC8R-HLFR	532RC8R-HLFR
Order number	Halogen-free and Flame-retardant in accordance with IEC 754, 332-1, 332-3C & 1034	
	4070A	4071
Cable Type	522MRC8RM-HLFR	532MRC8RM-HLFR
Order number	Halogen-free and Flame-resistant with circuit integrity in accordance with IEC 754, 332-1, 332-3C, 1034 & 331	
	4070B	4071C
Construction		
Inner conductor		
Material and construction	smooth copper tube	
Diameter (mm)	9.1	13.1
Dielectric		
Material	gas-injected low density cellular PE	
Diameter (mm)	23.5	33.2
Outer conductor		
Construction	Copper foil, with transverse slots, bonded to the outer jacket	
Outer jacket		
Thickness (mm)	1.7	2.0
Diameter (mm)	27.2	38.0
Theoretical weight (kg/km)	590	910



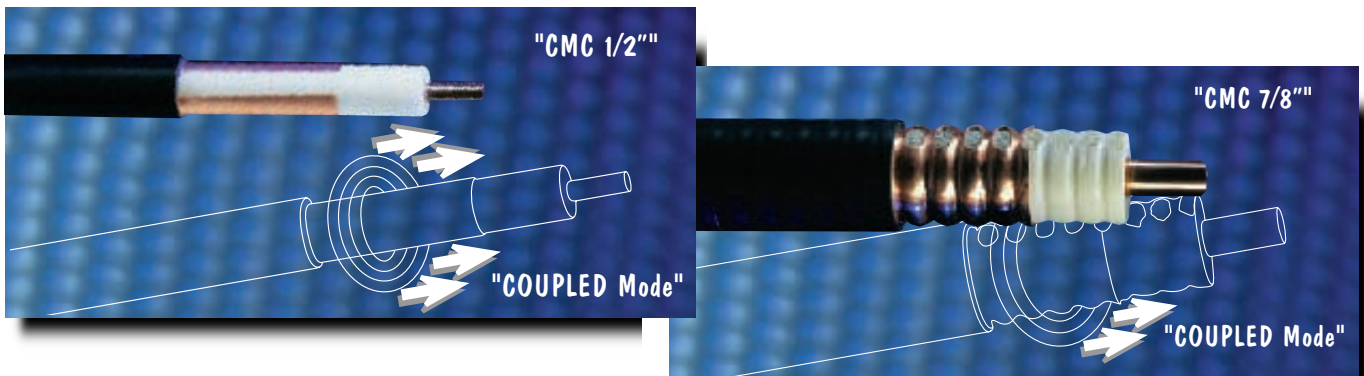
## RADIATING CABLES ■

Cable Group	RMC 7 / 8 "		RMC 1 1 / 4 "	
Mechanical characteristics				
Minimum bending radius				
single bending (mm)	400		500	
Maximum tensile strength (daN)	160		180	
Electrical characteristics				
DC resistance at 20°C				
- inner conductor (Ω/km)	0.93		0.68	
- outer conductor (Ω/km)	1.5		1.0	
Nominal capacitance (pF/m)	76			
Characteristic impedance (Ω)	50 ±3			
Velocity ratio (%)	88			
Nominal attenuation at 20°C				
30 MHz (dB/100m)	0.63		0.45	
50 MHz (dB/100m)	0.82		0.6	
100 MHz (dB/100m)	1.2		0.86	
150 MHz (dB/100m)	1.5		1.08	
450 MHz (dB/100m)	2.7		2.0	
900 MHz (dB/100m)	4.2		3.3	
1500 MHz (dB/100m)	6.5		5.3	
1700 MHz (dB/100m)	7.4		6.1	
1800 MHz (dB/100m)	7.9		6.6	
2000 MHz (dB/100m)	9.1		7.6	
2400 MHz (dB/100m)	11.7		10.2	
Coupling loss (according to IEC 96, distance = 2m)	c50 <sup>a)</sup>	c95 <sup>b)</sup>	c50 <sup>a)</sup>	c95 <sup>b)</sup>
450 MHz (dB)	80	88	73	82
900 MHz (dB)	70	75	66	72
1500 MHz (dB)	65	70	62	66
1800 MHz (dB)	65	70	61	66
2000 MHz (dB)	65	70	61	66
2400 MHz (dB)	65	70	61	66

a) b) c 50 (c 95) is the coupling loss with 50% (95%) probability

### 5.3. CMC - Coupled Mode Cables

These radiating cables are designed for in-building applications (where the system length is typically less than 100 m), for which a leaky sections cable may not be appropriate. The cable uses a low-loss dielectric and an outer conductor with a continuous slot or series of identical slots. These radiating cables are suited for high-performance applications in the 450 MHz, 900 MHz and 1800 MHz bands.



Cable Group	CMC 1 / 2 "		CMC 7 / 8 " – EC <sup>3 TM</sup>	
Cable Type	512RC8RI		5228R	5228RR
Order number	Halogen-free in accordance with IEC 754			
	1867A	0318		1268A
Cable Type	512RC8RI-HLFR		5228R-HLFR	5228RR-HLFR
Order number	Halogen-free and Flame-retardant in accordance with IEC 754, 332-1, 332-3C & 1034			
	1867	0910		1268
Cable Type	512MRC8RI-HLFR		522M8R-HLFR	522M8RR-HLFR
Order number	Halogen-free and Flame-resistant with Circuit integrity in accordance with IEC 754, 332-1, 332-3C, 1034 & 331			
	1867B	0910A		1268B
Construction				
Inner conductor				
Material and construction	Copper-clad aluminium wire		smooth copper-tube	
Diameter (mm)	4.8		9.1	
Dielectric				
Material	gas-injected low density cellular PE			
Diameter (mm)	12.4		23.5	
Outer conductor				
Construction	Copper foil with a continuous slot, bonded to the outer jacket		Welded annularly-corrugated copper with milled single or double slots	
Outer jacket				
Thickness (mm)	1.3		1.5	
Diameter (mm)	15.5		28.0	
Theoretical weight (kg/km)	231		670	

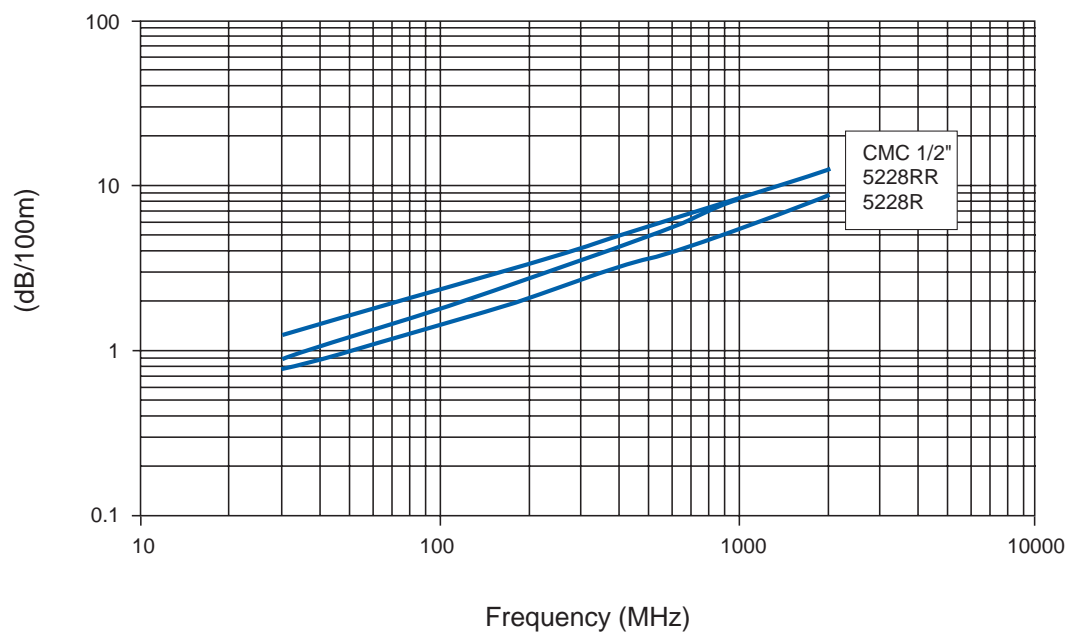
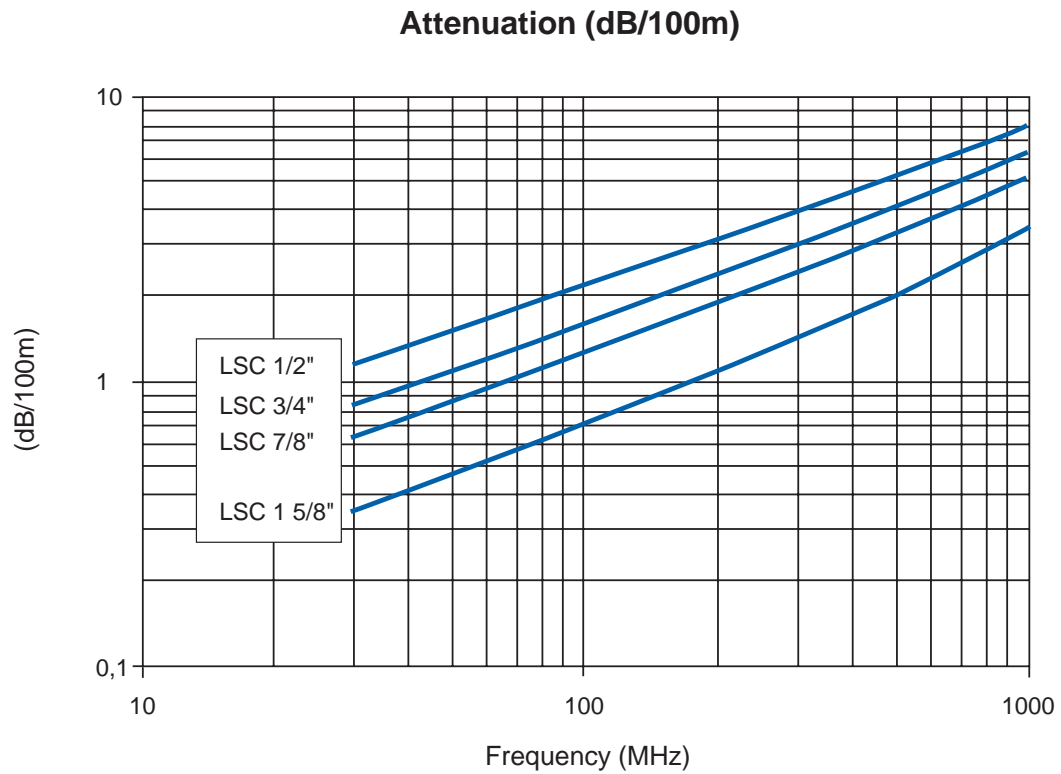


## RADIATING CABLES ■

Cable Group		CMC 1 / 2 "		CMC 7/8" – EC <sup>3 TM</sup>					
Mechanical characteristics									
Minimum bending radius									
a) single bending	(mm)	100		250					
b) multiple bending	(mm)	300		750					
Maximum tensile strength (daN)		110		160					
Electrical characteristics									
DC resistance at 20°C									
- inner conductor	(Ω/km)	1.48		0.93					
- outer conductor	(Ω/km)	3.3		0.88		1.05			
Nominal capacitance (pF/m)		76		76					
Characteristic impedance (Ω)		50 ±3		50 ±3					
Velocity ratio (%)		88		88					
Nominal attenuation at 20°C									
30 MHz	(dB/100m)	1.2		0.77		0.91			
80 MHz	(dB/100m)	2.05		1.3		1.6			
100 MHz	(dB/100m)	2.3		1.45		1.8			
150 MHz	(dB/100m)	2.85		1.8		2.3			
200 MHz	(dB/100m)	3.35		2.1		2.8			
300 MHz	(dB/100m)	4.2		2.65		3.6			
450 MHz	(dB/100m)	5.3		3.35		4.75			
900 MHz	(dB/100m)	8.0		5.0		7.7			
1000 MHz	(dB/100m)	8.5		5.35		8.3			
1800 MHz	(dB/100m)	12.2		7.9		13			
Coupling loss (according to IEC 96, distance = 2m)		c50 <sup>a)</sup>		c95 <sup>b)</sup>		c50 <sup>a)</sup>		c95 <sup>b)</sup>	
80 MHz	(dB)	-	-	73	82	57	68		
150 MHz	(dB)	69	80	75	85	63	74		
450 MHz	(dB)	73	84	75	85	64	75		
900 MHz	(dB)	70	79	75	85	62	73		
1800 MHz	(dB)	76	86	82	90	69	77		

a) b) c 50 (c 95) is the coupling loss with 50% (95%) probability

## 6. Diagrams





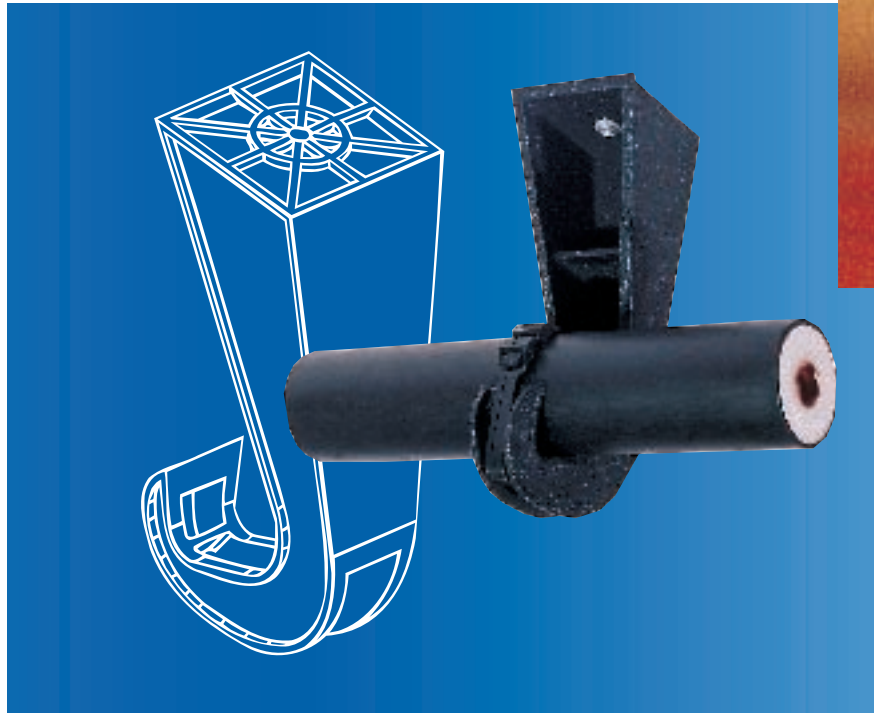
## 7. Accessories

### 7.1. Hangers for cable installation

EUPEN'S cable hangers are easy to install and provide an ideal non-metallic stand-off from the tunnel wall. They are halogen-free and flame retardant.

The kit includes a corrosion-resistant metal screw, dowel and plastic cable tie.

**Hanger for cable installation**  
(suitable for all cable sizes)



Order number		4795	4798
Hanger dimension	mm	175 x 85	
Maximum cable diameter	mm	50	
Minimum cable diameter	mm	15	
Recommended distance between hangers	cm	120	
Maximum load on hanger	daN	100	
Colour		black	
Type of dowel		plastic	metal



## 7.2. Connectors and Tools



Cable type	Connectors		Connector installation tools	
	Connector type	Order number	Tool type	Order number
LSC 1/2"	N Male 50 R 1/2"	0087	SPTC 50 R 1/2"	0088
CMC 1/2"	7-16 Female 50 R 1/2"	4075		
LSC 3/4"	N Male 50 R 3/4"	7087	SPTC 50 R 3/4"	0875
LSC 7/8"	N Male 50 R 7/8"	9441	SPTC 50 R 7/8"	9323
RMC 7/8"	N Female 50 R 7/8"	*		
	7-16 Male 50 R 7/8"	*		
	7-16 Female 50 R 7/8"	4076		
CMC 7/8"-EC <sup>3</sup>	N Male 50 R 7/8"	4873	No tool required	
	N Female 50 R 7/8"	4874		
	7-16 Male 50 R 7/8"	6325		
	7-16 Female 50 R 7/8"	6865		
RMC 1 1/4"	N Male 50 R 1 1/4"	0971	SPTC 50 R 1 1/4"	0972
	N Female 50 R 1 1/4"	0971A		
	7-16 Male 50 R 1 1/4"	0971B		
	7-16 Female 50 R 1 1/4"	0971C		
LCS 1 5/8"	N Male 50 R 1 5/8"	0874A	SPTC 50 R 1 5/8"	0876
	N Female 50 R 1 5/8"	0874B		
	7-16 Male 50 R 1 5/8"	0874C		
	7-16 Female 50 R 1 5/8"	0874		

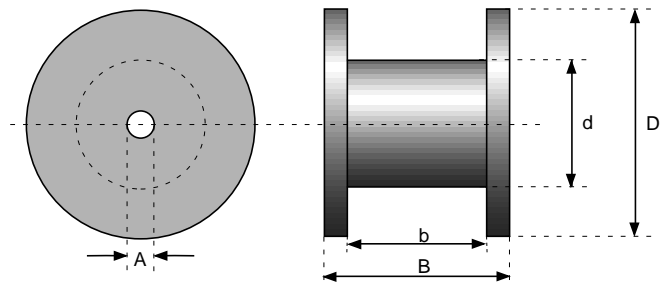
\* on request

## 7.3. Software and Application Note

For the assistance of the system designer we provide an application note and software which calculates the RF budget to help select the appropriate radiating cable.



## 8. Cable Packing Information



### 8.1. Drum dimensions and weight

<i>Dimensions &amp; Weight</i>	<b>D (m)</b>	<b>B (m)</b>	<b>b (m)</b>	<b>d (m)</b>	<b>A (mm)</b>	<b>Weight (kg)</b>
<i>Drum Type</i>						
712	1.2	1	0.72	0.80	90	115
712 S	1.2	0.48	0.40	0.80	90	100
714	1.4	1	0.84	0.80	90	190
717	1.80	1.12	0.94	0.95	90	280
717 S	1.80	0.76	0.70	1.20	90	240
720	2.05	1.24	1.02	1.10	120	470

### 8.2. Maximum cable length (m)/drum

<i>Size</i>		<b>1 5/8"</b>	<b>1 1/4"</b>	<b>7/8"</b>	<b>3/4"</b>	<b>1/2"</b>
<i>Drum Type</i>						
712	(m)					<b>1350</b>
712 S	(m)					<b>700</b>
714	(m)				<b>700</b>	
717	(m)	<b>400</b>	<b>570</b>	<b>1200</b>		
717 S	(m)	<b>280</b>	<b>400</b>	<b>700</b>		
720	(m)	<b>790</b>	<b>1010</b>	<b>1800</b>		

## 2. Additional products

- ◆ **RF-Cables 50 Ohms** - Coaxial cables for radio transmission systems
- ◆ **Euca Fast** - Fixings for the installation of RF-Cables
- ◆ **RF-Cables 75 Ohms** - Trunk and distribution cables with welded copper outer conductor
- ◆ **RF-Cables Braided** - RG, CCTV, CATV, Satellite and Video Coaxial cables
- ◆ **Optical Cables** - Optical Fibre Cables

