UTILISATION
OF Silec Cable CR
RADIATING CABLES

Telecom Cables Department / Commercial
Phone : +33 1 41 98 09 21 - Fax +33 1 49 98 09 29 - Email : contact@sileccable.com
Head office : Rue de Varennes Prolongée - 77876 MONTEREAU CEDEX - France
Phone : + 33 1 60 57 30 00 Fax : + 33 1 60 57 30 15 www.sileccable.com
SAS au capital de 60 037 000 € - 484 920 194 RCS Montereau

Silec Cable

1. Operating mode of Silec Cable CR radiating cables.

Silec Cable CR cables define a new generation of radiated mode cables with large bandwidth. Series of slots on the external conductor, with original patented patterns, enable operating modes from 30 MHz to 2500 MHz.

- **Frequencies below 300 MHz :**

  In this case, Silec Cable CR cables operate in coupled mode. The electromagnetic propagation mode, internal to the coaxial cable, excites through the slots an external propagation mode, along the cable. This external mode generates then a radiation around the cable. This operating mode will imply relatively high fluctuations of the electromagnetic field along the cable (20 à 30 dB peak to peak).
  Contrary to most of radiated mode cables, whose performance are rather poor at frequencies below their radiated mode frequency, the pattern of slots of the Silec Cable CR cables has been designed to enable satisfactory operation within the entire frequency range of 30 to 300 MHz.

- **Frequencies between 300 and 2200 MHz :**

  Silec Cable CR cables operate here in radiated mode with few interferences. Slots radiate then directly like antennas and the radiating cable behaves like an in-phase antennas network. Within this optimised range of frequencies, the secondary radiated modes are mostly cancelled, which infers few fluctuations of the electromagnetic field along the cable (10 to 15 dB peak to peak).

- **Frequencies above 2200 MHz :**

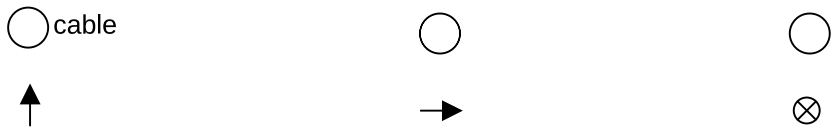
  Silec Cable cables operate then in radiated mode. However in this frequency range, interferences may happen between different modes. This translates into higher fluctuations of the radiated field along the cable (15 to 20 dB peak to peak).

Furthermore, the homogeneous distribution of the slots around and along the cable implies :
- An almost **cylindrical symmetry** of the radiation, whatever the frequency,
- An homogeneous radiation along the cable (absence of non-radiating zone).

Thus, the radiation diagram of Silec Cable CR cables is a cylinder which axis equates the cable axis, thus facilitating their utilisation. There is no privileged orientation to be taken into account while installing the cable. Further the Silec Cable CR cable are suited for radio coverage of straight zones as in railway tunnels as well as for non straight zones as in subway passage.

2. Influence of the polarization of the antenna

The electrical field radiated by a radiating cable has a spatial orientation which can be split within three polarizations :



Radial polarization Orthogonal polarization Parallel polarization

Following the type of radiating cable, the module of the measured field may vary rather significantly with the polarization.

For Silec Cable CR cables, orthogonal polarization is the most favourable and parallel one the worst.
In every cases maximal difference of coupling loss between those two polarizations is about 6 dB.

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3. Installation of the Silec Cable CR cables

3.1 Generalities

By definition, whatsoever its operating mode, a radiating cable is an open system linked with its external environment. Performance of the cable depends on this environment and in particular on :

- the shape and nature of the tunnel or of the place in which the cable has to be installed,
- its position within the tunnel,
- its distance to the wall
- the proximity of other cables or conductor elements,
- the type of fixations used (metallic or not).

As previously stated, the structure of the Silec Cable CR cables permits to avoid influences of additional parameters as cable orientation. It also makes them less sensible to environment than other types of radiating cables, such as coupled mode or radiating sections cables.

Silec Cable tested experimentally the performances of the CR cables range, in different conditions, standardised or not, following the three above-mentioned polarizations :

- in laboratory, with the “free space method"”, as defined in the IEC 61196-4 standard,
- in laboratory, with the “ground level method", as defined in the IEC 61196-4 standard,
- in tunnels of different shapes and structures.

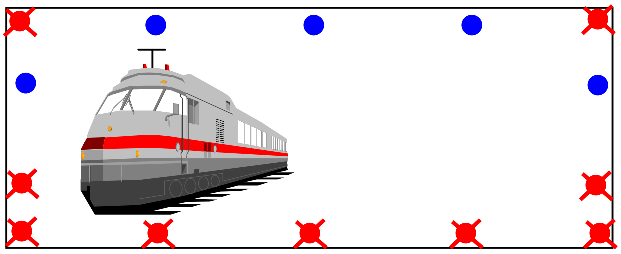
Performance mentioned in our particular data sheets are to be regarded as “worst case” values. Experience shows in particular that in tunnel measured coupling loss are generally lower by 5 to 10 dB.

3.2 Positioning of the cable in the tunnel

Experience shows that positioning of the cable might have a significant influence over the coupling losses. Those losses being eventually increased while the cable is installed in corner, especially if conductivity of the walls is important (presence of metallic armature for instance).
It is therefore highly recommended not to place the cable in a corner. A positioning in the middle of a wall (lateral wall or vault) shall be more recommended.

Furthermore, it is preferable for an optimised operation, that the antenna of the mobile emitter/receiver system be in direct view of the cable. So it is necessary to take into account the different possible positions of the antenna of the mobile communication system in order to choose the optimum positioning of the cable.

Sketches below show some positioning examples.



Legend :

Figure 1 : case of an antenna placed on the roof of a train

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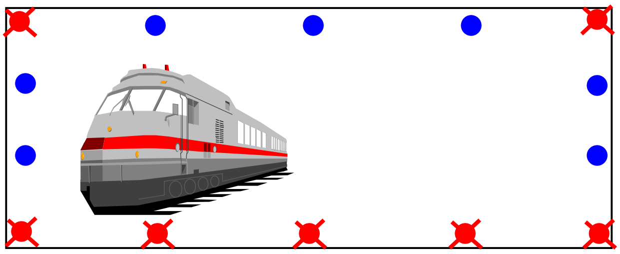

Legend :

Position to avoid

Possible position

Figure 2 : case of an antenna placed within the coach

3.3 Distance from the cable to the wall

Distance from the cable to the wall may influence significantly linear attenuation and even more the coupling loss. This influence may vary with the nature of the wall, but an increase of the linear attenuation (of a few 1/10^{e} of dB / 100 m) and of the coupling losses (of a few dB) is generally observed when distance between the axis of the cable and the wall is below 5 cm.
We recommend a distance of about 10 cm between the axis of the cable and the wall to which it is fixed.

3.4 Fixation systems

Silec Cable CR cables exist in two versions :
- cylindrical
- self-supporting in "8"

For cylindrical cables, we recommend to install radiating cables with a minimum of slag.
For all type of cables we recommend to use polyamide Zero Halogen hangers spaced from :
- 0,50 to 0,8 m for 1/2″ cables (0,7 m recommended)
- 0,8 to 1,1 m for 7/8″ cables (1 m recommended)
- 1m to 1.5 m for 1″1/4 cables (1,3 m recommended)

We also recommend to attach to cable at a distance of 80 to 100 m from the tunnel wall, by means of a spacer separated or included in the hanging clamp. For better safety, it is possible to substitute every 10 Polyamide clamp a stainless steel clamp (see note hereunder).

The self-supporting version in "8" enables, due to the tensile strength added by the metallic or dielectric member, to increase the distance between the fixation points. Thus, we recommend to place a fixation point every five metres for the self-supporting cables. In some cases, self-supporting cable might significantly reduce installation costs.

In all cases we recommand the use of a minimum of metallic clamps. In particular, it has been observed that metallic hangers placed around the cable every metre might cause very important increases of the linear attenuation at some frequencies.

Following the configuration of the installation place, hangers might be advantageously clamped to existing elements such as hooks, racks or cable trays, in order to avoid systematic drilling of the wall.

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4. System calculation

4.1 System losses

For a link by radiating cable, we define the system losses as the sum of linear losses and coupling losses (see figure 3).

$$SL\ (dB) = \alpha\ (dB/100m)\ \frac{L\ (m)}{100} + CL\ (dB)$$

where SL : system losses
α : linear attenuation
L : length of cable
CL : coupling losses

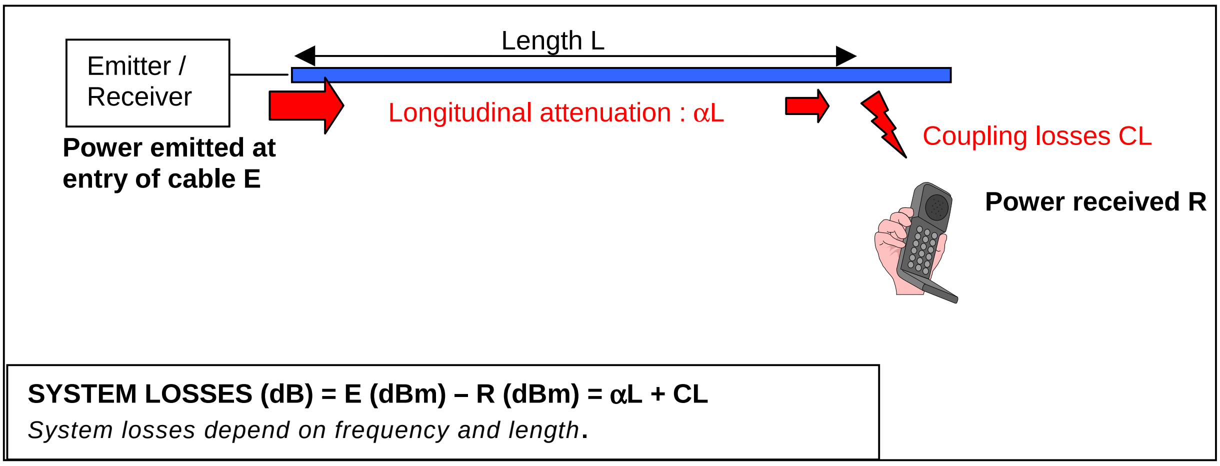

Figure 3

Coupling losses indicated on **Silec Cable** CR cables data sheets are statistical values at 50% or 95%, as defined in the IEC 61196-4 standard.

Definition of coupling coefficient at 50 % C50 : *50% of measured coupling losses are below C50 value.*
Definition of coupling coefficient at 95 % C95 : *95% of measured coupling losses are below C95 value.*

System losses are equally defined as statistical values at 50% or 95%, depending on whether coupling losses within the formula are C50 or C95.
Generally, values at 50% are used for analog systems and values at 95% for numerical systems.

Coupling losses depend on distance between measurement antenna and the radiating cable. In our technical documentation, coupling losses are indicated for a standardised distance of 2 metres.
For a cable placed in free space, this variation can be expressed by the following formula :

$$CL(d) = CL(2m) + A\log\left(\frac{d}{2}\right)$$

where CL(d) is the coupling loss in dB at the distance d (in m) of the cable
CL(2m) is the coupling loss in dB at the distance of 2 m of the cable
A is a coefficient depending on frequency and type of cable.

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A study led by RFS and presented at the IWCS 1999 (article titled *Outdoor coverage by radiating cables* by Erhard Mahlandt) shows that there is no significant difference between coupled mode cables and radiated mode cable with regard to this parameter, and that in free space condition, in both case, coefficient A is between 8 and 12.

Experimentation led by **Silec Cable** on CR radiating cables confirm those findings with a mean coefficient of 10.

In confined environment, as in tunnel, this coefficient A is lower, due to reflections on walls, but interferences due to multiple paths are more important.

4.2 Other losses

Other losses (OL) to be taken into account within the power budget are :

- Losses of other cables and connectors (feeder, …)
- Losses due to eventual power splitters,
- Attenuation of penetration within a vehicle (case of a communication from the interior of a vehicle)
- Crowd effects (case of mobile telephone systems in particular)
- …

4.3 Calculation of a power budget

The margin of a system M is determined from emitted power E, from the receiver sensitivity S and from the antenna efficiency G by the following formula :

$$M\ (dB) = E\ (dBm) - SL\ (dB) - OL\ (dB) + G\ (dB) - S\ (dBm)$$

Taken into account uncertainty induced by hardly foreseeable parameters as tunnel structure, it is recommended to specify a margin of about 10 to 15 dB for communication systems using radiating cables in tunnels.

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