RADIO FREQUENCY SYSTEMS
The Clear Choice®

Installation Guideline RADIAFLEX® Cables

Edition J

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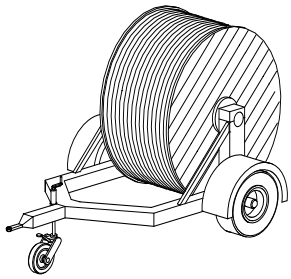
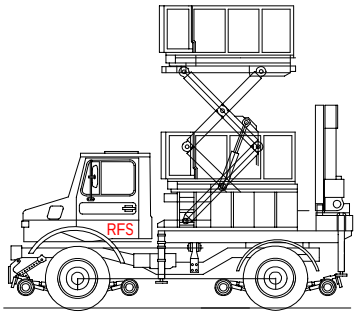
1 Vehicles and Machines



- A cable trolley or cable-laying truck is suitable for transporting the drums to the site.
- Installation in buildings is normally carried out using ladders or mobile scaffolds.
- When installing in tunnels, track-bound trolleys belonging to the respective railway operator or other special vehicles can be used.
- A conventional chalk line can be used for marking out. A roller marker is recommended for installations at a greater height.

- Both mains- and battery-powered drills may be used for drilling the necessary holes for clamps etc.
- The use of a cordless electric screwdriver is recommended for mounting the clamps.
- Hydraulic cable drum jacks are required for lifting the drums.
- If cables have to be pulled over long distances (e.g. over the ground), then ground rollers should be used to protect the cable jacket.



- The respective preparation tools should be used for mounting the connectors. These competitive items considerably ease the mounting of connectors. The quality of the connection is substantially improved.
- A gas blowlamp or hot-air gun is required to shrink the heat-shrink sleeves over the connectors.
- If cables have to be drawn through vertical cable ducts or conduits, then hoisting stockings should be used.

Various roller frames

Hydraulic cable drum jack

2 Tools

2.01 Toolbox

We recommend the use of the tool kit for CELLFLEX® cable; model number **TRIM-T01**, for the fitting of connectors and earthing kits to feeder or jumper cables (LCF and SCF cable).

Toolbox:

2.02 Preparation and Stripping Tools for CELLFLEX® cables

The use of the appropriate stripping tools enables connectors and earthing kits to be fitted with a consistently high standard.

Preparation tools:

Model number **TRIM-SET-S12-D01**	Main set including the insert to prepare the SCF12 for OMNI FIT Premium Connector D01 on SCF12 cable
Model number **TRIM-SET-L12-D01**	Main set including the insert to prepare the LCF12 for OMNI FIT Premium Connector D01 on LCF12 cable
Model number **TRIM-SET-L78-D01**	Main set including the insert to prepare the LCF78 for OMNI FIT Premium Connector D01 on LCF78 cable

Inserts:

For other connector types you can get the relevant insert for the above mentioned tools. Please have a look to the comparison chart in the following document

OMNI FIT™ Connectors and Universal Trimming Tools

TRIM-SET-L12-D01

JSTRIP-78-2

Stripping tools are also available for fitting earthing kits.

Stripping Tools:

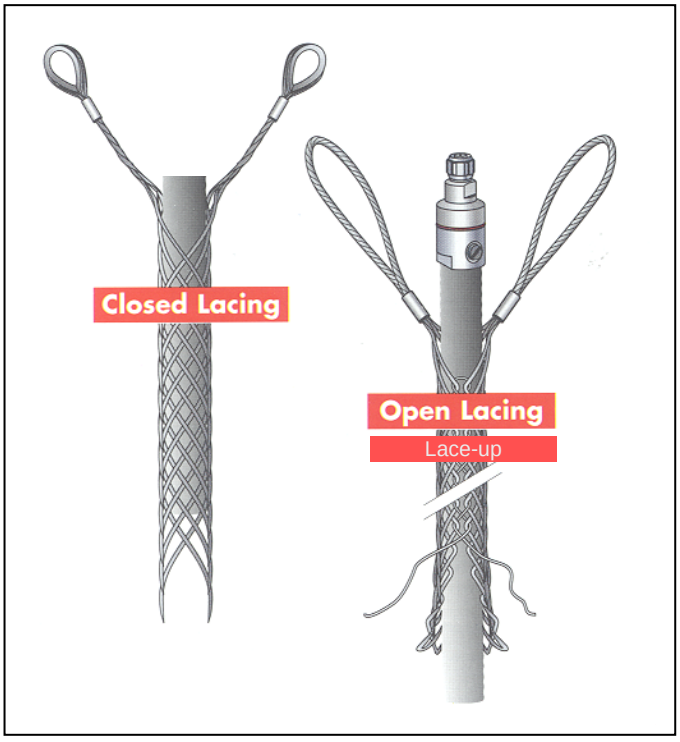
Model number **JSTRIP-12-3** for LCF 12 - 50

Model number **JSTRIP-78-2** for LCF 78 - 50

2.03 Hoisting grips

If cables have to be drawn through vertical cable ducts or conduits, then hoisting grips should be used. The following table will enable you to select the correct **hoisting grips**:

for 1/2” cable	open type	Model number **HOIST1-12L**
for 1/2” cable	closed type	Model number **HOIST1-12C**
for 7/8” cable	open type	Model number **HOIST1-78L**
for 7/8” cable	closed type	Model number **HOIST1-78C**
for 1 1/4” cable	open type	Model number **HOIST1-114L**
for 1 1/4” cable	closed type	Model number **HOIST1-114C**
for 1 5/8” cable	open type	Model number **HOIST1-158L**
for 1 5/8” cable	closed type	Model number **HOIST1-158C**



Note:

The closed type hoisting grips can only be used before a connector is terminated.

2.04 Additional Tools

In addition, the following tools are necessary or recommended for the installation of radiating cable systems:

Hammer drill	fitting clips etc.
Cordless electric screwdriver (recommended)	installing large numbers of clamps
Masonry bits for hammer drill 6, 8, 10, 12, 15 mm	fixing clamps and equipment
Air-pump	cleaning out drilled holes
Manual Setting Tool for plugs M8, M10, M12	inserting metal plugs
Hammer 1000 g	inserting plugs
Allen keys 5, 6, 8, 10 mm	various fixings
Socket 13 mm (and/or bit for drill)	fixing Heavy duty clamps
Torx screwdriver T 25 (and/or bit for drill)	fitting standard Clic clamps
Hot-air gun or small gas blowlamp	for heat shrinking
Lamp (min. 1000 W) (recommended)	illuminating the workplace
Spike bar	removing cable drum covering planks
Folding wooden rule, tape measure	general works
Wire cutters	general works
Slip-joint wrench	general works

2.05 Additional Materials

A number of sundry items are required for installing RADIAFLEX® and CELLFLEX® cables. These are neither included with the connectors nor in the toolkit.

The following sundries may be required:

Heat shrink caps for sealing cables

- 1/2”
- 7/8”
- 1 1/4”
- 1 5/8”

Heat shrink sleeves for additional sealing of connector to cable in lengths of 1.0 m

- connector - cable 1/2” Model number **HEAT-0328-18**
- connector - cable 7/8” Model number **HEAT-3812-014**
- connector - cable 1 1/4” Model number **HEAT-5016-024**
- connector - cable 1 5/8” Model number **HEAT-6319-026**

Cold shrink sleeves as protective insulation and for sealing connectors

- 1/2” - 1/2” Model number **COLD-020**
- 1/2” - 7/8” Model number **COLD-021**
- 1/2” - 1 1/4” 1/2” - 1 5/8” Model number **COLD-022**
- 7/8” - 7/8” Model number **COLD-023**
- 7/8 ” - 1 1/4” 7/8 ” - 1 5/8” Model number **COLD-024**
- 1 1/4” - 1 1/4” 1 1/4” - 1 5/8” Model number **COLD-025**
  1 5/8” - 1 5/8”
- Diameter Line Extension Model number **COLD-035**

- Cable cleaner
- “Scotch” tape
- Electrical tape
- Emery cloth (280 grain)
- Cleaning cloths

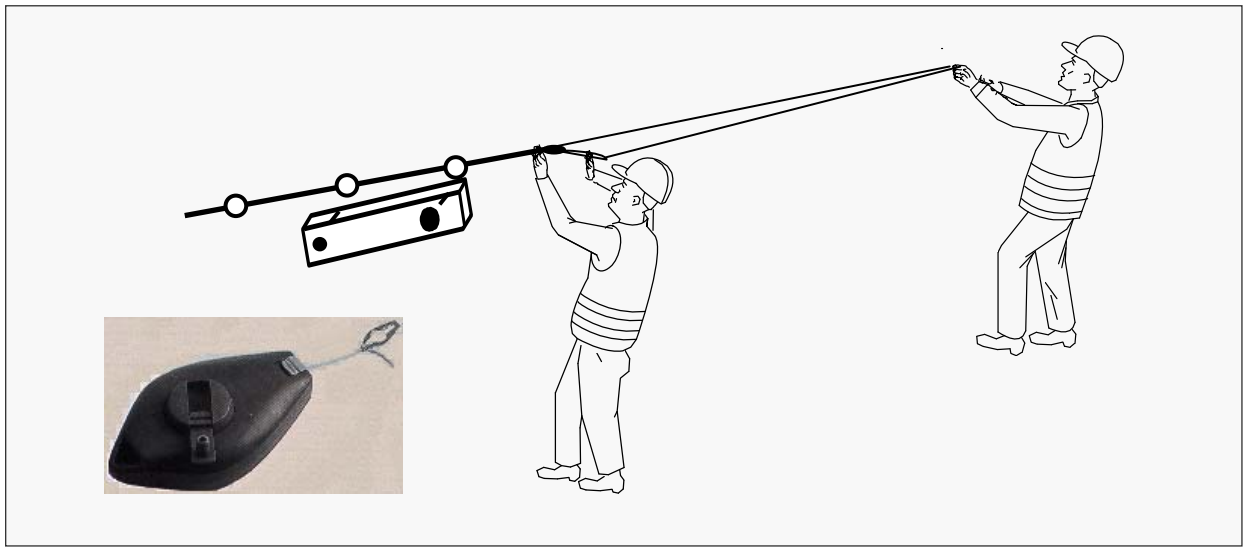
3 Marking the height of the cable clamps

In order to be able to work efficiently when drilling the holes for the clamps, it is necessary to mark the positions of the cable clamps accurately. There are several ways of doing this:

3.01 Snap-line

The horizontal mounting height for the clamps is marked using a standard chalk line. This task is normally carried out on a ladder.

The clamp spacing (see RADIAFLEX® and CELLFLEX® data sheets) is then marked along this line using a spacer gauge. For example, a strip of wood with a screw at the right position and a pencil can be used.



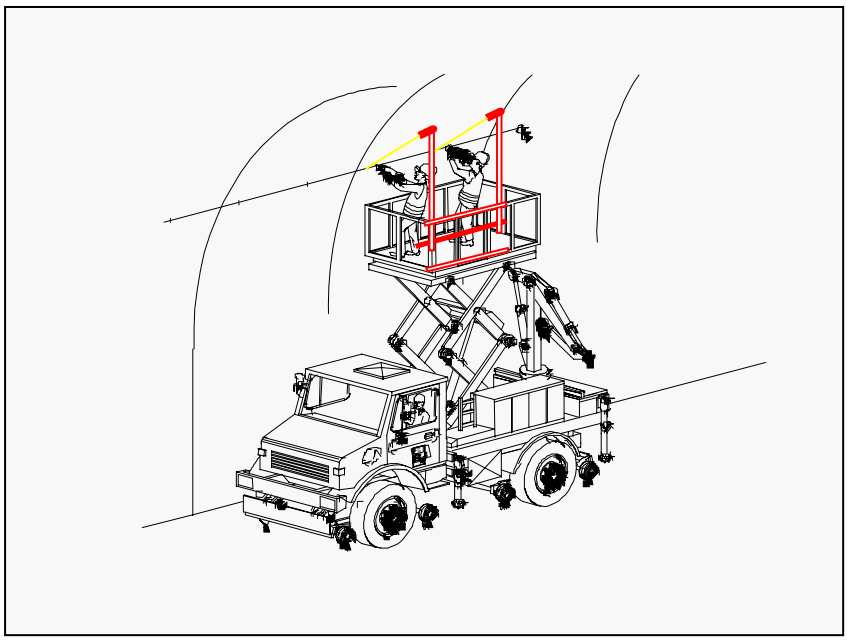
3.02 Marking roller

In this method a roller is run along the wall at the mounting height. The roller is coated in chalk dust and is fixed to a mobile frame or directly on the installation vehicle. The spacing of the clips is then marked along this line using a spacer gauge as described above.

3.03 Point-of-light method

Here, at least two light sources (lasers or similar) are fitted to the platform of the installation vehicle in such a way that the points of light on the wall correspond exactly with mounting height and clamp spacing. Mounting both light sources on a mobile frame on the scaffold is advantageous.

This method enables marking and drilling to be combined in one operation. However, the movement of the vehicle's suspension can complicate this work considerably. The clamp spacing is shown automatically as the second point of light (as seen in the direction of movement) is aimed at the last hole drilled.



3.04 Rotating laser

This device is attached to a tripod or directly to the installation vehicle (scaffold or platform). The rotating laser (e.g. Hilti rotating laser PR 10) projects a continuous laser beam onto the wall intended for the installation. But in this system too, the movement of the vehicle's suspension can complicate the work.

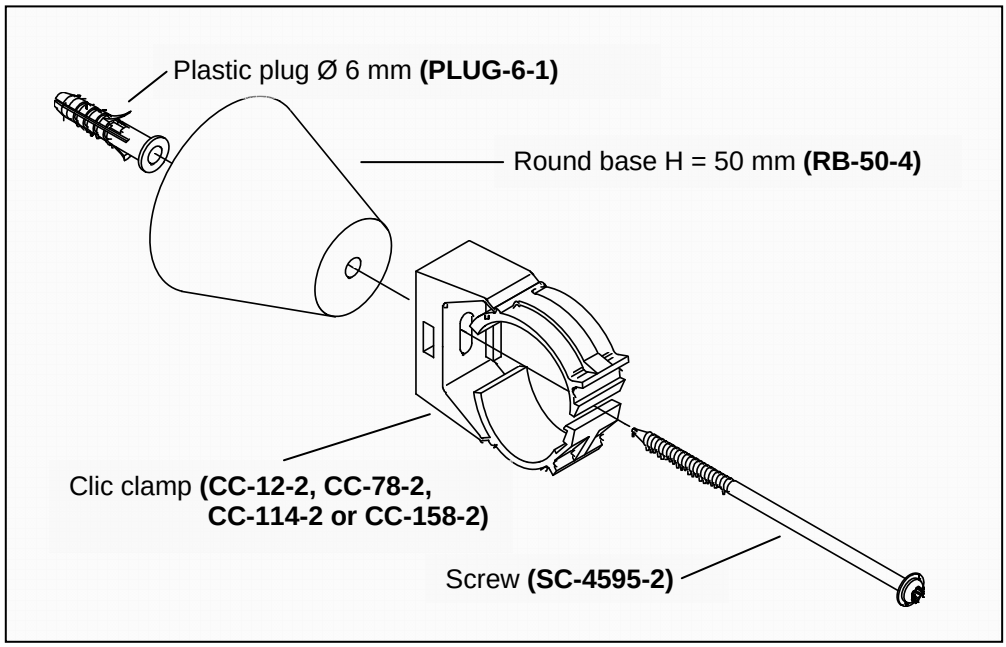
4 Cable Clamps

4.01 Assumption for all wall mounting fixing points

The dowels are mounted to concrete walls with a concrete quality of at least C20/25 and maximum C50/60 (acc. to EN 206-1:2000-12). **It is not under the responsibility of RFS to demonstrate that the concrete quality being used in the project meets this requirement.**
Installation materials, according to the recommendations of RFS, are used.

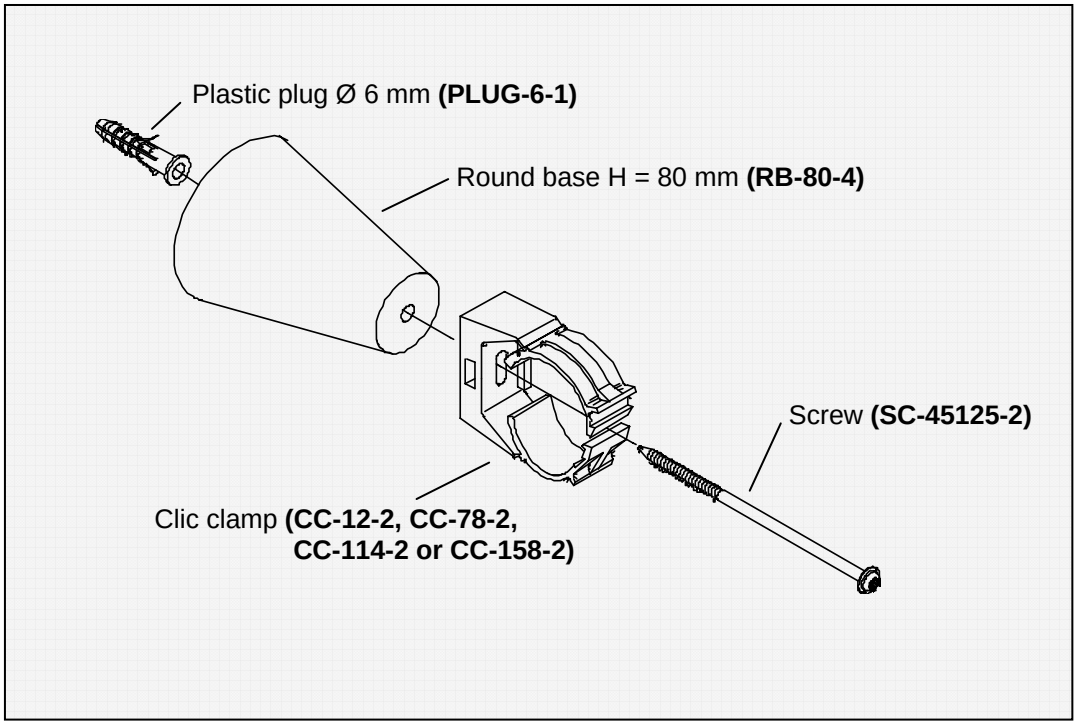
4.02 Standard Clic clamp with round base, H = 50 mm

The RADIAFLEX cables of the RLF and RCF/RSF series require a round base with min. height H = 50 mm.
The clamps are fixed with a plastic plug Ø 6 mm **(PLUG-6-1)** and a screw **(SC-4595-2)**. A hole Ø 6 mm x 40 mm deep has to be drilled for each of these.
Care should be taken to ensure that the hole is drilled at right angles to the surface of the wall so that the clamps fit correctly to the wall during the subsequent assembly. The hole should be cleaned out with air-pump after drilling. The clamp is fixed by means of a round head wood-screw tightened with a TORX bit screw driver (T 25) or with a cordless electric screwdriver and corresponding TORX bit.
Make sure the clamps are lined up; otherwise the cable will not run in an absolutely straight line.
The min. bending radii for installing cables should also be taken into account when fixing the clamps.
When attaching the cable, the action of pressing the cable into the clamp with the hand causes the clamp to close automatically
Regarding the recommended clamp spacing, please refer to the data sheet of the individual cable.



4.03 Standard Clic clamp with round base, H = 80 mm

RADIAFLEX cables of the RLK, RAY and RLV series require a round base with a height H = 80 mm. These clamps are fixed with a plastic plug Ø 6 mm **(PLUG-6-1)** and a screw **(SC-45125-2)**.
A hole Ø 6 mm x 40 mm deep has to be drilled for each of these. Care should be taken to ensure that the hole is drilled at right angles to the surface of the wall so that the clamps fit correctly to the wall during the subsequent assembly. The hole should be cleaned out with air-pump after drilling. The clamp is fixed by means of a round head wood-screw tightened with a TORX bit screw driver (T 25) or with a cordless electric screwdriver and corresponding TORX bit.
Make sure the clamps are lined up; otherwise the cable will not run in an absolutely straight line.
The min. bending radii for installing cables should also be taken into account when fixing the clamps.
When attaching the cable, the action of pressing the cable into the clamp with the hand causes the clamp to close automatically.
Regarding the recommended clamp spacing, please refer to the data sheet of the individual cable.

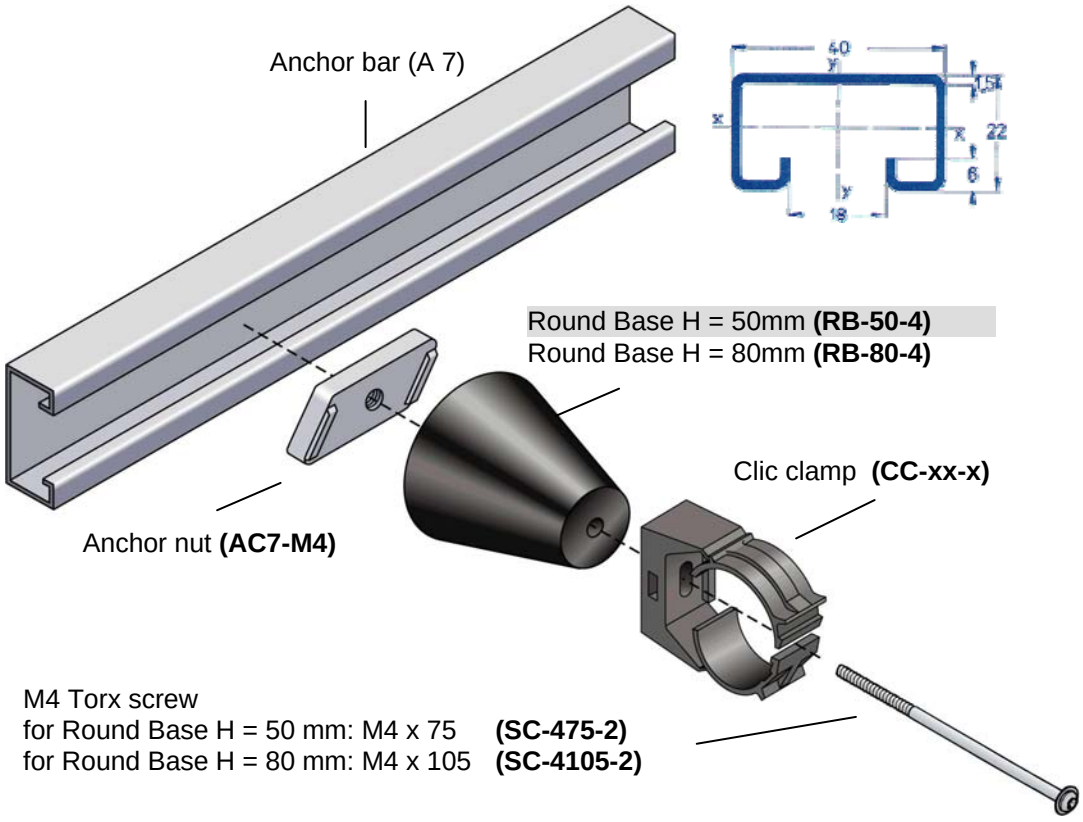


4.04 Attaching standard Clic clamps to existing anchor bar

The Clic clamps and round bases (H = 50 mm or H = 80 mm depending on cable type) are fixed to the Anchor bar with a round head Torx-screw M4 x ... (length depends on type of anchor bar and height of round base) and an M4 anchor - nut corresponding to the respective anchor bar type.

Note concerning the use of standard machine screws:
The heads of metric screws are too large for Clic clamps smaller than **CC-158-2**;
the heads of the screws dig into the cable jacket.

Each clip is fixed with a TORX screw tightened with a TORX bit screw driver (T 25) or with a cordless electric screwdriver and corresponding TORX bit.
Make sure the clamps are lined up; otherwise the cable will not run in an absolutely straight line.
The min. bending radii for installing cables should also be taken into account when fixing the clamps.
When attaching the cable, the action of pressing the cable into the clamp with the hand causes the clamp to close automatically.
Regarding the recommended clamp spacing, please refer to the data sheet of the individual cable.

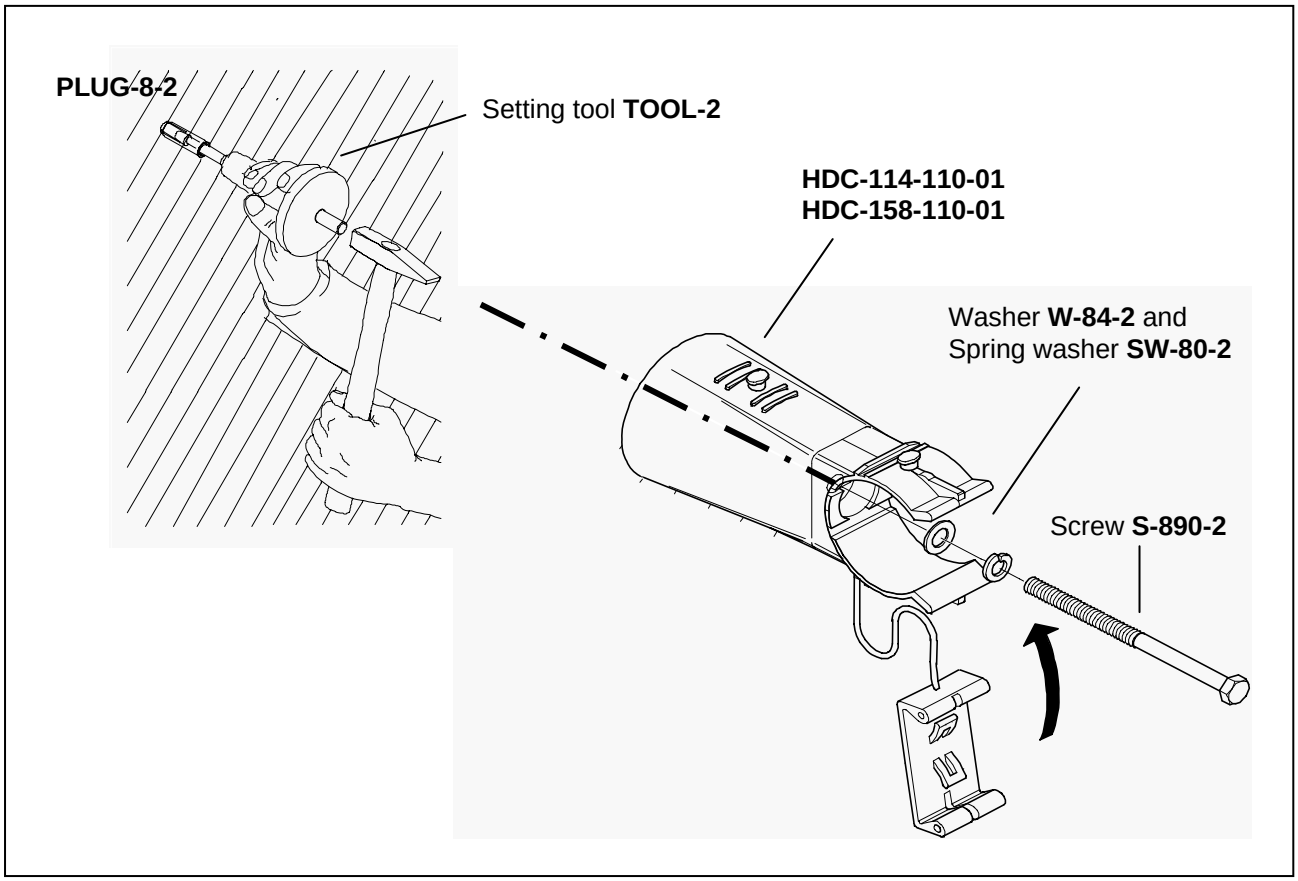


4.05 Heavy Duty Clamps fixed with metal plugs

This clamp was specially developed for use in railway tunnels for high-speed applications up to 300 km/h. These clamps are fixed using stainless steel plugs **(PLUG-8-2)**. A hole Ø 10 mm x 32 mm deep has to be drilled for each of these.

Care should be taken to ensure that the hole is drilled at right angles to the surface of the wall so that the clamps do not become twisted during the subsequent installation. The hole should be cleaned out with air-pump after drilling. The plugs are driven into the wall with the Manual Setting Tool **(TOOL-2).** The tool leaves behind a visual setting check.

The screws can be tightened with a powerful cordless electric screwdriver. Make sure the clamps are lined up; otherwise the cable will not run in an absolutely straight line. The min. bending radii for installing cables should also be taken into account when fixing the clamps. After installing the cable, the clamps can be closed with the lock frame. Regarding the recommended clamp spacing, please refer to the data sheet of the individual cable.

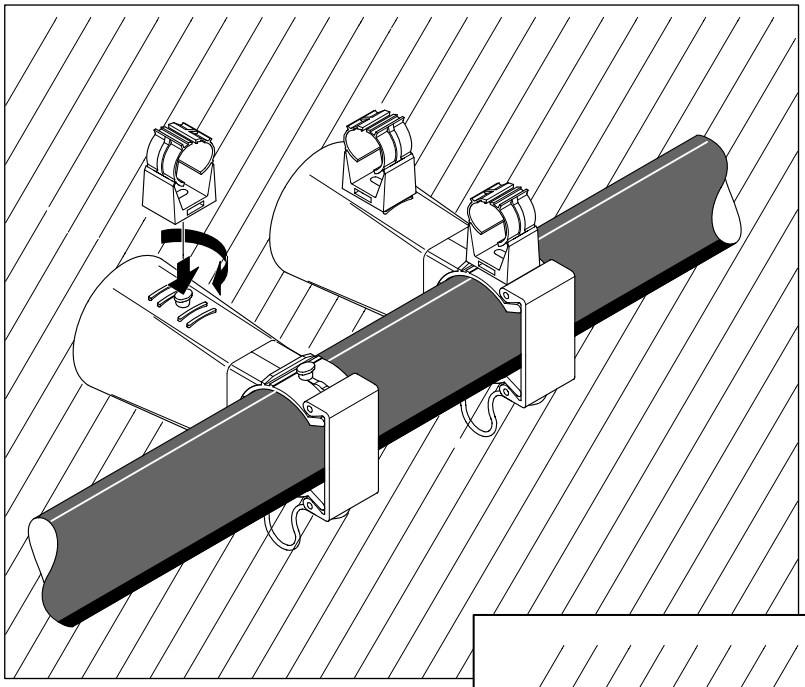


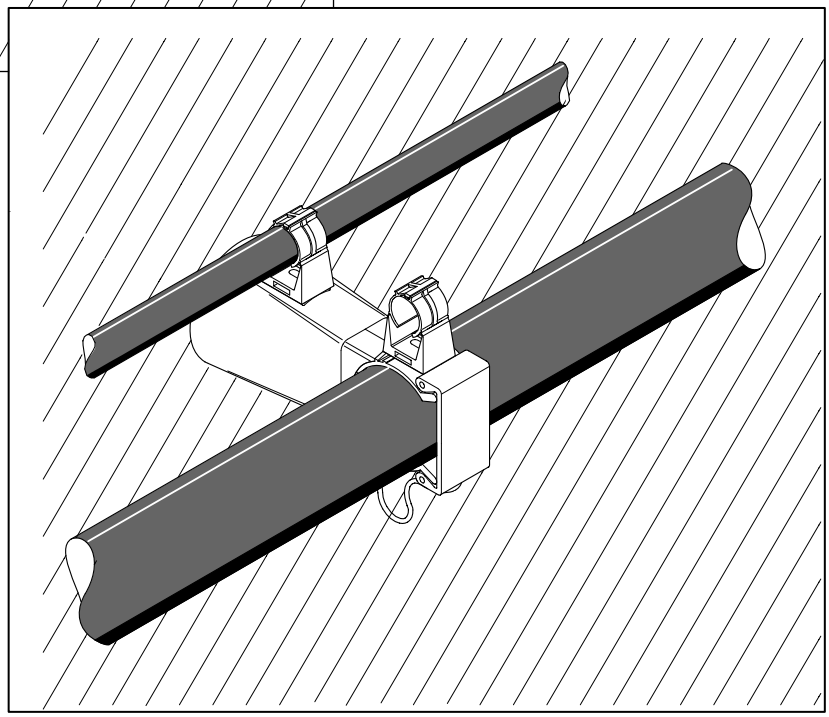
4.06 Heavy Duty Clamps with additional Clic clamps

The Heavy Duty Clamp **HDC-114-110-01** and **HDC-158-110-01** is equipped with four ports to carry additional Clic clamps. Optionally up to four Clic clamps could be mounted for installation of fibre optic backbone cables. We recommend using only two ports and mainly the back ports.

Suitable types are:

CC-12-2, CC-58-2 and CC-78-2. They can directly be mounted without any tools and further accessories.





4.07 Fire-resistant clamps

This clamp type was developed for situations, which require the cable to remain functional for as long as possible in the event of a fire. The cable should not become detached from the wall or ceiling and in doing so perhaps also block an escape route.

These clamps are fixed using a stainless steel plug **(PLUG-8-2)**. A hole Ø 10 mm x 32 mm deep has to be drilled for each of these. The clamps should be installed in addition to the normal clamps, not as a substitute.

Care should be taken to ensure that the hole is drilled at right angles to the surface of the wall so that the clamps do not become twisted during the subsequent assembly. The hole should be cleaned out with air-pump after drilling.

The plugs are driven into the wall with the Manual Setting Tool **(TOOL-2)**. The tool leaves behind a visual setting check.

Before installing the clamps, the fixing hole in the round base must be drilled out to 8.5 mm.

The RSB-clips **(RSB-12, RSB-78, RSB-114, RSB-158-001)** are fixed on a round base with H = 50 mm **(RB-50-4)** by means of a hexagon-socket screw M8 x 65 **(S-865-2)** or a hexagon-socket screw M8 x 95 **(S-895-2)** when using a spacer with H = 80 mm **(RB-80-4)**.

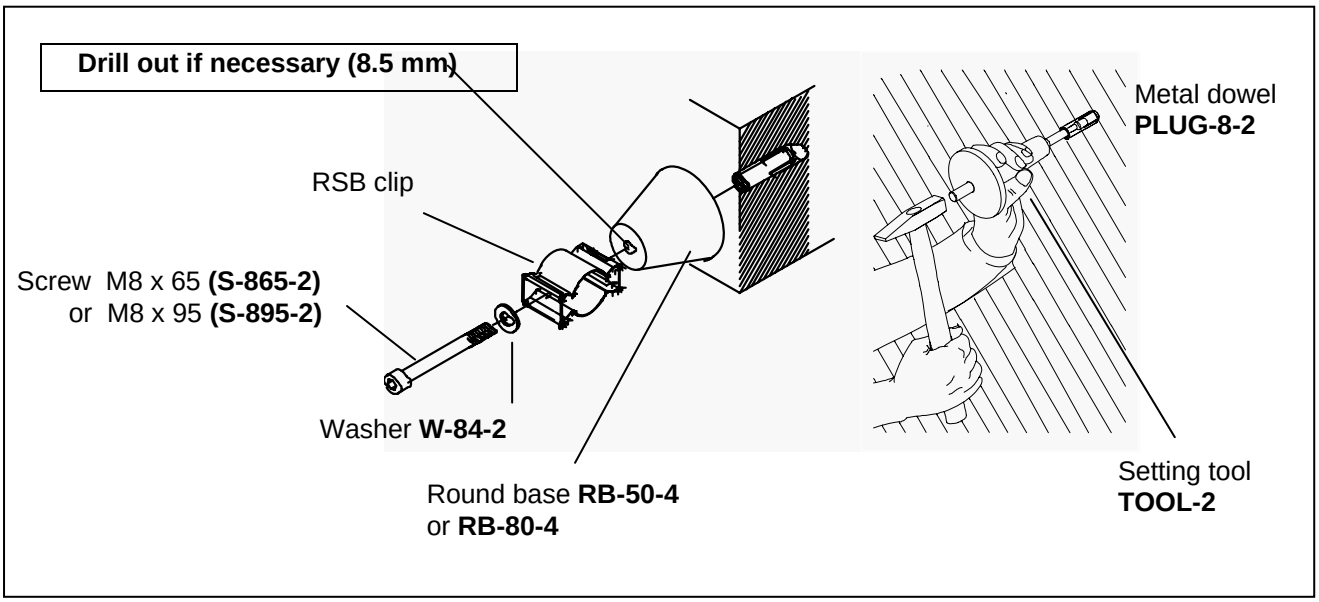
In doing so, a washer **(W-84-2)** is placed between head of screw and RSB clip.

As the recommended installation spacing for these clamps is every approx. 8-10 m, the installation can be carried out with an Allen key; the use of a cordless electric screwdriver is hardly an advantage in this case.

Make sure the clamps are lined up; otherwise the cable will not run in an absolutely straight line.

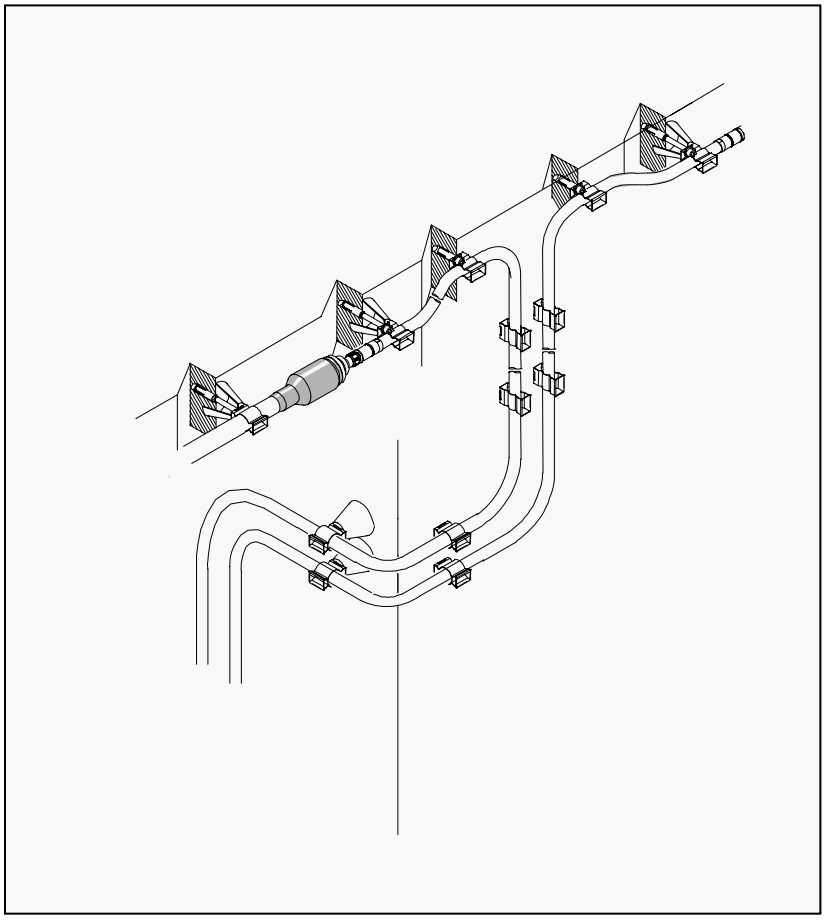
The min. bending radii for installing cables should also be taken into account when fixing the clamps.

After installing the cable, the clips are closed by simply pressing the closure into position.



4.08 RSB clip for CELLFLEX® cable

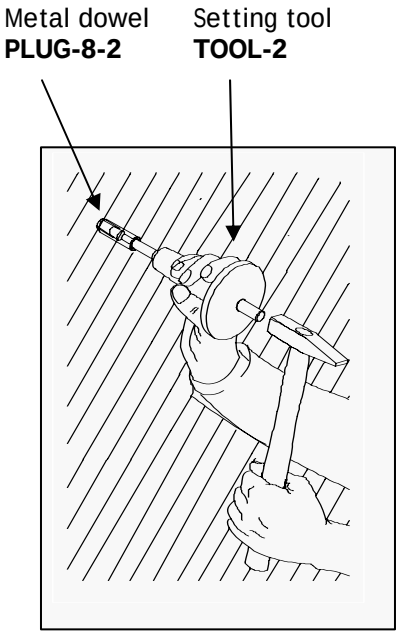
RSB clips are recommended for fixing CELLFLEX® cable used as a feeder line. In radiating cable projects these clamps are mainly fixed directly to walls and ceilings. To equalize the distance between RADIAFLEX® cables and walls as well as in sharp bends around corners the use of standard round bases is recommended.

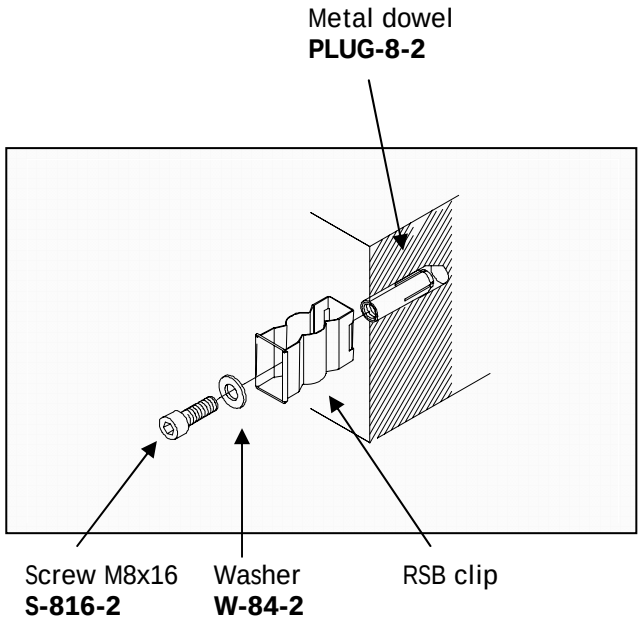


For the cable types **SCF14-50** and **SCF12-50** an additional clamp lining is used to fix the cable into the RSB clip.
These RSB clips are fixed using stainless steel plugs **(PLUG-8-2).** A hole Ø 10 mm x 35 mm deep has to be drilled for each of these.

Care should be taken to ensure that the hole is drilled at right angles to the surface of the wall so that the clamps do not become twisted during the subsequent installation. The hole should be cleaned out with air-pump after drilling. The plugs are driven into the wall with the Manual Setting Tool **(TOOL-2).** The tool leaves behind a visual setting check.

The RSB-clips are fixed by means of a hexagon-socket screw M8 x 16 **(S-816-2)**.
In doing so, a washer **(W-84-2)** is placed between head of screw and RSB clip.

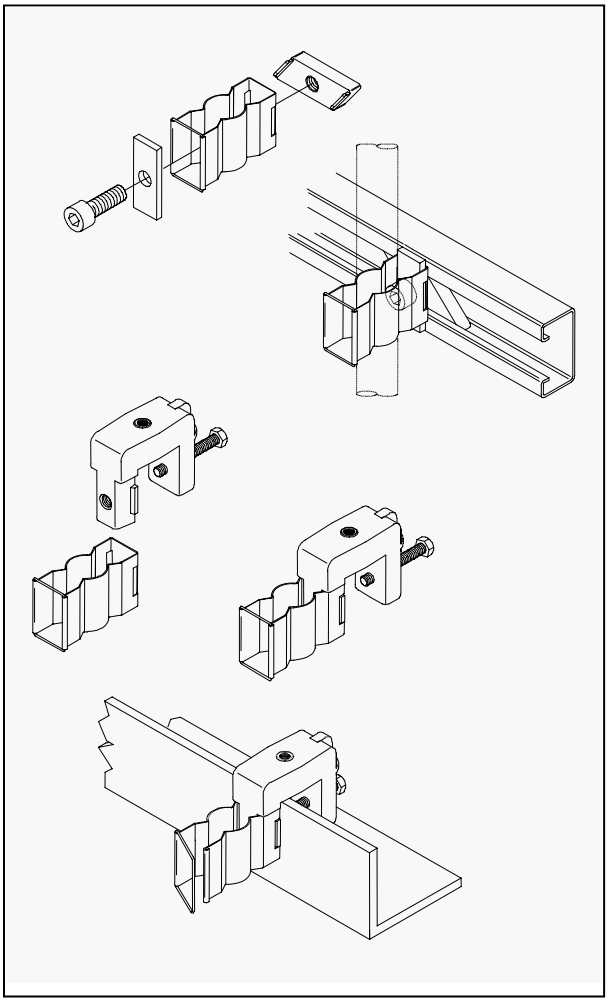


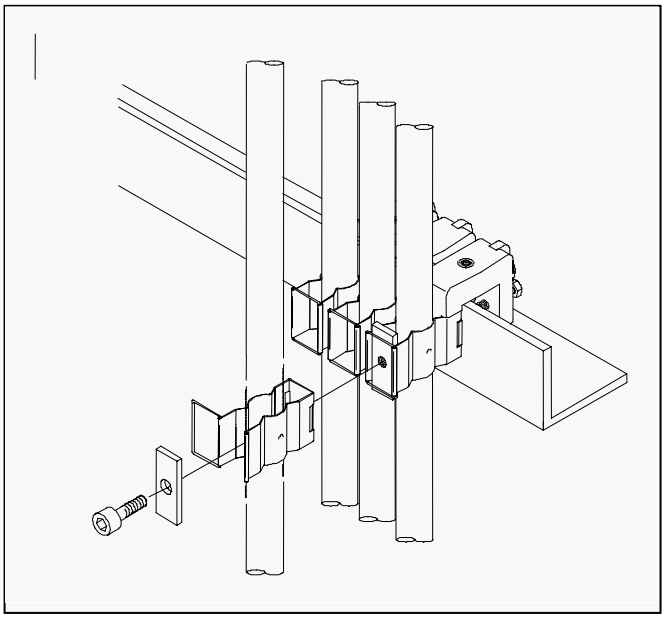


The screws can be tightened with a powerful cordless electric screwdriver.
Make sure the clamps are lined up; otherwise the cable will not run in an absolutely straight line.
The min. bending radii for installing cables should also be taken into account when fixing the clamps.
Simply pressing the closure into position closes the clips. The use of RSB clips prevents the cable from deforming. However, the clips should only be closed after the cable has attained its final position, i.e. the cable should not be pulled through clips, which have already been closed.

For fixing the RSB clip to existing steelwork (e.g. iron angles, cable ladders, or anchor bars) a range of accessories are available.

Fixing to angle irons, flat irons or similar components can be carried out with the help of a fixing cleat.
The ”Fixing set with clamping plate on anchor bar ” is used for fixing to anchor bars. The use of the spacer plate is essential in this case.





Refer to the ”RSB Clip” data sheet for detailed information.

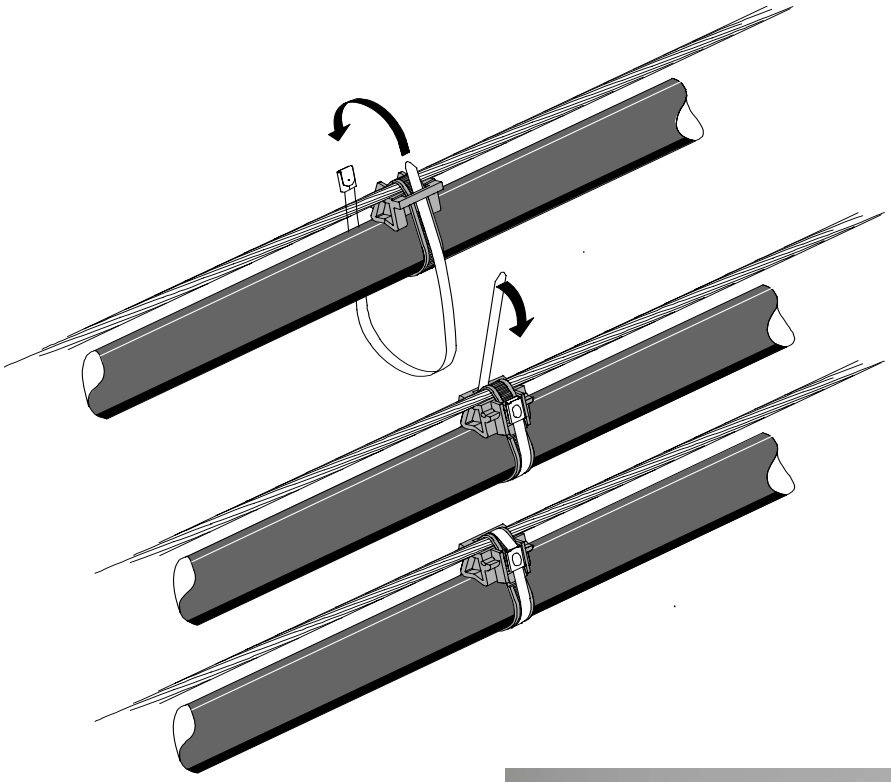
Download AN 040511.pdf

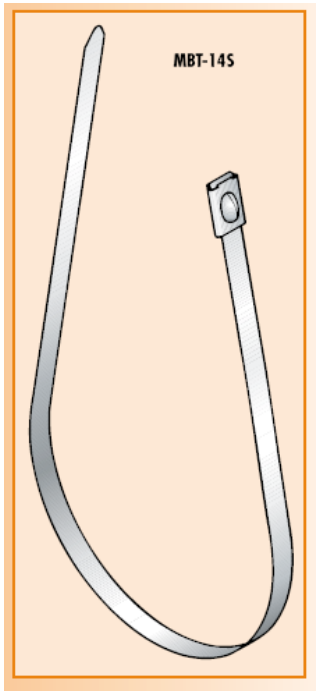
4.09 Installation with Cable tie to an external messenger wire

A very time saving method to fix radiating cables to an existing messenger wire is the use of the cable tie **TAS-100L.** This tie is halogen free and UV-resistant. It fits to all cable sizes. To make sure that the cable will not be squeezed due to ties closed with too much power, it is strongly recommended to use the force-adjustable tool **MK9HT**.

MK9HT

To achieve a fire protected fixation in conjunction with the **TAS-100L** an additional metal tie **MBT-14S** can be used. The recommended installation spacing is 8 – 10 m. To make sure that the cable will not be squeezed due to ties closed with too much power, it is strongly recommended to use the force-adjustable tool **MK9SST**.





MK9SST

As an alternative to the fixing of radiating cables on separate external messenger wires, RADIAFLEX cables with an integrated messenger wire are available.

4.10 RADIAFLEX® mounting accessories guide

cable type	ALFU12-50 RSF-12-50 RCF12-50	RLK*12-50	RLF*78-50 RCF78-50	RLK*78-50	RLF*114-50 RCF114-50	RLK*114-50 RLV*114-50 RAY*114-50	RLF*158-50 RCF158-50	RLK*158-50 RLV*158-50 RAY*158-50
for installation onto wall and ceiling								
Standard Solution (wall / ceiling)								
Clic Clamp	CC-12-2	CC-12-2	CC-78-2	CC-78-2	CC-114-2	CC-114-2	CC-158-2	CC-158-2
Round Base	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4
Plastic plug	PLUG-6-1	PLUG-6-1	PLUG-6-1	PLUG-6-1	PLUG-6-1	PLUG-6-1	PLUG-6-1	PLUG-6-1
Screw for above plastic plug	SC-4595-2	SC-45125-2	SC-4595-2	SC-45125-2	SC-4595-2	SC-45125-2	SC-4595-2	SC-45125-2
Fire protection (wall / ceiling)								
RSB-clip	RSB-12	RSB-12	RSB-78	RSB-78	RSB-114	RSB-114	RSB-158-001	RSB-158-001
Round Base	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4
Metal plug for RSB-clip	PLUG-8-2	PLUG-8-2	PLUG-8-2	PLUG-8-2	PLUG-8-2	PLUG-8-2	PLUG-8-2	PLUG-8-2
Screw for RSB-clip	S-865-2	S-895-2	S-865-2	S-895-2	S-865-2	S-895-2	S-865-2	S-895-2
Washer for RSB-clip	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2
Setting tool for metal plug	TOOL-2	TOOL-2	TOOL-2	TOOL-2	TOOL-2	TOOL-2	TOOL-2	TOOL-2
Standard Solution (anchor bar)								
Round Base	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4
Clic Clamp	CC-12-2	CC-12-2	CC-78-2	CC-78-2	CC-114-2	CC-114-2	CC-158-2	CC-158-2
Anchor nut	AC7-M4	AC7-M4	AC7-M4	AC7-M4	AC7-M4	AC7-M4	AC7-M4	AC7-M4
Screw for above anchor nut	SC-475-2	SC-4105-2	SC-475-2	SC-4105-2	SC-475-2	SC-4105-2	SC-475-2	SC-4105-2
Fire protection (anchor bar)								
RSB-clip	RSB-12	RSB-12	RSB-78	RSB-78	RSB-114	RSB-114	RSB-158-001	RSB-158-001
Round base	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4	RB-50-4	RB-80-4
Anchor nut	AC7-M8	AC7-M8	AC7-M8	AC7-M8	AC7-M8	AC7-M8	AC7-M8	AC7-M8
Screw for above anchor nut	S-865-2	S-895-2	S-865-2	S-895-2	S-865-2	S-895-2	S-865-2	S-895-2
Washer for RSB-clip	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2	W-84-2
High Speeed Solution								
Heavy duty clamp (HDC)	---	---	---	---	HDC-114-110-01	HDC-114-110-01	HDC-158-110-01	HDC-158-110-01
Metal plug	---	---	---	---	PLUG-8-2	PLUG-8-2	PLUG-8-2	PLUG-8-2
Screw for above metal plug	---	---	---	---	S-890-2	S-890-2	S-890-2	S-890-2
Washer	---	---	---	---	W-84-2	W-84-2	W-84-2	W-84-2
Spring washer	---	---	---	---	SW-84-2	SW-84-2	SW-84-2	SW-84-2
Setting tool for metal plug	---	---	---	---	TOOL-2	TOOL-2	TOOL-2	TOOL-2
Installation to external messenger wire								
Cable tie (plastic)	TAS-100L	TAS-100L	TAS-100L	TAS-100L	TAS-100L	TAS-100L	TAS-100L	TAS-100L
Adjusting tool	MK9HT	MK9HT	MK9HT	MK9HT	MK9HT	MK9HT	MK9HT	MK9HT
Fire protecting								
cable tie (metal)	MBT-14S	MBT-14S	MBT-14S	MBT-14S	MBT-14S	MBT-14S	MBT-14S	MBT-14S
Adjusting tool	MK9SST	MK9SST	MK9SST	MK9SST	MK9SST	MK9SST	MK9SST	MK9SST

5 Introduction – Installation in Tunnels or Buildings

Generally, a distinction is made between installing in tunnels or in buildings (e.g. offices, factories, etc.). When installing in tunnels, a further distinction has to be made between road, rail, and underground tunnels owing to the different installation conditions.

The following criteria are crucial for the planning and realisation of installations:
In order to find an optimum position and method of fixing for the radiating cable, knowledge of the materials and design of the wall, ceiling or floor intended for the fixing are vital. The installation height of the cable is critical for the design of the installation and for determining the costs. Restricted working hours may have to be taken into account on some installation sites. This can be caused by other firms working on the site at the same time or the brief intermissions between the trains of an underground already in operation and in extreme cases can lead to working times of merely a few hours at night.
Such circumstances must be considered at the planning stage. The type of fixing has a decisive influence on both the installation work and the costs. When fixing to the wall, a basic distinction can be made between the use of plugs and fixing to existing cable ladders or anchor bars. In the latter case, time is saved by not having to drill holes but the position of cables and spacing of clamps is usually very restricted. In both cases the use of round bases is advisable.

Note: The height of the round bases depends on the cable type.

In special cases (e.g. in tunnels through rock or when spanning over larger distances in underground stations) the use of a messenger wire is advisable. Here, the correlation between the sag and the necessary wire tension has to be taken into account. Furthermore, it should be ensured that the structure could carry the necessary wire tension in the case of large spans and minimum sag. As an alternative to the fixing of radiating cables on separate external messenger wires, RADIAFLEX® cables with an integrated messenger wire are available.

When selecting installation vehicles for new railway and underground tunnels, it is important to know whether the track will have been laid before work starts.

The speed of the trains and the associated pressure fluctuations in the tunnel are crucial for the selection of fixing materials, especially the clamps for the radiating cable.

5.01 Installing RADIAFLEX® and CELLFLEX® cables

The planking of the cable drums should not be removed until the cables are required at the place of installation.

A cable-laying truck is recommended for transporting the drums. A cable drum trailer, open at the rear, which can be loaded by simply rolling the drum into the trailer from behind (no crane necessary) is advantageous. The integrated cable drum jack lifts the drum in the trailer.

If a cable drum trailer is not available, then stable drum supports should be used for uncoiling the cable from the drum. It is recommended that the shaft be adequately greased in order to guarantee smooth rotation of the drum when uncoiling the cable. The installation crew must ensure that the cable uncoils evenly. For further information about the min. bending radii, max. tensile forces, recommended clamp spacing, etc. see the corresponding data sheets.

On no account may a cable be bent to a radius smaller than the min. bending radius for single bending as given in the data sheet. During installation the larger radius for repeated bending must be adhered to.

If it is not possible to install cables directly from the drum, then short lengths can be pulled from the drum and wound into a coil. The diameter of the coil should not be less than that of the core of the drum.

The max. tensile forces given in the data sheet may not be exceeded when drawing the cable.

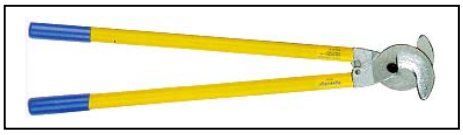
The use of a cable hoisting stocking is strongly recommended – especially when pulling cables through vertical cable ducts.

It must be ensured that the cable is never pulled across sharp edges or corners. If cables have to be pulled over the ground for long distances or over small obstacles, then the use of ground rollers is recommended. When pulling the cables around corners or through narrow openings, installation personnel should monitor these critical points.

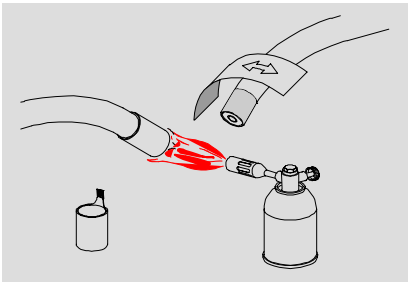
When cutting the cable it should be ensured that the place at which it is being cut is the lowest point in the cable run in order to prevent the ingress of dirt or copper particles into the inside of the cable. Both ends are to be cleaned and sealed. For this, the use of heat shrinking caps is strongly recommended. When bending the cable, apply the whole palm of the hand and avoid pressure at specific points.

After the connector has been fitted to the cable, the contact surfaces must be protected against dirt and moisture until the final connection is made. Temporary protection can be achieved by slipping the connector's plastic packaging over the end.

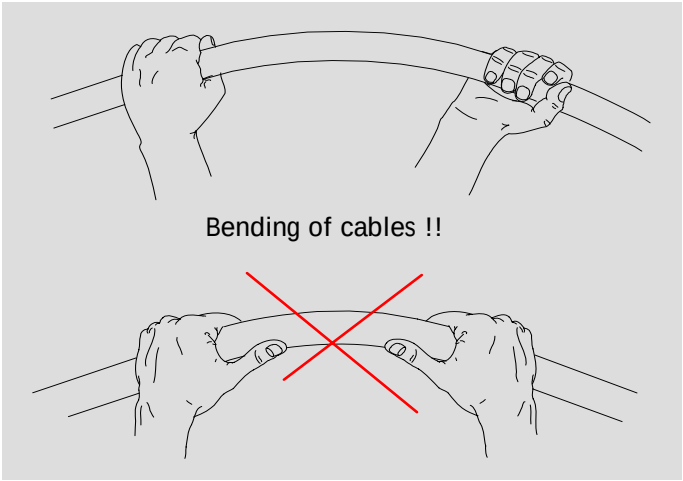
Keep the cutting area down, in order to avoid dirt or copper particles falling into the



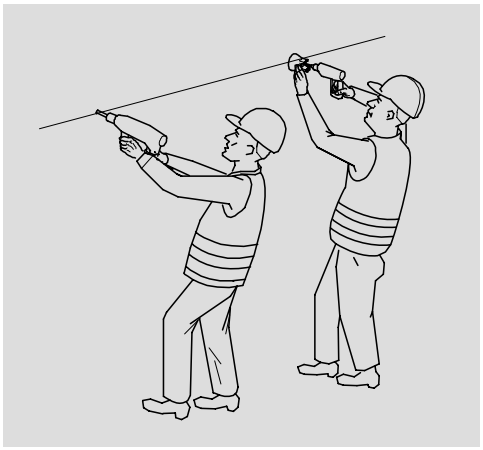
We recommend using a cable shears to cut the cable.
It produce nearly no particles during cutting



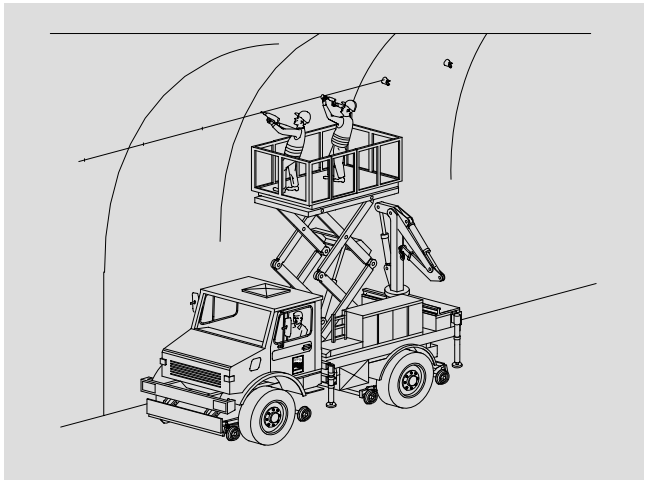
Seal ends of cables
(e.g. with heat shrink caps)



Installation Methods



Installation from the floor or ladder



Installation with special vehicle

Installation with platform

Installation with movable scaffold

5.02 Installation in Tunnels

Because of many different tunnel designs it is not possible to set up a specific detailed installation instructions for all tunnels.

The following items have a particular influence:

- working time
- day shift or night shift
- installation maybe only possible in brief intermissions in operation
- access to the installation site
- installation height of cable
- tunnel construction (concrete/steel), brick wall
- fixing system chosen
- etc.

The details given below are merely recommendations resulting from our many years of experience. The selection and use of the equipment used is the responsibility of the installation company.
The requirements of the tunnel operator as well as the employers liability insurance associations (industrial safety rules) must be adhered to when working in tunnels.
The installation height of the cable and any possible deviations from this must be established exactly before starting work. This also includes establishing the space between cables and passing trains.
In tunnels fitted with catenary wires or tunnels already in use, there is a danger of induced voltages in the outer conductor. Therefore, it is necessary for the cables to be earthed immediately after installation.
It may be necessary to establish a temporary earth connection. Particular attention should be paid to the earthing system of the railway operator.

Note:
There are various earth potentials available in tunnels (water, tunnel or building earth). On no account these should be connected together by means of the cable that has been installed! If necessary, DC blocks must be integrated in order to isolate the various potentials. When connecting RADIAFLEX® cables by means of jumper cables, DC blocks must be integrated at the appropriate positions.

After the installation, the connectors should be provided with protective insulation. The use of cold shrink sleeves is recommended. Special attention should also be paid to fire regulations, as in particular, the proper sealing of openings in walls.

5.02.1 Installation in tunnels with only short interruptions in operation

If installation is to be carried out in a tunnel in operation, normally the cable has to be installed during short interruptions in the night. In this case the use of special vehicles is usually uneconomic.
In such cases the clips should be fixed using ladders. Installation can also be carried out with the help of a mobile scaffold, possibly moved on the rails.

Note:
If this work is performed without switching off the catenary wire, then only ladders made from non-conductive materials (e.g. wood, plastic) are permitted.

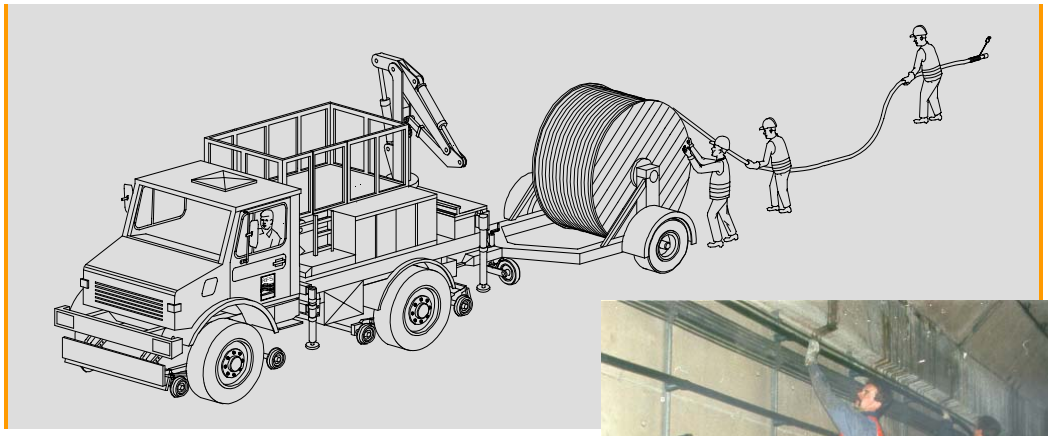
Requirements of the tunnel operator and industrial safety rules must be adhered to, in particular, safety clearances between radiating cable and live conductors.
If the installation work is carried out without or with only very short ladders, then some railway authorities also permit installation during periods of low traffic. In such cases, specially trained safety personnel are deployed to protect the installation crew.
The use of cordless electric drills is strongly recommended so that personnel can quickly evacuate the track area in the event of any danger.
Due to the short interruptions in railway operations, bringing the cable into the tunnel and installing it at the same time cannot be carried out directly from a track-bound trolley or cable drum trailer.
In such cases the cables are brought into the tunnel with a track-bound trolley or other special vehicle and initially placed adjacent to the track.

The installation crew for this work comprises of the following persons:

- driver of installation vehicle
- 1-2 installers for pulling the cable
- 1 installers for turning/braking the drum
- 1 installer for depositing the cable adjacent the tunnel wall
- safety personnel as required by local regulations

Secure the cable drum properly and drive into the tunnel. Raise the drum with the help of the drum jack. Secure the drum jack to prevent it slipping or toppling during all further operations. Cut the rope securing the cable to the drum, uncoil a few metres of cable and use rope to temporarily fix the end to the ground a few metres before the first clamp. As there should not be excessive tensile forces at this point while uncoiling more cable, a simple hand-tied loop is adequate for this fixing.

Now pull the cable from the drum by hand as the drum trailer continues to move forward slowly. Make sure that the drum is turned only by the force of the drawing and not by the forward movement of the vehicle!
Slow the rotation of the drum down by hand if necessary in order to prevent the cable from uncoiling too quickly. Wear gloves for this in order to avoid injuries caused by wooden splinters.
At the same time, place the uncoiled cable close to the tunnel wall or install it temporarily in a cable tray. Secure the cable against sliding. Make sure that passing trains cannot catch the cable and emergency routes are not blocked. Do not underestimate the pressure wave of an approaching train nor the suction in its wake! Any cables must not block escape routes; check the requirements of the tunnel operator if necessary. Always consider the minimum bending radii during installation.
Furthermore, make sure that the cable is never pulled across sharp edges and corners. It is recommended to only uncoil as much cable as can be completely installed in a foreseeable time. This prevents the cable not fixed yet, being accidentally damaged by another installation or maintenance work. The advantage of this method is that the cable can stretch out a little while in its temporary position, which reduces the work required to straighten the cable while fixing it into the clamps. The personnel required for this depends on the mounting height of the RADIAFLEX® cable to be installed. Normally, one installer picks up the cable from the ground and lifts it up for a second installer to hold at the height of the clamps while a third installer presses the cable into the clamps and straightens it. Close the clamps depending on the type of clamp being used. If the mounting height is not too high, then two installers can carry out the installation work.

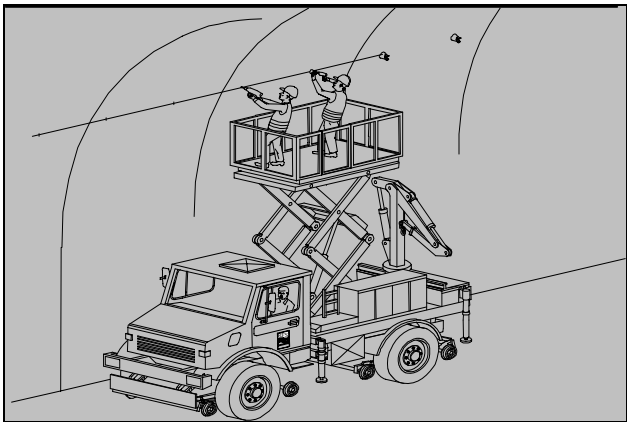


5.02.2 Installation in tunnels - not in operation during installation work

If the installation work is carried out in a tunnel, which is not yet in operation, then this work can be performed with the help of special vehicles, or suitably prepared trailers, track-bound trolleys, platforms or scaffolds. All vehicles and generators should be fitted with the latest exhaust filters. In tunnels where the tracks are already installed, two-way vehicles are ideal. These vehicles can travel on both roads and rails (e.g. two-way Unimog).

The following additional equipment on the installation vehicle has, in our experience, also been proved as useful:

- lifting platform or securely installed scaffold for working at great heights
- adequately sized floodlights (approx. 3 No. @ 2000 W)
- mobile generators for powering lights, drills and chargers
- trailer coupling for cable-laying truck
- lead-in rollers for reliable guiding of the cable during installation
- flashing warning beacons on the vehicle
- if necessary, a crane for loading the cable drums
- The installation crew required for the following example is:
  - driver of installation vehicle
  - installer(s) for fixing the clamps (corresponding to width of lifting platform and permissible load: 1-3 persons)
  - safety personnel as required by local regulations



Move the vehicle into position and drill the first holes. The cable route should have been marked beforehand as described in **”3 Marking the height of the cable clamps”**. Move the vehicle to the next position and drill the next holes. At the same time, insert plugs into the previous holes and fit the clamps.

To install the cable, load the cable drum onto the track-bound trolley or the cable drum trailer taking into account the direction of rotation. Make sure that the drum is handled carefully and that it is secured properly to prevent it sliding while driving into the tunnel. Always take into account the considerable gradient of the tracks in curves. Drive into the tunnel and only remove the planking after arriving at the place of installation. For safety reasons, it is recommended to remove all nails immediately. After removing the planking, raise the drum with the help of the cable drum jack.

It is recommended to grease the shaft of the drum thoroughly, so that the drum can turn easily. Cut the rope securing the cable to the drum, uncoil a few metres of cable and temporarily fix the end to the ground a few metres before the first clamp. As there should not be excessive tensile forces at this point while uncoiling more cable, a simple hand-tied loop is adequate for this fixing. Now pull the cable from the drum by hand as the drum trailer continues to move forward slowly. Make sure that the drum is turned only by the force of the pulling and not by the forward movement of the vehicle!

Slow the rotation of the drum down by hand if necessary in order to prevent the cable from uncoiling too quickly. Wear gloves for this in order to avoid injuries caused by wooden splinters.

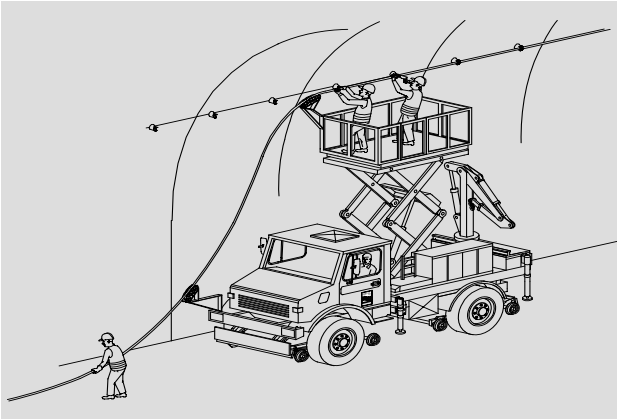
At the same time, place the uncoiled cable close to the tunnel wall or install it temporarily in a cable tray. Secure the cable against sliding. Make sure that passing trains cannot catch the cable and emergency routes are not blocked. Do not underestimate the pressure wave of an approaching train nor the suction in its wake! Any cables must not block escape routes; check the requirements of the tunnel operator if necessary. Always consider the minimum bending radii during installation.

This prevents the cable not fixed yet, being accidentally damaged by another installation or maintenance work. The advantage of this method is that the cable can stretch out a little while in its temporary position, which reduces the work required to straighten the cable while fixing it into the clamps.

With the appropriate equipment, the cable can be uncoiled from the drum and fixed in the already mounted clips at once. Move the vehicle into position once again in order to place the cable in the clamps. One installer now picks up the cable already uncoiled and hands it to the installers on the lifting platform. They place the cable in the clams, close the clamps and straighten the cable. Lead-in rollers mounted on the vehicle are very helpful in this work. To guarantee uninterrupted working, the installation vehicle moves forward slowly according to the speed at which the installers on the platform can work.

Install earth connections and connectors in accordance with the respective installation instructions.

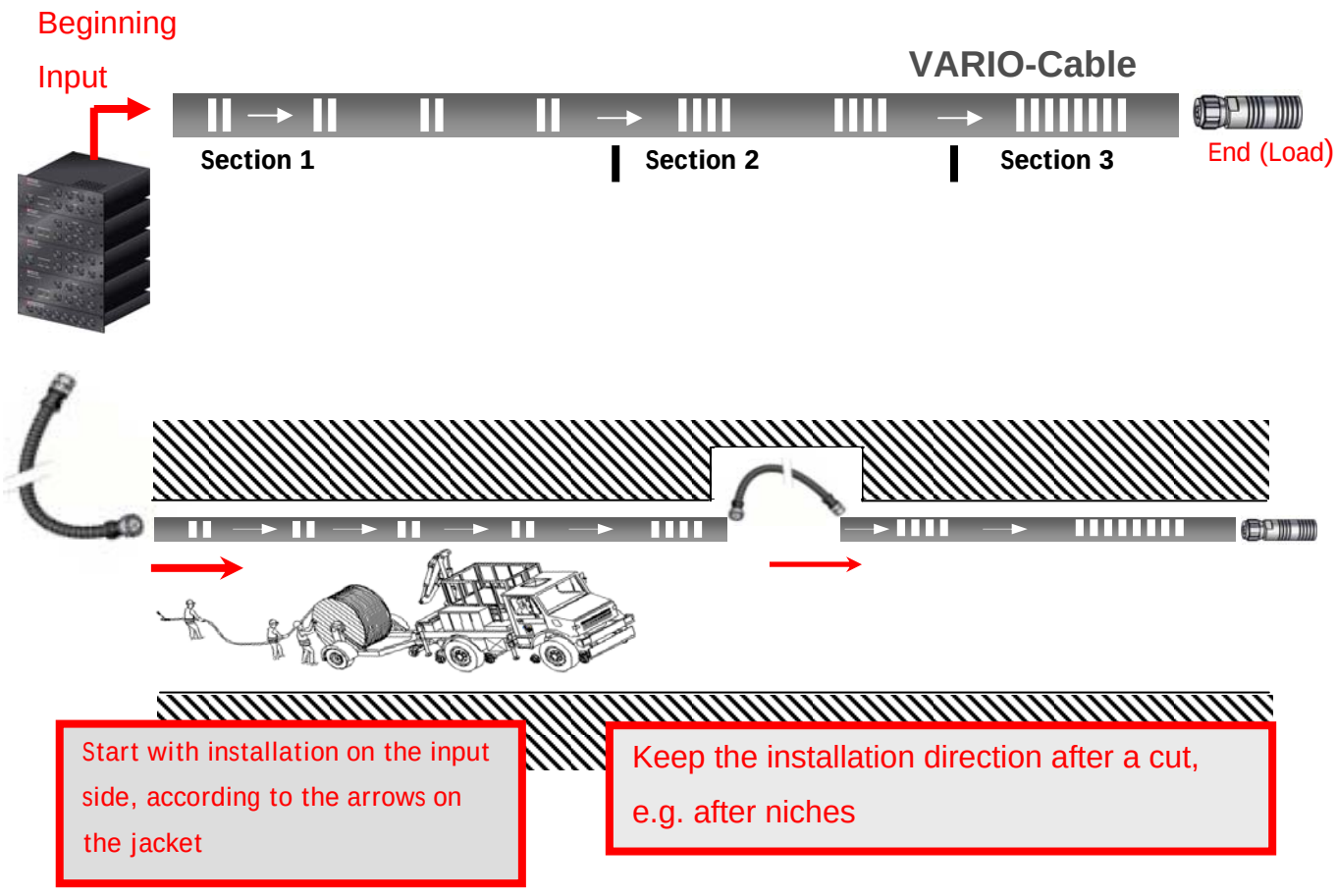
If a two-way vehicle cannot be used, because several installation companies are using the same track or its use appears uneconomic, then the installation can be carried out with the help of a mobile scaffold. A track-bound version is also possible.



5.02.3 Installation of VARIO radiating cable types

In order to reach a constant system loss, the VARIO cable has graded slot groups in different sections. During installation it has to be assured that the input side (BTS side) will be installed first - meaning the beginning of the drum (outer ring/first available meters) is the input side of the cable, therefore the installation has to be started always on the input side (BTS side). In addition an arrow marking is printed on the cable jacket (every meter), which shows the downlink direction.

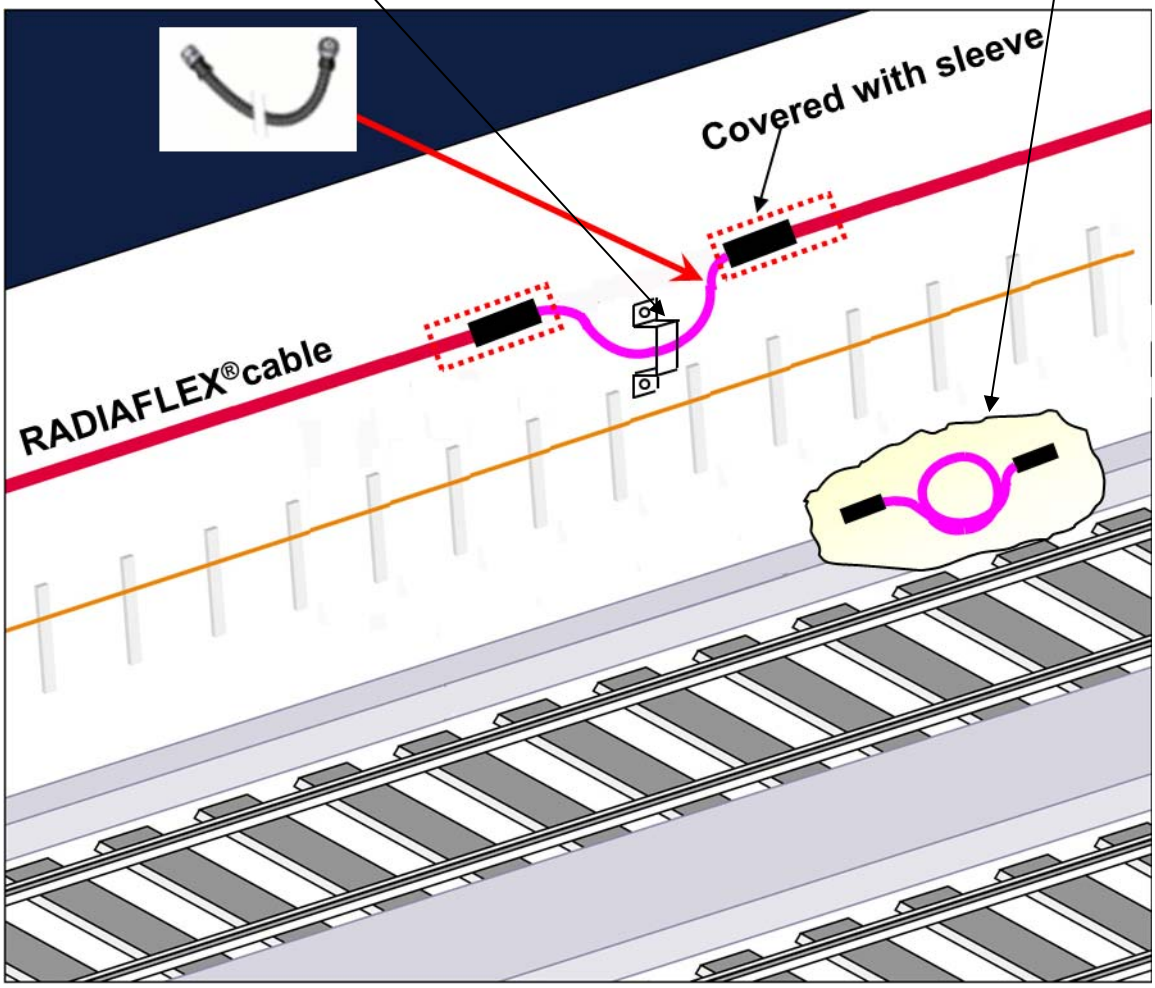
If the cable has to be cut, e.g. in areas of niches or to overcome other obstacles the installation has to be kept in this direction.



5.02.4 Jumper connection of two RADIAFLEX® cables

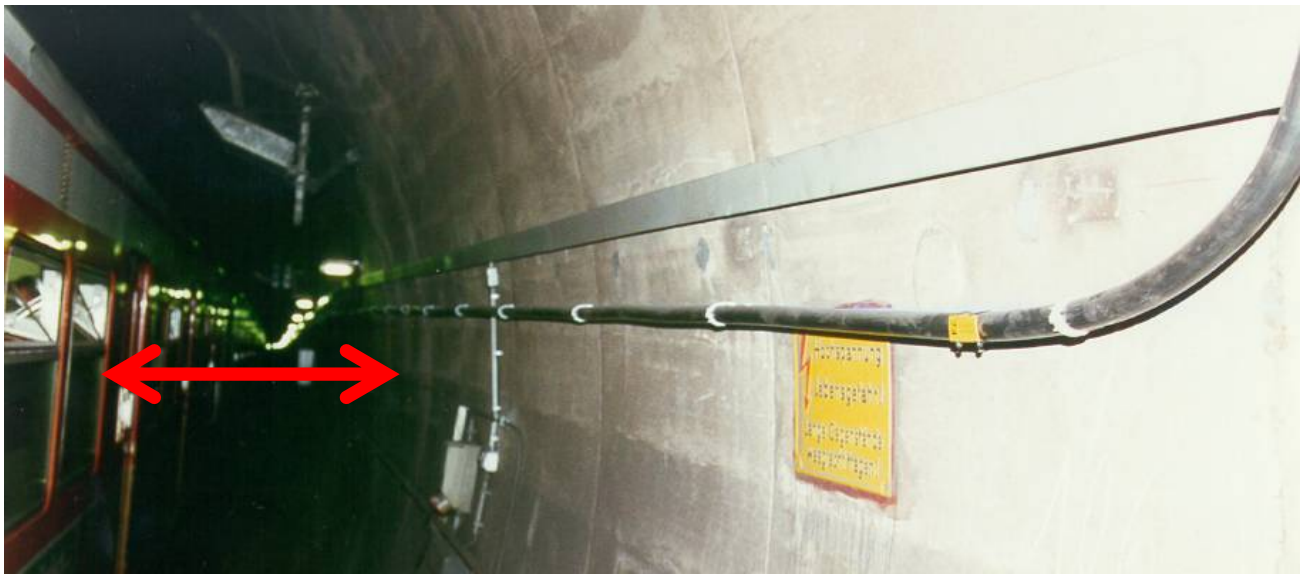
In order to prevent any mechanical stress on the connection of two longer RADIAFLEX® cable runs we recommend the use of a Jumper Cable which runs in a bow (or as a ring). Using this technique, the Jumper Cable absorbs extensions due to temperature cycles.

Take care of the safety distance between cable and train. In case there is a risk that the jumper can move into this safety area, we recommend the installation of a RSB-Clip or a special distance holder (to be provided by the customer himself) allowing move of jumper.

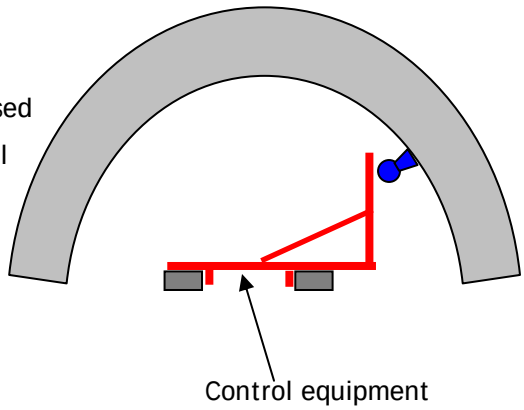


5.02.5 Safety Distance

During installation of the RADIAFLEX® cable, take care of the safety distance between cable and train. The rules from the railway operators are different, therefore ask the local operator.



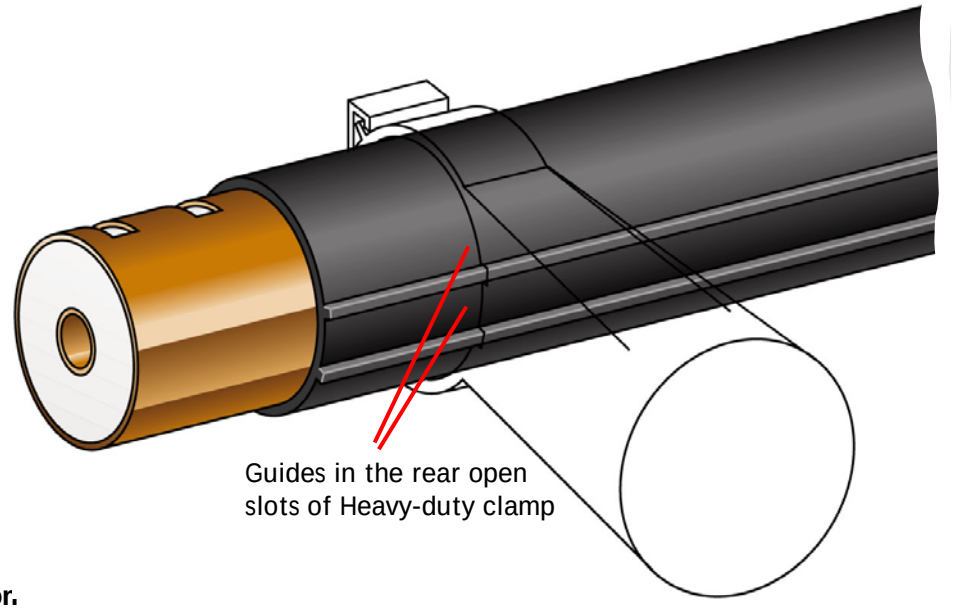
If there is just a marginal distance between the cable and the supposed vehicle, this distance has to be checked regularly. Self made control equipment can make work easier (e.g. made of wooden laths, push flexible on the rails).



5.02.6 Installation of RADIAFLEX® cables with a jacket with guides

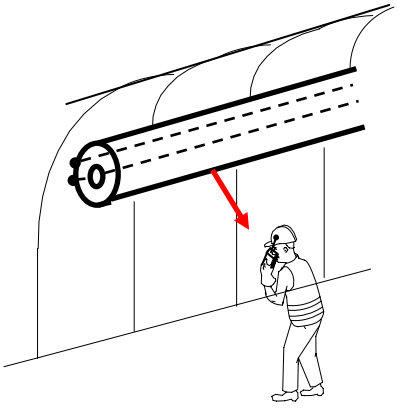
To achieve the best performance of a RADIAFLEX® cable, it is recommended to install it in a defined position with the slot groups pointing away from the wall/ceiling, towards the area to be covered. This becomes more important, the higher the frequency is.

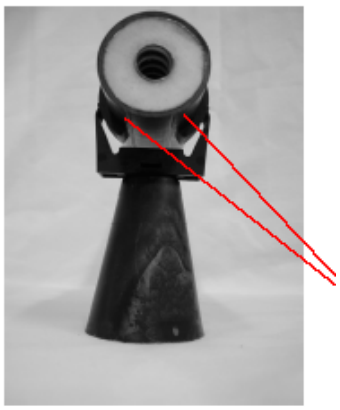
All RADIAFLEX® cable types in size 1 1/4" and 1 5/8" have two guides on their jacket at the opposite site of the slot groups. This simplifies the installation and finding the correct position, because the guides do fit exactly into the rear open part of RFS' standard Clic-and Heavy-duty clamps.



Installatior.

After installing the standard Clic-clamps or the Heavy-duty clamps in accordance of this installation Guide-line, it is recommended to uncoil the RADIAFLEX® cable and lay it on the ground next to the wall. This allows the cable to stretch and minimizes loops caused being coiled on a drum. Then cable has to be fixed into the clamps with the guides pointed to the wall (ceiling). To keep the cable in this position these guides fit into the rear open part of the Clic- and Heavy-duty clamp. If you need to rotate the cable into its correct posi-tion, create a loop of cable before the first clamp and use it as a large crank to align the cable. In order to do this you will need to uncoil an extra length of cable from the drum before lining it up with the clamps.

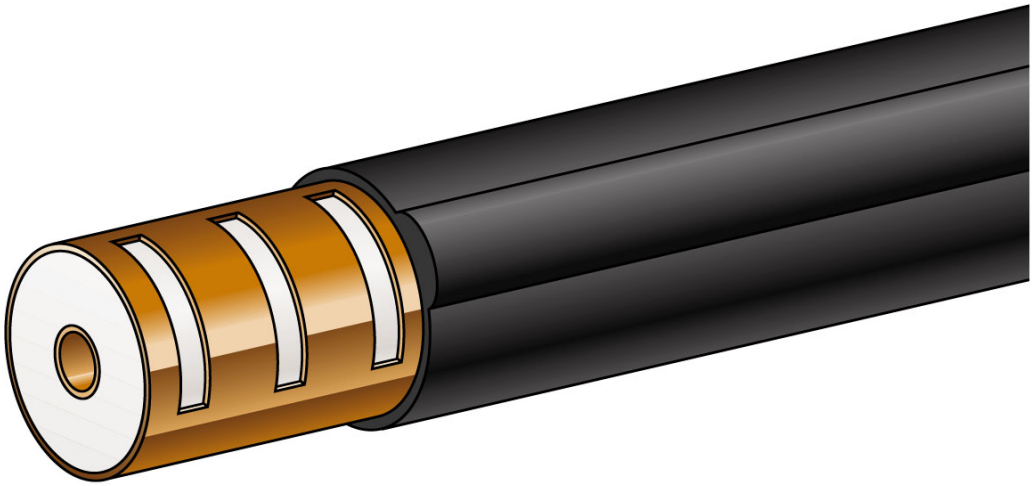




Guides in the rear open
part of clic clamp

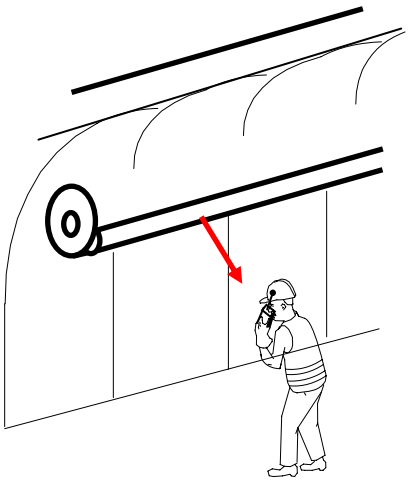
5.02.7 Installation of RADIAFLEX® cables with a jacket with bulge

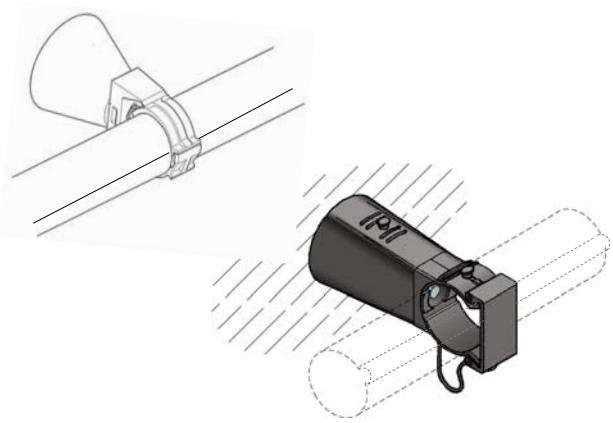
To achieve the best performance of a RADIAFLEX® cable, it is recommended to install it in a defined position with the slot groups pointing away from the wall/ceiling, towards the area to be covered. This becomes more important, the higher the frequency is.
All RADIAFLEX® cable types in size 1/2" and 7/8" have a thin bulge on their jacket which is atop of the slot groups and should hence face towards the area to be covered.



Installation:

After installing the standard Clic-clamps or the Heavy-duty clamps in accordance of this installation Guideline, it is recommended to uncoil the RADIAFLEX® cable and lay it on the ground next to the wall. This allows the cable to stretch and minimizes loops caused being coiled on a drum. Then cable has to be fixed into the clamps with the bulge pointed away from the wall (ceiling) in direction of coverage. The cable can be fixed in any direction into the clamp without any risk of damaging it, because the bulge is very thin. If you need to rotate the cable into its correct position, create a loop of cable before the first clamp and use it as a large crank to align the cable. In order to do this you will need to uncoil an extra length of cable from the drum before lining it up with the clamps.





5.03 Installing cables in buildings

General

Because of many different building designs, it is not possible to set up a specific detailed installation instructions for all buildings.

The following items have a particular influence:

- installation height
- access to the building and installation areas
- construction of walls, ceilings and floors to which clamps are to be fixed
- fixing system chosen
- etc.

The details given below are merely recommendations resulting from our many years of experience. The selection and use of the equipment used is the responsibility of the installation company.
The requirements of the house owner as well as the employers liability insurance associations (industrial safety rules) must be adhered to when working in buildings, factories, etc.
Cable routes, installation heights, earthing connections, etc. must be established exactly before starting work. Particular attention should be given to the space between cables and other building components, e.g. conductors, cables, and metallic objects. Special attention should also be paid to fire regulations, as in particular, the proper sealing of openings in walls.

Installing cables in buildings

Clamps can be installed from ladders or stable scaffolds depending on installation height and local circumstances. If possible, transport the cable drums directly to the place of installation. Make sure that the drum is handled carefully. The planking of the cable drums should not be removed until the cables are required at the place of installation. For safety reasons, it is recommended to remove all nails immediately. Stable hydraulic cable drum jacks are suitable for lifting the drums; note the direction of rotation of the drums. It is recommended that the shaft be adequately greased in order to guarantee smooth rotation of the drum when uncoiling the cable.

After the drum has been lifted, pull the cable and lay it on the floor next to the cable run. One installer should supervise the uncoiling. Helping to rotate the drum can considerably ease the pulling for the other installers. Slow the rotation of the drum down by hand if necessary in order to prevent the cable from uncoiling too quickly. Wear gloves for this in order to avoid injuries caused by wooden splinters.

Always consider the minimum bending radii during installation. It must be ensured that the cable is never pulled across sharp edges or corners. If cables have to be pulled over the ground for long distances or over small obstacles, then the use of ground rollers is recommended. Take precautions, e.g. wooden planks or similar, to prevent damage to the jacket when drawing the cable through wall openings. Installation personnel should monitor these critical points.

All cables, which are to be fed through conduits, should be pulled into those before fitting the connectors. For short elbows, bend the front end of the cable carefully in the direction of the elbow. To pull the cable through longer conduits, it is highly recommended to attach a taut wire to a hoisting stocking to which the cable is attached for pulling through the conduit. The use of a cable hoisting stocking is strongly recommended – especially for pulling cables through vertical cable ducts.

If it is not possible to transport the cable drum to the place of installation and install directly from the drum, then short lengths can be pulled from the drum and wound into a coil. To do this, raise the drum with the cable drum jack as described above. Then pull a long section from the drum on a plane and clean surface. The diameter of the coil should not be less than the core of the drum. After a few coils have been produced, it is recommended to tie those together, using for example insulation tape. This makes the winding and subsequent installation considerably easier.

Cut the cable and then seal both ends in accordance with the recommendations. It is recommended to only produce as many coils as can be installed in a foreseeable time. This prevents the cable not fixed yet, being accidentally damaged by another installation or maintenance work. On no account may the bending radius be less than the minimum bending radius given in the data sheet. When bending the cable, apply the whole palm of the hand and avoid pressure at specific points. Install earth connections and connectors in accordance with the respective installation instructions.

6 Earthing

6.01 Earthing points

Earthing of radiating cables installed in road tunnels is of minor importance than it is for those installed in train tunnels (provided that there is no outdoor overlap antenna and no high-voltage/high current system nearby).

We generally recommend to earth the jumper cable that feeds the radiating cable (‚near end' of cable run respective to active equipment). The ‚far end' of indoor/tunnel systems do not need to be earthed. Exceptions to this rule are systems with an overlap antenna because of the risk of lightning strike and systems with a risk of high-induced voltage by train catenaries. If there is an earthing at both ends of a long cable run we recommend an additional DC block in between to avoid closed current loops because of the risk of induction, parasitic high reverse currents in train tunnels etc. Furthermore, a DC block may help to separate earthing points that are connected to different earth systems in tunnels (tunnel earth, water earth, building earth, depending on local conditions) because of the risk of potential differences.

We do not recommend using cable earthing kits for the radiating cables, as this might damage the thin foil outer conductor. This is rather due to the risk of mechanical damage of the outer conductor foil then by improper installation than due to deterioration of electrical performance by covering some slots.

The earthing standards required for a proper installation of the entire system are to be established prior to the installation based on the local regulations.

The following list is a rough breakdown:

- Protection against over voltage caused by external influences (lightning protection).
- In the case of high frequency cables, the earthing of the outer conductor and the use of overvoltage adapters (e.g. surge suppresser, DC block) is advisable. The risk of lightning damage is very high in those areas where system components are installed both internally and externally.
- Over voltage protection within buildings

  The possibility of voltage induction is the first point to watch out for in this issue. As power cables with high voltages (U > 500 V) are not normally installed in buildings, high frequency cables are earthed via standard earthing kits. In these areas, with the generally shorter section lengths of approx. 100 m of radiating cable, it is sufficient to earth the feeder or jumper cables. The danger of induced voltages can be counteracted by a single-sided earthing of the radiating cable in conjunction with a DC block in order to prevent a loop and hence a flow of current by the induced voltage.
- Over voltage protection within tunnels or similar

  In these situations the risk of induced voltages comes from high-voltage cables, overhead conductors, approaching trains, etc. A study of the existing risk potential must be carried out in such cases.

6.02 Installation of earthing kits

In DC systems, DC blocks can usually be omitted. However, for the majority of railway systems with traction voltages up to 25 kV AC, DC blocks will normally be included for each section of radiating cable, whatever length. All connectors in between must be sealed against touching by shrinking sleeves.

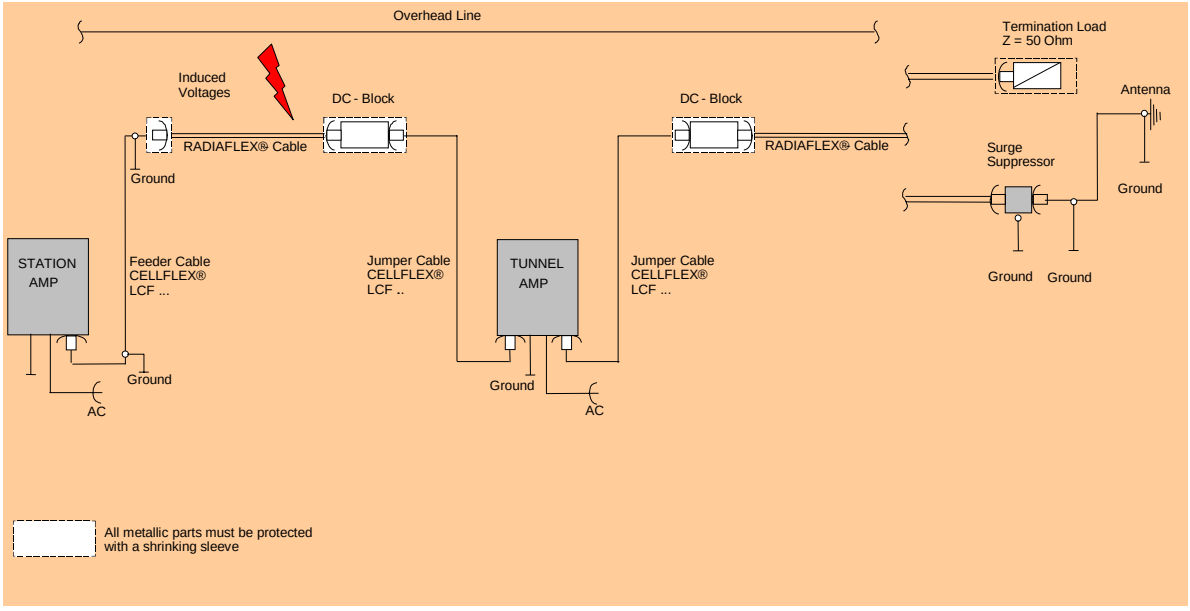
- Potential equalisation

  These procedures have to be carried out to protect people and equipment and are the minimum requirement that an installation has to satisfy. This protection is easily achieved with earthing kits or connector earthing for the cable as well as by earthing the equipment housings.

The specification and provision of earthing procedures is the No. 1 priority because people and equipment are subject to a high-risk potential. The earthing points must be planned consistently for the whole system, especially for railway systems having several earth potentials (e.g. rail-, equipment-, water-earth, etc.).
The components used for earthing must be chosen carefully so that they can fulfil their function properly. This means, for example, connecting an earthing cable of adequate size to the existing earthing system. Connections are either direct, using bi-metallic connections fixed to existing earthing cables or ring earth electrodes or made by means of spade terminals connected to existing earthing points. An anchor-bar can serve as a bus bar for several earthings.
When joining earthing cables, unsuitable combinations of metals, e.g. copper and zinc, must be acoided. In such cases, bimetal connectors must be used in order to counteract the risk of galvanic corrosion.

Earthing of RADIAFLEX® Systems

RADIAFLEX® cables itself are not earthed. The connection is carried out by earthing of the respective jumpers or feeders. In this case a cable earthing kit or a connector earthing kit has to be used.



Installing earthing kits

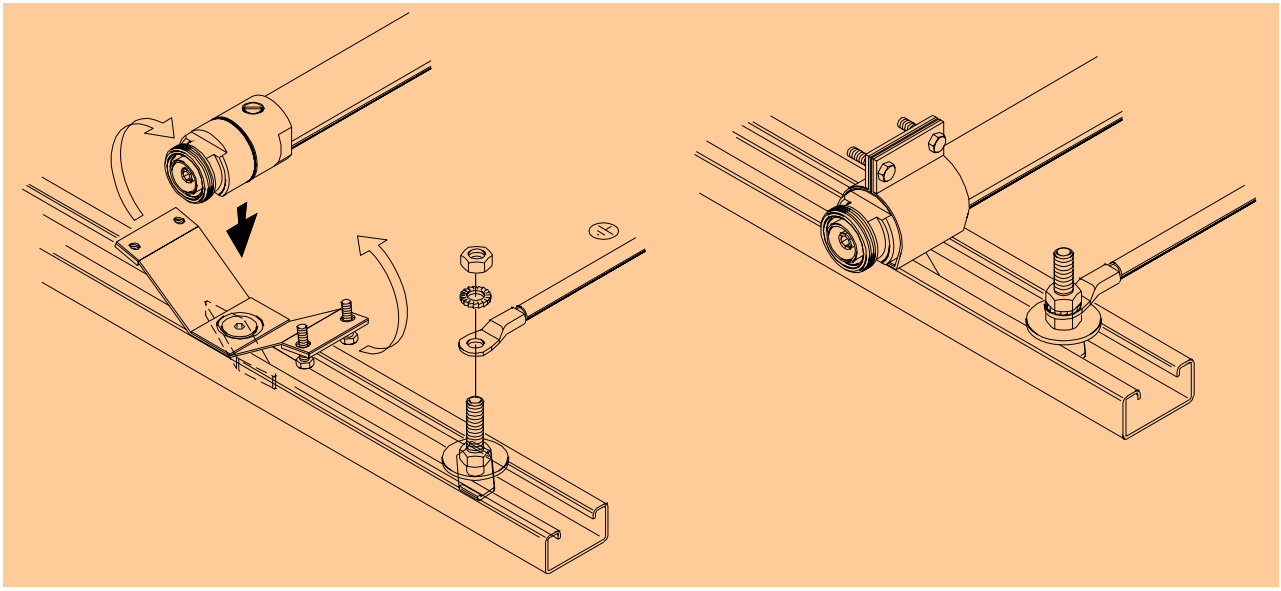
The installation instructions included with every unit must be followed when installing earthing kits. To avoid unnecessary mechanical loads on the cable, earthing kits may only be placed in straight sections of cable.

Attaching a connector earthing or earthing kit to a feeder cable

The connector earthing can be installed to earth the feeder and jumper cables, with the connector itself being earthed. It is not necessary to open the cable jacket for this. Single or multiple connector earthings can be mounted on an anchor bar. The connection between anchor bar and potential equalisation rail must be made with an adequately dimensioned earthing cable; in most cases a wire cross-section of 16 mm^2 copper is sufficient.

Installation of a connector earthing

The connector earthing kit contains a lozenge-shaped channel nut and a screw for fixing to an anchor bar. After fixing the connector earthing bracket to the anchor bar, the connector is inserted and the earthing bracket bent around and closed using the screws included. Apply a little grease to these screws beforehand.
An earthing kit for anchor rails is available for connecting an earthing cable to the anchor bar. This contains all the necessary items. The earthing block is fixed to the anchor rail by means of a lozenge-shaped channel nut. The earthing block has a threaded connection for fixing cable terminals. The earthing kits used for earthing the feeder and/or jumper cables can also be connected to this earthing point.



7 Inspection and tests after installation

After installation perform the following inspection and tests:

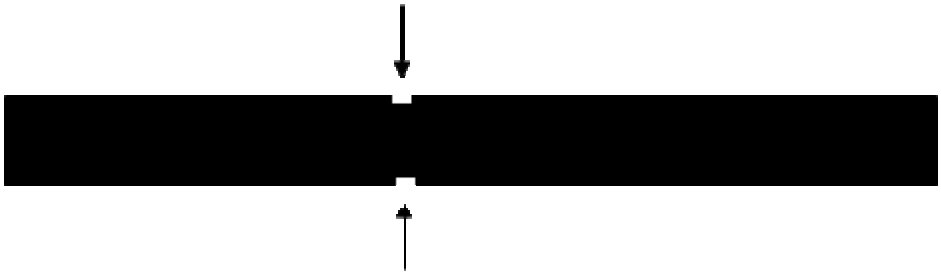
7.01 Visual inspection

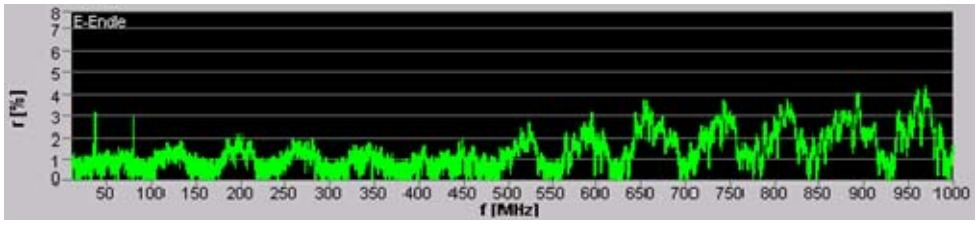
The cable should not show sharp bends, dents or other deformations. The recommended wall spacing should be kept over the entire length.

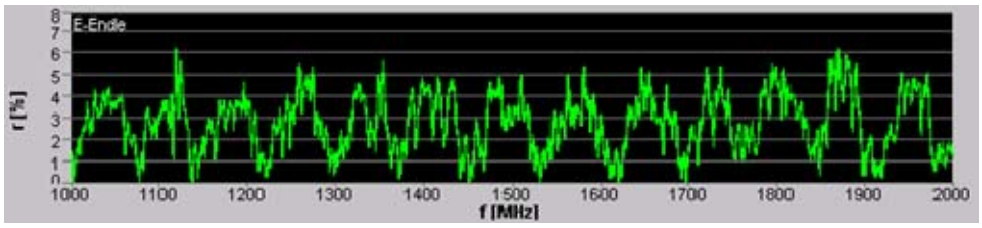
7.02 Return Loss

A return loss measurement indicates a proper installation of connectors and cables. In case of radiating cable some experience is required for the evaluation.

Single Fault

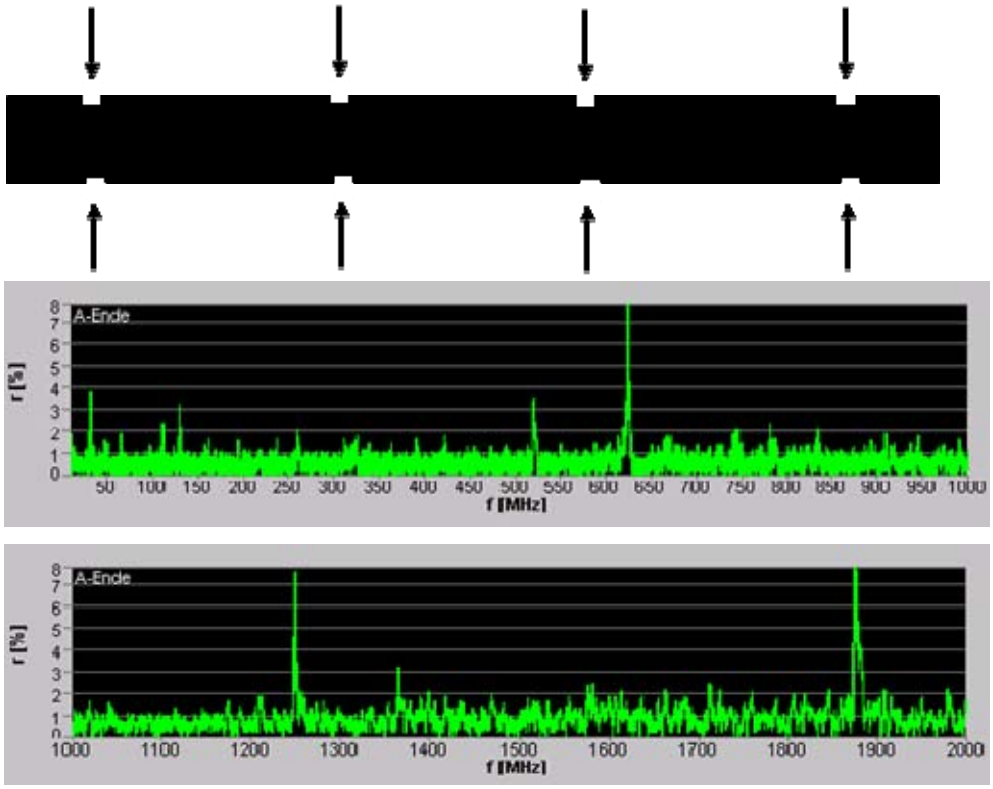






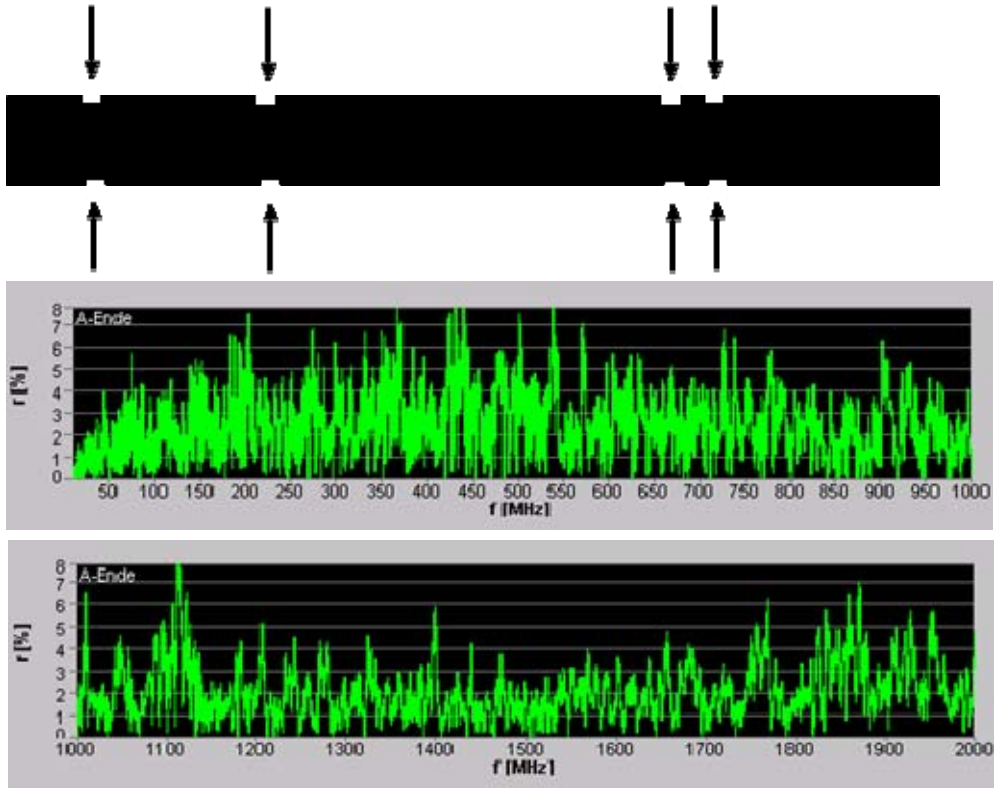
-> Creates „Sinus-like“ Return Loss

Periodic Faults



-> Create Narrow Band Peaks

Stochastic Faults



-> Create „Noise Like“ Return Loss

Network Analyzers Measure at Discrete Frequency Points with a limited Resolution.
Periodic cable faults cause narrow return loss peaks. If level of peaks shall be measured accurately, sufficient resolution has to be chosen.

7.03 Time Domain Reflection

The measurement is commonly used for site acceptance tests of cable runs in base stations. Generally a radiating cable is a coaxial cable with periodic or non-periodic apertures in the outer conductor. Due to the impedance step at every aperture a small local reflection is created. The level of the reflected wave depends on the slot size and orientation. With a DTF measurement small cable fault can't be distinguished from slotted areas. Only significant cable damages, like cracked conductor could be detected. Instead RFS recommends to perform frequency domain return loss measurements, which gives more information about the accuracy of the slot pattern. Significant cable fault would become obvious also.

7.04 Longitudinal Loss

The longitudinal loss indicates proper connections of all components and proper installation of radiating cables. Note that environmental conditions influence the performance of radiating cables!

Measurement

Calibrate the power meter or network analyzer.

Input a signal to one port and record the power level at the other port of the cable.

Evaluation

Calculate attenuation as: $$\alpha = \frac{Ne - Ns}{L} \cdot 100$$ in dB/100m at 20°C

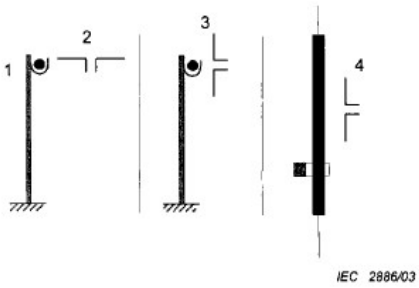
Ne power level at cable input [dBm]
Ns power level at cable output [dBm]
L length of cable [m]
Remark: Since resistive loss and coupling loss are both present, α can not be corrected for the temperature.

7.05 System Loss

The system loss is the most important figure to verify the performance of the complete system. Note that environmental conditions influence the performance of radiating cables!

Measurement (see fig. 2)

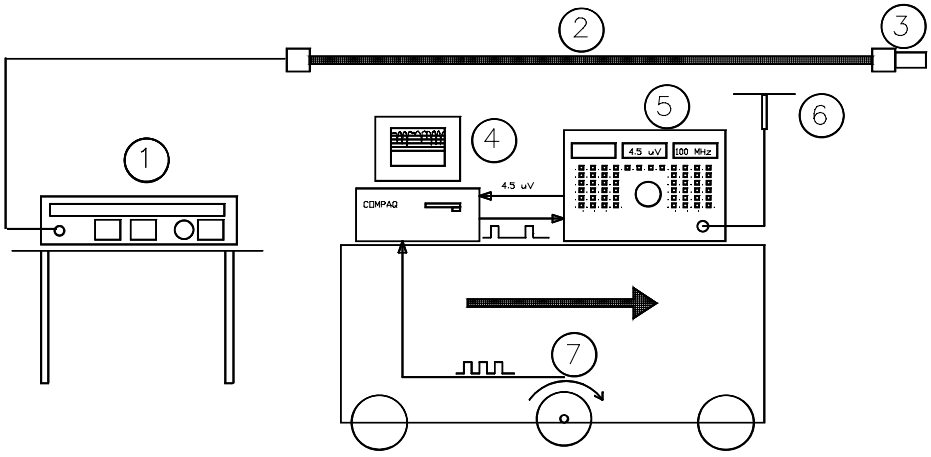
- The generator frequency and output power level is adjusted.
- The signal fed into the test receiver via the antenna´s cable for calibration (output level, cable attenuation).
- The signal is fed into the radiating cable.
- The power level received by the antenna is recorded as a function of the distance of the antenna from the input end of the radiating cable by the test receiver. Sampling rate of measuring points ≥ 20 per half wavelength in free space.
- The system loss measurement is made with three different dipole orientations towards the cable (figure 1).



1	Cable	3	Orthogonal
2	Radial	4	Parallel

P: Parallel (former Horizontal Parallel)
R: Radial (former Horizontal Orthogonal)
O: Orthogonal (former Vertical)

figure 1: spatial orientations of dipoles



1: synthesizer
2: radiating cable
3: load
4: control unit
5: test receiver
6: λ/2 - dipole-antenna
7: distance sensor

figure 2: measurement equipment

Evaluation

The local system loss is calculated as follows:

asys(z) = Lin – Lm

asys(z): system loss at the location z
Lin: input level to the radiating cable
Lm: measured level at the antenna

The system loss is characterized by two statistical figures of reception probability: 50 % and 95 %. The average system loss figures obtained with different dipole orientations are calculated with (1). Usually only sections of the system are taken into account for the calculation of the local system loss.

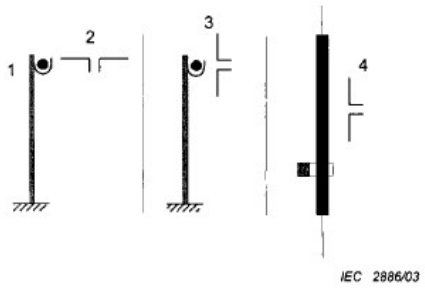
$$a_{sys,av} = -10 \cdot \log\left(\frac{1}{3}\left(10^{-\frac{a_{sys,r}}{10}} + 10^{-\frac{a_{sys,p}}{10}} + 10^{-\frac{a_{sys,o}}{10}}\right)\right) \quad (1)$$

7.06 Coupling Loss

The coupling loss measurement is an indirect measurement, derived from the direct system loss and longitudinal loss measurement. It has to be noted that the environment will influence the performance of radiating cables! Data sheet values are derived from free space measurements, conditions see in the chapter below.

Measurement (see fig. 2)

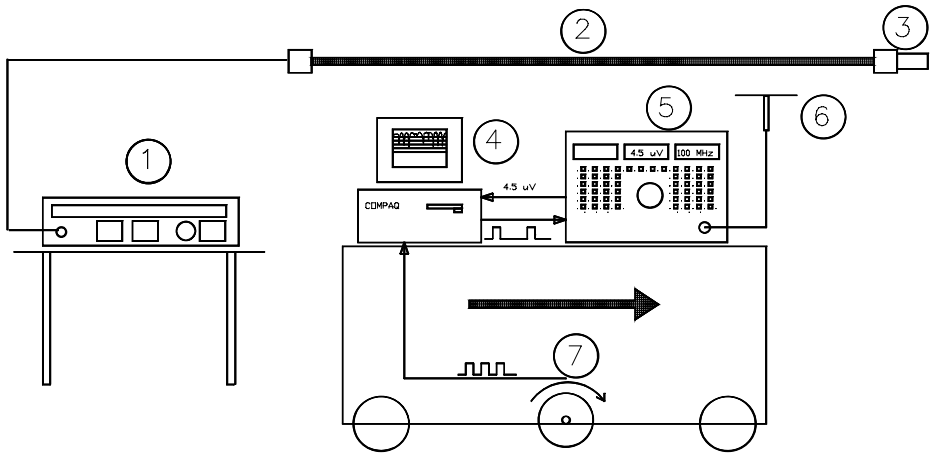
- The generator frequency and output power level is adjusted.
- The signal fed into the test receiver via the antenna´s cable for calibration (output level, cable attenuation).
- The signal is fed into the radiating cable.
- The power level received by the antenna is recorded as a function of the distance of the antenna from the input end of the radiating cable by the test receiver. Sampling rate of measuring points ≥ 20 per half wavelength in free space
- The coupling loss measurement is made with three different dipole orientations towards the cable (figure 1).



1	Cable	3	Orthogonal
2	Radial	4	Parallel

P: Parallel (former Horizontal Parallel)
R: Radial (former Horizontal Orthogonal)
O: Orthogonal (former Vertical)

figure 1: spatial orientations of dipoles



1: synthesizer
2: radiating cable
3: load
4: control unit
5: test receiver
6: λ/2 - dipole-antenna
7: distance sensor

figure 2: measurement equipment

Evaluation

The local coupling loss is calculated as follows:

ac(z) = Lin – a(z) – Lm

ac(z): coupling loss at the location z
Lin: input level to the radiating cable
a(z): attenuation at the location z
Lm: measured level at the antenna

The coupling loss is characterized by two statistical figures of reception probability: 50 % and 95 %. The average coupling loss figures obtained with different dipole orientations are calculated with (2).

$$a_{c,av} = -10 \cdot \log\left(\frac{1}{3}\left(10^{-\frac{a_{c,o}}{10}} + 10^{-\frac{a_{c,p}}{10}} + 10^{-\frac{a_{c,r}}{10}}\right)\right) \qquad (2)$$

Free Space Method

The cable is laid on non metallic posts in a height of 2 m. A tuned half-wavelength dipole is put on a trolley and moved parallel to the cable. The height of the antenna centre is the same as that of the cable. The horizontal distance from the cable is also 2 m.

Standard conditions of testing:

- ambient temperature t_{amb} = +5 °C ÷ 40 °C (limitations of test equipment)
- rel. humidity < 100 % , no rain
- cable has to be clean and dry

7.07 Time Domain Reflection

The measurement is commonly used for site acceptance tests of cable runs in base stations. Generally a radiating cable is a coaxial cable with periodic or non periodic apertures in the outer conductor. Due to the impedance step at every aperture a small local reflection is created. The level of the reflected wave depends on the slot size and orientation. With a DTF measurement small cable fault can't be distinguished from slotted areas. Only significant cable damages, like cracked conductor could be detected. Instead RFS recommends to perform frequency domain return loss measurements, which gives more information about the accuracy of the slot pattern. Significant cable fault would become obvious also.