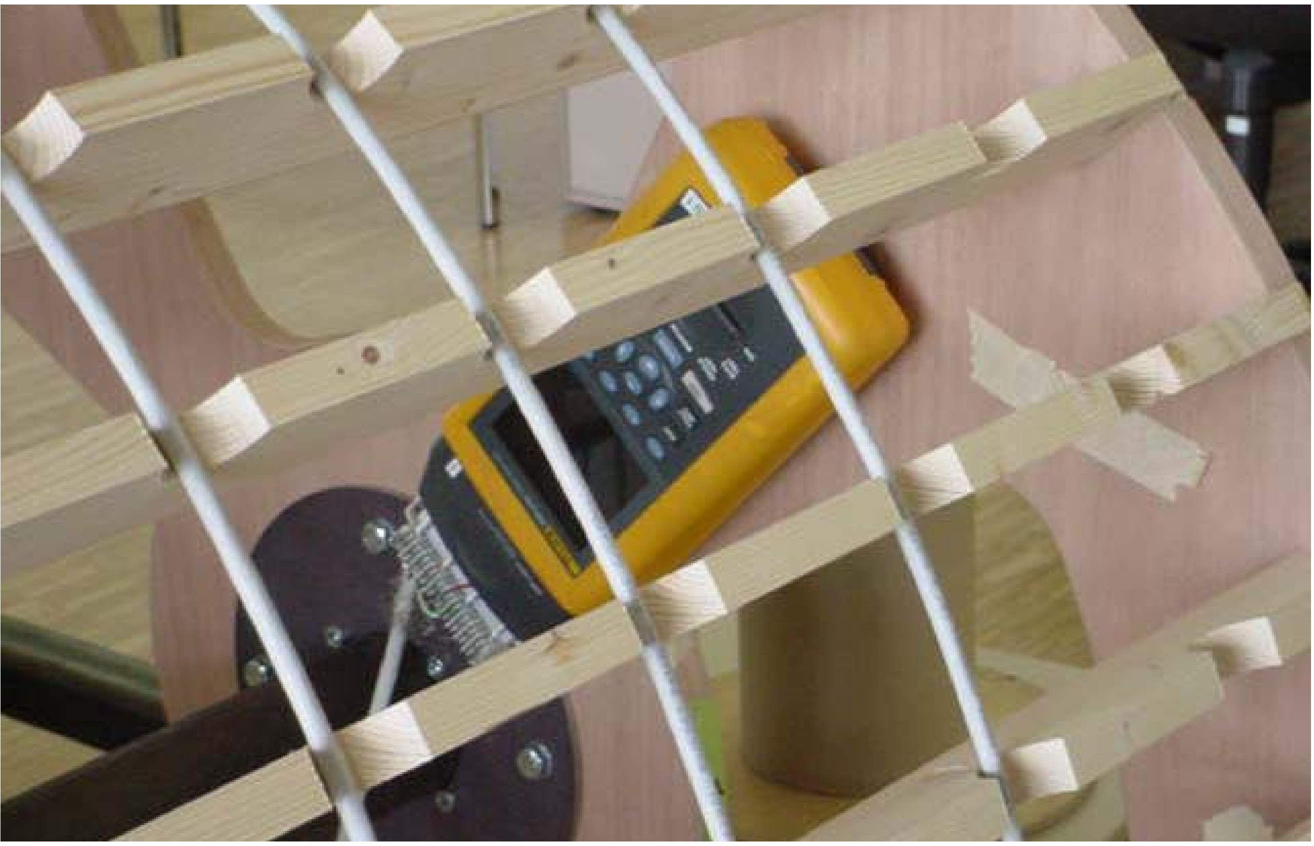
White Paper



Mechanical stability of installation cables

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Convincing cabling solutions

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1. Introduction

On the roll, the cable was fine. All the modules were impeccable. And yet the installed permanent link did not pass its acceptance test. Is this the installer's fault?

If an acceptance test fails due to degraded cable values, then there are basically two possibilities: either the cable is not able to withstand normal installation conditions, or it was not handled properly by the installer.

R&M wanted to be quite sure about its own cables. After all, tests are better than pointing the finger. That's why R&M simulates the installation procedure with a device that was developed as part of an academic thesis at the Swiss Federal Technical University, ETH, in Zürich. The device handles cable under real-life conditions and leads to objective and reproducible results.

2. Mechanical stability and electrical characteristics

Unfortunately, it happens time and again that an acceptance test on a permanent link fails due to deficiencies in the cable, although according to the data sheet and during testing on the roll, the cable has good to outstanding values and reserves. The reason may well be a lack of mechanical stability. For

- tight radii,
- excessive draw-in forces and
- excessive friction

can alter the cable geometry in many ways: the position of the conductors in relation to each other, their position in relation to the shield or screen, the uniformity or otherwise of distribution of the lay along the cable, etc. Any change in geometry is reflected in a change in the electrical characteristics. The following parameters are particularly affected:

- NEXT (near-end crosstalk),
- FEXT (far-end crosstalk) and
- RL (return loss).

In the case of a simple installation, where the cable is not subjected to strong mechanical forces, a "pass" in the acceptance test can be expected. In difficult installations, however, care must be taken not to subject the cable to excessive mechanical loads. But where are the limits?

3. Common limit values

Most installation cables are designed to withstand tensile loads of up to 100 N. Up to this value, there must be no visible changes in the cable. In practical application, however, this unit of measurement is somewhat hard to relate to. Few installers are known to have their biceps trained via a load sensing device with Newton gradations – and even then installers could damage the cable if they happen to be particularly "enthusiastic".To put it into clearer perspective: 100 N is approximately equivalent to the tensile force which a bucket of water exerts on the arm.*)

*) In the earth's gravitational field, 1 kg mass exerts a weight of approximately 9.8 N (Newton). 100 N thus corresponds to a mass of approximately 10.2 kg.

Keeping an eye on the permitted bending radii of cables is much easier. These radii are shown in the table on the right (information from data sheet details for R&M Freenet).

Anyone who finds there is too much information in this table can be guided by the following rule of thumb:

Category	**During draw-in**	**Installed**
Cat. 5	50 mm	25 mm
Cat. 6	60 mm	50 mm
Cat. 7	70 mm	50 mm

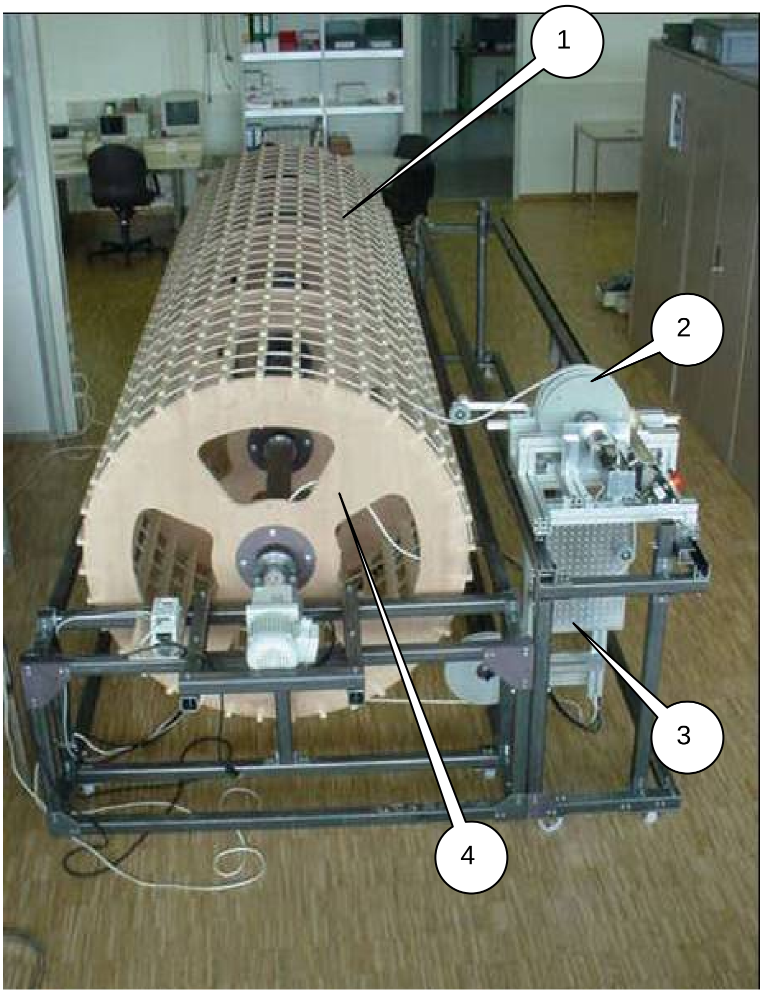
When drawing cables in, larger radii must be observed than in the final installed state. This is because the danger of the conductor geometry in the cable changing is greater under load than it is in the relaxed state.

4. Simulation

In order to simulate the installation procedure in a reproducible manner, R&M has had a test device developed. A large wooden reel (1) accommodates up to 100 m of installation cable. The cable is drawn in over defined obstacles (3). The tensile load is controlled via a drive reel (2) – independent of the physical constitution and "enthusiasm" of an installer. A measuring instrument (4, see also the title page) is arranged inside the reel (1).

Cable type: R&M Freenet	**Category**	**During draw-in**	**Installed**
U/UTP (UTP)	Cat. 5e	42 mm	25 mm
U/UTP (UTP)	Cat. 6	63 mm	50 mm
F/UTP (FTP)	Cat. 5e	50 mm	50 mm
SF/UTP (S-FTP)	Cat. 5e	52 mm	50 mm
S/FTP (S-STP)	Cat. 6	60 mm	50 mm
S/FTP (S-STP)	Cat. 7	60 mm	50 mm

Cable designations according to ISO IEC 11801 (see appendix).
The older catalogue designations appear in brackets.

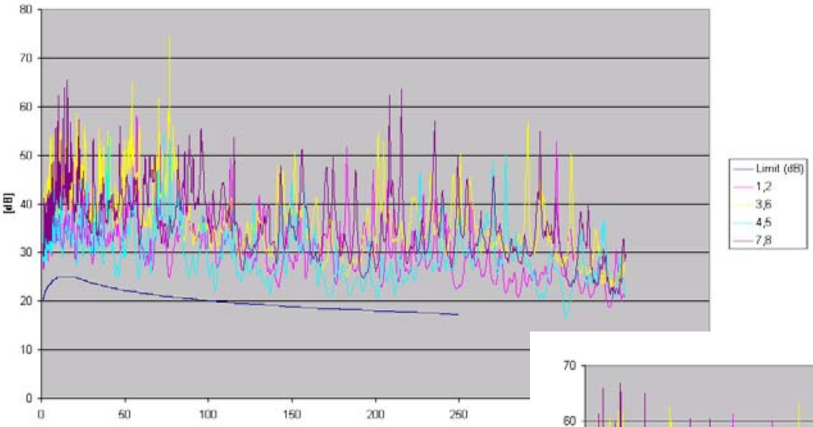


Defined installation obstacles: rolls, 50 mm in diameter, spaced apart by 300 mm (left). If the cable is additionally pulled over a sharp edge (right), the abrasion resistance of the cable jacket can be determined at the same time.

Using this simple test device, informative test series were carried out on our own cables and on third-party cables as follows:

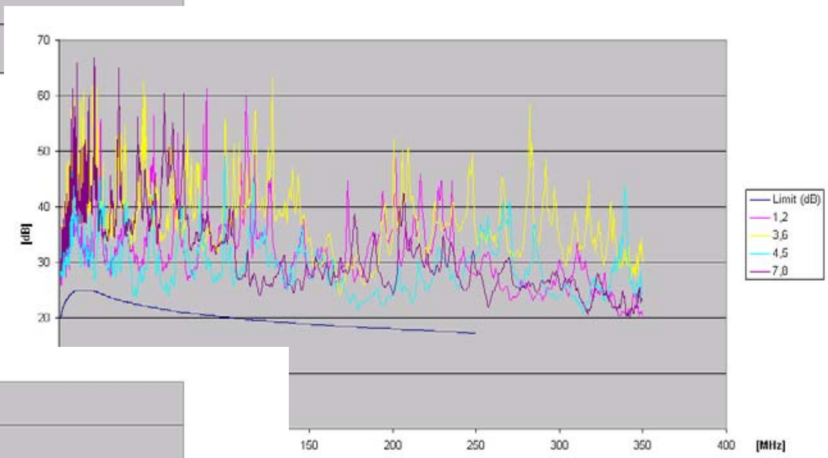
a) simple installation involving little tension and large radii;
b) installation of medium difficulty involving tensile forces of up to 50 N and 10-times bending to the minimum radius; and
c) difficult installation involving tensile forces of up to 100 N and 8-times bending to the minimum radius.

5. Results

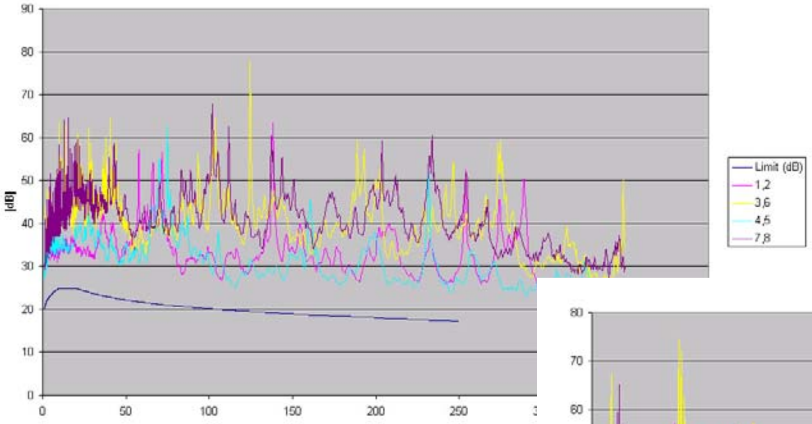


As expected, almost all the cables available on the market passed the tests involving conditions a) and b) above. Case c) was then used to separate the wheat from the chaff.

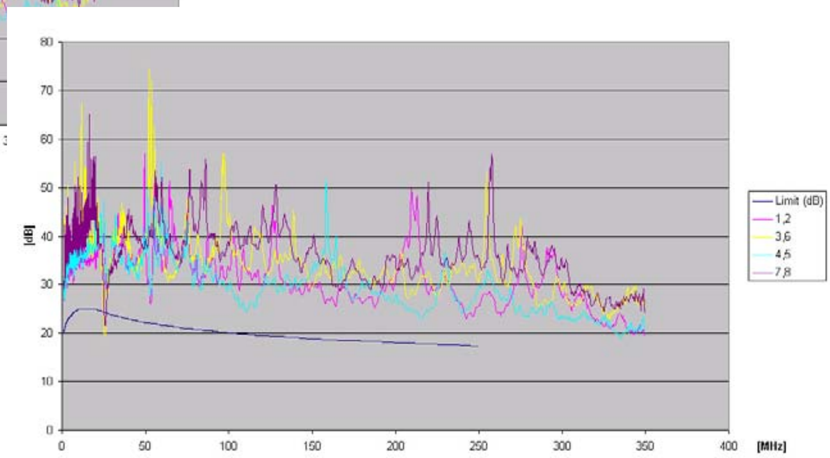
As an example, only the results relating to return loss RL are shown.



The illustration shows a mechanically stable cable before (left) and after (right) being subjected to mechanical loads as in c) above.



Despite slight changes in the pair of conductors 4, 5, the limit value curve is not touched.



In comparison, the illustration on the right shows an unstable cable. After the cable was subjected to mechanical loads as in c) above, the return loss of the pairs of conductors 1,2 and 3,6 exceeds the permitted limit value at pprox. 25 MHz.

6. Recommendation

What then is the significance of these test results as far as practical application is concerned? In major installations it is advisable, in cases where long cable lengths are required and difficult conditions are encountered, to first install one or several permanent links. After this, the link should be measured. The results obtained will provide information on the handling and quality – in other words stability – of the cable: values which can be expected to apply to the entire installation. With this knowledge, an expert installation which conforms to industry standards can then be carried out.

Further information

For further information on products and solutions from R&M, visit our web site: www.rdm.com

Appendix: Cable designations according to ISO IEC 11801

TP	Twisted pair
U	Unshielded
F	Foil shielded
S	Screened
SF	Screened and foiled

Up to five characters (XX/XXX) provide information on the type of cable. The information in front of the slash refers to the screening of the entire line bundle, while information behind the slash relates to individual pairs of conductors. For example, S/FTP indicates a cable type in which four pairs of conductors are individually foil shielded and together are screened on the outside.