WHITE PAPER

STANDARD-COMPLIANT EVALUATION OF FIBRE OPTIC CABLING IN LOCAL AREA NETWORKS AND DATA CENTRES

The standards for generic cabling systems keep being adapted to new technical conditions. Only recently have new revisions been published. This White Paper examines what the most recent revisions mean for the evaluation of fibre optic cabling in local area networks and data centres, and specifically for one and three reference cord methods.

International Cabling Standard ISO/IEC 11801 was published in six parts in November 2017. European Standard EN 50173 followed in October 2018.

Years beforehand EN 50173 had already been divided into various parts. Here the first part, "General Requirements" for "Generic Cabling Systems", is of particular importance to all network users, planners and installers.

Of course the requirements of the EN 50174 family also need to be taken into account. These Standards appeared at the same time as EN 50173.

But what is new about these Standards now in terms of evaluating fibre optic cabling in local networks and data centres?

- Optical classes have been dropped in these standards. German Standard DIN VDE 0800-173-100 was therefore drawn up by the VDE and published in June 2019. Some manufacturers of measurement/acceptance testing equipment intend introducing these optical classes on their testing devices.

- In determining the attenuation of a detachable fibre optic connection (plug-in connection) the 95% rule was dropped, which means that in accordance with the cabling standards a plug-in connection is standard-compliant at 0.75 dB. Poor attenuation value for a splice remains 0.3 dB.

- In informative Appendix F.3 further "Supported applications for optical fibre cabling", e.g. 40GBase-SR4 and 1000GBase-SR4, were introduced.

- Multimode fibres OM1 and OM2 are still included in informative annex C. From Datwyler's perspective cables with these fibres should no longer be installed in new networks, as in normative terms they make no demands on the effective modal bandwidth (laser-bandwidth-length product, EMBc in MHz*km), and the possible link lengths at very high transmission rates are very short and the necessary transceivers for "uncommon" protocols are very expensive.

- A new type of fibre, OM5, was introduced for multimode fibres. For these the transmission-related parameters of "attenuation per kilometer" and "effective modal bandwidth" are given at wavelengths 850 and 953 nm (until now 850 and 1300 nm). OM5 fibre is intended to be used for multiplexing four wavelengths in this range.

What can be measured on optic cabling?

The number of parameters which can be recorded during the measurement of optical cabling is significantly lower than in

the twisted pair environment. The parameters below can be determined by the various measurement methods:

- Attenuation per kilometer;
- Insertion loss of events (connectors and splices) or of the entire cabling system;
- Return loss of reflective events;
- Chromatic dispersion in single-mode systems (not described and unnecessary within the scope of the cabling standards mentioned).

The parameter "effective modal bandwidth" in multimode fibres, important for transmission length, particularly for high transmission rates, cannot be measured or determined in the field. The installer must take this parameter from the fibre data sheets of the cable/fibre manufacturer.

The suitability of a length of fibre optic cabling for a specific protocol can only be established with suitable network testers at protocol level.

What should be tested?

The "Testing of optical fibre cabling channels and links" is described in normative Appendix I.2.3 to EN 50173-1.

Quote: "Testing to determine conformance with the transmission performance is not a requirement of the EN 50173 series of standards. Testing should be performed in the following cases:
a) evaluation of cabling to determine its ability to support one or more applications;
b) confirmation of performance of cabling implemented using using cables, connecting hardware and cords in accordance with clauses 7, 8 and 9.

The test procedures for optical fibre cabling channels and links are specified in EN 61280-4-1 and EN 61280-4-2."

German national footnote N5 refers to ISO/IEC 11801-1:2017, this in turn refers to ISO/IEC 14763-3.

The latter will be discussed here in more detail. The standard says that in a fibre optic cabling system checks must be carried out on both the quality compliance of the components and of the complete installation. The transmission-related parameters of attenuation, run time, polarity and length are measured. At the same time a transmission link must provide the performance capability necessary for supporting the relevant network applications (Annex F).

Attenuation must be determined at wavelengths 850 and 1300 nm for multimode fibres and at 1310 and 1550 nm for single-mode fibres.

The length measurement of multimode cables is necessary in order to be able to estimate whether the transmission rate (network protocol) is possible on the basis of the fibre optic cable installed or supplied.

At this point the installer must be able to rely on the information given by the cable manufacturer on the data sheet.

DIN ISO/IEC 14763-3

This amendment 1 of these standard appeared in 2018. It describes preparation for the acceptance testing of a fibre optic link, i.e. the visual examination and cleaning of the connectors, the requirements for the measuring cable and measuring conditions, and the various measurement methods.

The measurement of attenuation with an attenuation meter (LSPM - light source power meter) is given as the preferred method of characterising installed fibre optic links.

Alternatively an OTDR (Optical Time Domain Reflectometer) may also be used.

The following procedure must be observed prior to acceptance testing:

- Check the connectors of the measuring cable, of the link to be measured and of the measuring devices. In most cases a manual assessment using a simple video microscope is insufficient, as this leaves too much room for interpretation.

For this reason an automatic evaluation in accordance with IEC 61300-3-35 is preferable.

- Should the result of this evaluation prove unsatisfactory, at best cleaning must be carried out or the measuring cables must be exchanged.

- The success of the operation should then be checked and if necessary the whole process repeated.

General requirements for the measuring cables

The reference cables for attenuation measurement as well as the launch and tail cords must have connectors of a measurement quality which have the same connector type as the test object. This means that each type of fibre and connector needs to have its own measuring cable.

For this measuring quality there exist only parameters standardised to a limited extent:

- Single-mode fibres: IEC 61755-2-4;

- Multimode fibres: IEC 61755-6-2 (in this standard further parameters must be specified even more precisely; usually single-mode connectors are used for preassembled connectors for multimode fibre measuring cables);

- A first draft exists for connectors of standard IEC 61754-7 (MPO).

Attenuation measurement with LSPM

When measuring cabling systems with multimode optic fibres the standard calls for the coupling of light into the test object under encircled flux excitation conditions (EF, according to IEC 61280-1-4).

On the one hand the EF conditions can be achieved directly from the light source and then coupled into the test object with a mode-transparent measuring cable or with an EF measuring cable.

ISO 14763-3 describes two methods of measurement:
1. The method with one reference cable;
2. The method with three reference cable.

One-test-cord reference method

This method is carried out in three steps. In the first step, the reference measurement, a connection is made between light source and power meter. The power meter is set to zero (see Figure 1).

In the second step, the test measurement, the tail cord is introduced and the connection checked. If the insertion loss of the connection according to ISO/IEC 14763-3 is less than 0.1 dB for multimode cabling or less than 0.2 dB for single-mode cabling, it is assumed that the connectors are of reference quality (see Figure 2). (N.B.: This measured value is not set to zero!)

In the third step, the measurement, the test object is introduced and the result read off and stored (Figure 3).

Cable reference method one can only be used when the connectors of the permanent link are of the same type. If this is not the case, these reference method one generally only works if a hybrid coupler can be inserted in step 2. However, these hybrid couplers are sometimes difficult to obtain and usually very expensive.

Three-test-cord reference method

So normally cable reference method three is used. Here, after the reference measurement (see Figure 1), in the second step the tail cord and the substitution cable are introduced and the connector is then checked (see Figure 4).

If the total insertion loss of both connections (fibre attenuation is ignored, as the measuring cables should only be a few metres long) according to ISO/IEC 14763-3 is less than 0.2 dB in multimode cabling or less than 0.4 dB in single-mode cabling, it is assumed that the connectors are of reference quality. (N.B.: This measured value is not set to zero.)

In the third step the substitution cable is replaced by the cable under test (CUT) , the result is read off and stored (Figure 5).

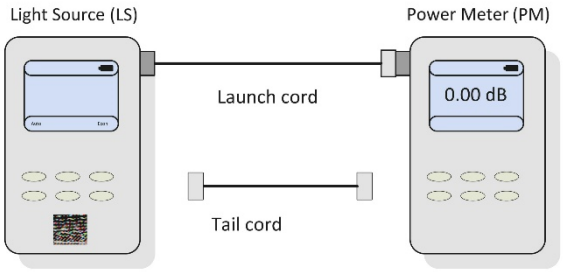

Figure 1: One-test-cord reference method and three-test-cord reference method, step 1

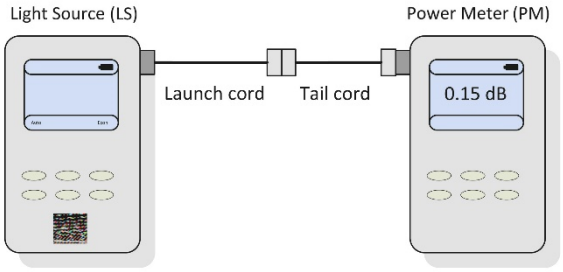

Figure 2: One-test-cord reference method, step 2

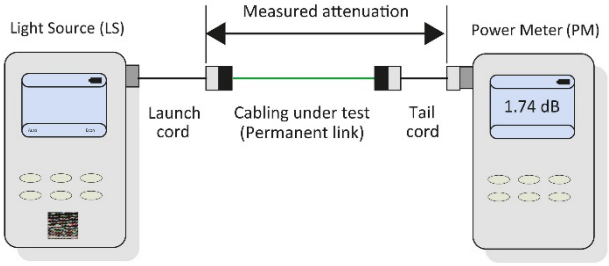

Figure 3: One-test-cord reference method, step 3

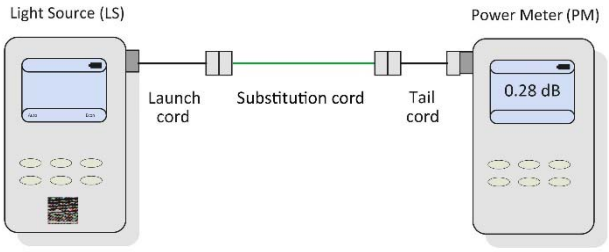

Figure 4: Three-test-cord reference method, step 2

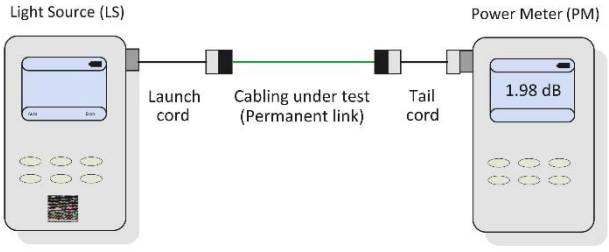

Figure 5: Three-test-cord reference method, step 3

Obviously the couplers (adaptor) for adjustment must also be of reference quality. It is equally important after referencing and checking the measuring cable that the connections between launch and tail cord to transmission and power meter should no longer be separated.

If the attenuation values during checking are higher than stated here, the connectors should be cleaned and the measuring cables exchanged if necessary.

In both LSPM methods the following measurement uncertainties can occur with a "confidence level of 95%":

- Single-mode fibre: ±0.24 dB for fibre lengths of under 2 km;
- Multimode fibre: ±0.27 dB at measured attenuations <1.9 dB;
- Multimode fibre: ±0.14 dB at a measured attenuation >1.9 dB.

The uncertainty or accuracy of the measuring equipment is an additional factor to consider.

Attenuation values from the cabling standard

According to Table 4 of ISO/IEC 14763-3 insertion losses for the connection between test object and reference connector of 0.5 dB are allowed for multimode installations and 0.75 dB for single-mode systems. From Datwyler's perspective these attenuation values listed in the standard for an optical connector of 0.75 dB are much too high.

Here is an example: When using OM4 fibre at a wavelength of 850 nm inclusive of the link's patch cables the Ethernet protocol with a transmission rate of 10 Gbit/s – 10GBase-SX according to IEEE 802.3ae – has a total attenuation (transmission link) of 2.9 dB. If the so-called 4-connector connection is used in a data centre, these four connections already have 3.0 dB.

Fibre attenuation is still not taken into account in this example, nor should splicing occur. The attenuation of a splice is given as 0.3 dB in the cabling standard, but is considerably lower than this with modern devices. Taking into consideration permitted tolerances of the fibre core and the mode field diameter, values <0.1 dB are therefore realistic.

Following this line of reasoning users/planners ought to call for more exacting parameters, for example for the supply of the preassembled connectors for pigtails, patch cables and trunks. Attenuation against the reference connectors is <0.25 dB in production. Values when measuring the detachable connection of 0.5 dB can thus be ensured following installation.

Measuring direction

ISO/IEC 14763-3 specifies that when permanent links comprise known and unknown components measurement must be carried out on both sides. Working Group 10, which has been in existence for two years, in German GUK 715.3 (GUK = Joint Subcommittee) which is responsible for editing the German 50173/51074, is of the opinion that two-sided measurement is also necessary for attenuation measurement, as there is no guarantee that the fibres used are of the same quality. For example, it is very unlikely that the measuring cables contain the same fibres as the fibres to be measured.

Fibre optic measurement with OTDR

Evaluating fibre optic cabling with an OTDR is more complicated and more expensive that measuring attenuation, due to the costly equipment and the need to interpret the measurement result.

If a measurement result significantly exceeds the anticipated (estimated) link attenuation, first of all the quality and cleanliness of the connections – as well as of the measuring cables – should be checked. If there are other reasons for the deviation it is necessary to fall back on an OTDR measurement. A locally resolved attenuation determination is possible only with the OTDR. This means that with this device excessively high attenuation of the connector or splice or even attenuation increases due to excessive bending or kinking of the cable (macrobending), for example, can be found.

