



Annex D:

Requirements to be met by measurement technology

Authors: **BMW Group**
Datacenter Technology
 Bremer Str. 6
 80788 Munich, Germany
 Telephone: +49-89-382-0

GHMT AG
 In der Kolling 13
 66450 Bexbach, Germany

Status: April 2016

Version: 4.0

© Copyright BMW Group and GHMT AG 1999 – 2016.
 All rights reserved. Please observe the note on industrial property rights pursuant to DIN ISO 16016.

This document is for internal use only or, as the case may be, for projects directly related to the BMW Group. It is prohibited to pass on or copy this documentation and to exploit and disclose the contents thereof to any to any third parties.

Any infringement of this condition is subject to the payment of damages. All rights reserved, in particular as far as the issuing of patents or contracts on the protection of utility models is concerned.

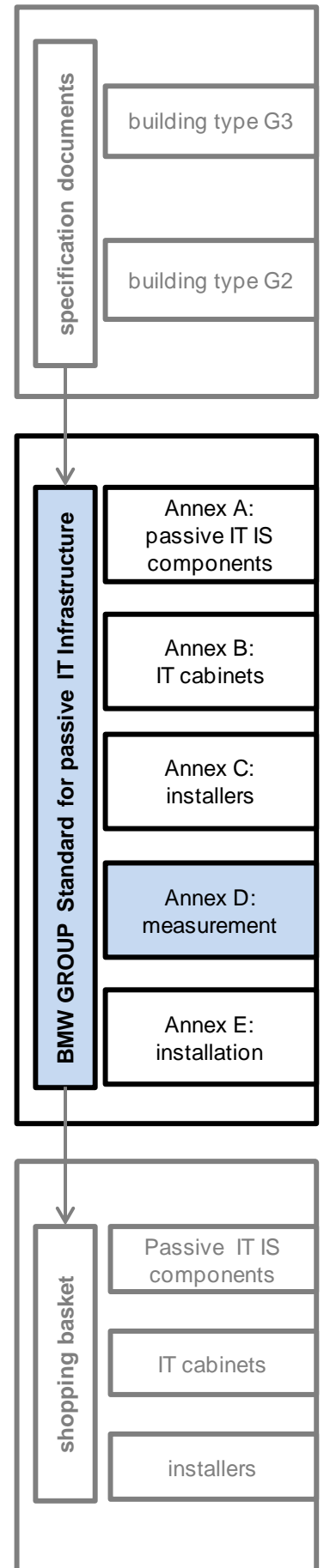




Table of Revisions

Version	Date	Modified chapters	Comments
1.0	June 1, 2006		Creation of document
1.1	August 20, 2007	2; 2.5	Addition of chapter 2.5
1.2	May 31, 2008	All	Update, modification according to current standard
2.0	April 1, 2012	All	Update, modification of department designation at client side and of annex letters
4.0	April 30, 2016	All	Comprehensive update and revision of the standard and its annexes



Table of contents

1 Preliminary Remarks	5
2 Measurements copper link	5
2.1 Assessment criteria	5
2.2 Approved test equipment	5
2.2.1 Calibration	5
2.2.2 Software version	5
2.2.3 Test heads	5
2.3 Important test equipment settings	6
2.4 Test parameters	6
2.5 Storing of measuring results	7
2.6 Documentation	7
3 Measurements fibre optic link	10
3.1 General information	10
3.2 Acceptance measurements for fibre optic cabling	10
3.3 Checking the clean condition of the fibre-optic connector end faces	11
3.4 Cleaning fibre optic connector end faces	13
3.5 OTDR measurement	15
3.5.1 Selection of test equipment	15
3.5.2 Pulse length and measuring time	16
3.5.3 Information and requirements relating to OTDR measurements	16
3.5.4 Specification for reference measurements (once per measuring point)	17
3.5.5 Specifications pertaining to length measurement (once per cable)	18
3.5.6 Specifications on bidirectional OTDR measurement including averaging	19
3.5.7 Limit values	21
3.5.8 Documentation	22
3.6 Level measurement within the framework of commissioning / fault analysis	23
4 Optical network applications	25
4.1 Single-mode	25
4.2 Multi-mode	26



List of Figures

Figure 1:	Example of a class E _A permanent link measurement (Fluke DTX-1800)	8
Figure 2:	Example of a class E _A permanent link measurement (IDEAL Lantek II)	9
Figure 3:	Flow chart pursuant to IEC 61300-3-35 for assessing fibre optic connector end faces	11
Figure 4:	Example of assessing a fibre-optic connector end face	12
Figure 5:	Utensils permitted for cleaning optical connector end faces (selection)	13
Figure 6:	Example illustrating the LSA method (5-point method)	16
Figure 7:	Positioning the cursors during length measurement	18
Figure 8:	Graph illustrating an OTDR measurement	19
Figure 9:	OTDR backscatter measurement of the couplings/connectors (schematic diagram)	20
Figure 10:	Zero adjustment (schematic diagram)	23
Figure 11:	Level measurement test set-up (schematic diagram)	23
Figure 12:	Level measurement equipment by way of example	24

List of Tables

Table 1:	Pulse width and resolution by way of example	16
Table 2:	Insertion loss limit values	21
Table 3:	Return loss limit values	21
Table 4:	Documentation of the results from a level measurement by way of example	24
Table 5:	Supported network applications for single-mode cabling (OS2)	25
Table 6:	Supported network applications for fibre-optic multi-mode cabling (OM3/OM4)	26

1 Preliminary Remarks

All installed copper and fibre-optic data links must be tested by the installation company within the framework of quality assurance. The test methods to be employed and the applicable assessment criteria are explained in detail in the following section.

Any packaging/safety guards removed for the purposes of measurement-based tests must be replaced in order to restore the requisite protection against environmental impact and the physical damage of components.

If protective caps or similar items are used for the protection of components, these must only be removed for the purposes of performing the test and must be restored without delay or, if required, must be replaced until the installation has been completed.

2 Measurements copper link

2.1 Assessment criteria

Structured copper cabling has to meet the requirements laid down for class E_A permanent links 2 (2 connectors) in accordance with ISO/IEC 11801.

2.2 Approved test equipment

Test measurements must only be carried out with test equipment that is approved by the BMW Group and that can be proven to correspond to "Level IV" quality pursuant to IEC 61935-1. Proof of this must be submitted on the basis of a certificate issued by a test institute accredited according to DIN EN ISO/IEC 17025.

The following hand-held testers have been approved by the BMW Group for copper acceptance measurements:

- Fluke (for example, DTX-1800, DSX-5000)
- IDEAL (for example, Lantek II)

2.2.1 Calibration

Test measurements must be carried out with test equipment that can be proven to have undergone calibration very recently only (maximum time period of one year since the last calibration).

2.2.2 Software version

The test equipment used must be operated with up-to-date software versions at the time when measurements are taken.

2.2.3 Test heads

The following test heads must be used for taking measurements:

- Fluke DTX-1800 → DTX-PLA002 Permanent Link Adapter with modular RJ45 contact tips
- Fluke DSX-5000 → DSX-PLA004 Permanent Link Adapter with modular RJ45 contact tips
- IDEAL Lantek II → high-performance category 6A adapter

Important notice for the use of Fluke DTX-1800 and DSX-5000:

The installation service provider must ensure that the contact tips used are replaced without delay at the latest when there are signs of wear and tear (for example by reducing the ACR value determined).

Otherwise the BMW Group IT IS Function Datacenter Technology (Rechenzentrumstechnik) reserves the right to demand that the installation service provider take the measurements concerned again with proper contact tips at his expense.

Important notice for the use of IDEAL Lantek II:

Since the IDEAL Lantek II measuring instrument does not use any specific permanent link adapter, and the permanent link measurements are taken with a standard work area/patch cord, the installation service provider must ensure that the following requirements are met:

- The work area/patch cables must meet the following requirements:
 - o Currently approved by the BMW Group
 - o Connector interface: RJ45
 - o Length: 2.0m each
- Every work area/patch cable can be used for a maximum of 200 measurements and has to be marked clearly.
- The work area/patch cables marked accordingly must be handed over to the planner together with the measuring results upon the completion of the acceptance measurements. The hand-over process must clearly document which work area/patch cable was used for which acceptance measurement.

*If these requirements are not met in their entirety, the BMW Group IT IS Function Datacenter Technology (Rechenzentrumstechnik) reserves the right to demand that the installation service provider take the measurements concerned again as specified at his expense.

2.3 Important test equipment settings

The following parameters must be adjusted in the tester/measuring instrument set-up in every case:

- Correct NVP value (to be taken from the installation cable data sheet)
- The "limit value" is laid down in ISO/IEC 11801 class E_A permanent link 2 (2 connectors)

2.4 Test parameters

The following parameters must be determined per copper data link:

- Wiring test
- Cable length
- Direct-current resistance
- Delay
- Delay skew

In addition, the following parameters have to be determined in the frequency range from 1 MHz up to at least 500 MHz:

- Insertion loss
- Near-end cross-talk loss (both ends)
- Return loss (on both ends)
- ACR-F (on both ends)
- ACR-N (on both ends)
- PS NEXT (on both ends)
- PS ACR-F (on both ends)
- PS ACR-N (on both ends)



2.5 Storing of measuring results

The results of the acceptance measurements must be stored in line with the following example:

EVT1/VT23345/L5CD

EVT1: Floor distributor 1

VT23345: Distribution cabinet 23345

L5CD: IDENT code of the data link

2.6 Documentation

All measuring results (including the graphical presentation of the frequency-dependent parameters) must be handed over on a data carrier (CD or DVD) in a well-structured layout to the specialist designer in charge in a manufacturer-specific, electronic form including viewer software.

- Fluke DTX-1800 and DSX-5000 → Fluke linkware database format (*.flw)
- IDEAL Lantek II → IDEAL IDC project (*.sdf)
report type: brief (cf. Figure 2)

Submitting the measuring data in PDF format or on paper only is not permitted.

The installation service provider must ensure that all test records created by him are stored correctly without any faults in the documentation system (COMMAND).

Comment:

The detailed requirements pertaining to "Documentation for acceptance" are specified in "Annex E: Requirements installation".

Annex D: Requirements to be met by measurement technology



The following pictures show test records produced by the two approved measuring instruments by way of example.

GHMT®



Cable ID: EVT/VT23345/L5CD(RC)

Date / Time: 01.02.2016 11:49:50

Headroom 7.4 dB (NEXT 36-45)

Test Limit: ISO11801 PL2 Class Ea

Cable Type: Cat.7 S/FTP

Calibration Date: 20.11.2015

Operator: Hr. Mustermann

Software Version: 2.7700

Limits Version: 1.9400

NVP: 79.0%

Test Summary: PASS

Model: DTX-1800

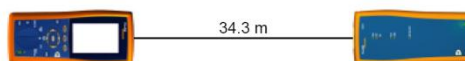
Main S/N: 8717069

Remote S/N: 8717070

Main Adapter: DTX-PLA002

Remote Adapter: DTX-PLA002

Length (m)	[Pair 45]	34.3
Prop. Delay (ns), Limit 496	[Pair 36]	151
Delay Skew (ns), Limit 43	[Pair 36]	6
Resistance (ohms), Limit 20.6	[Pair 36]	3.9
Insertion Loss Margin (dB)	[Pair 36]	27.1
Frequency (MHz)	[Pair 36]	500.0
Limit (dB)	[Pair 36]	41.6

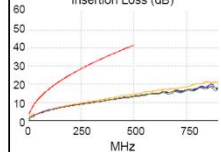


Wire Map (T568A)

PASS



Insertion Loss (dB)



Worst Case Margin Worst Case Value

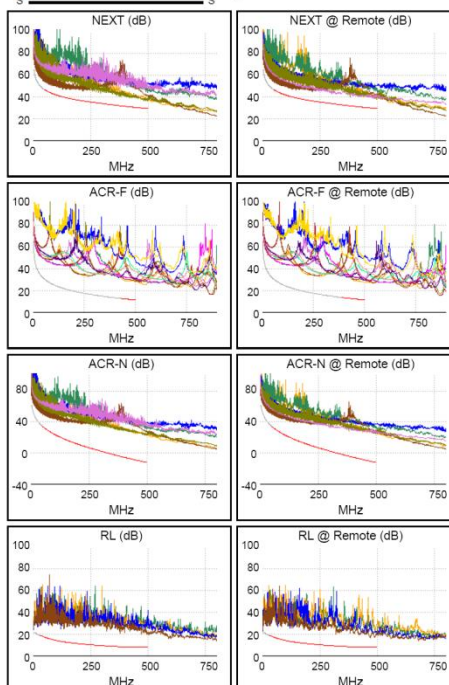
PASS	MAIN	SR	MAIN	SR
Worst Pair	12-36	36-45	12-36	45-78
NEXT (dB)	7.6	7.4	7.6	9.8
Freq. (MHz)	499.0	84.8	499.0	479.0
Limit (dB)	29.3	43.0	29.3	29.6
Worst Pair	36	45	36	36
PS NEXT (dB)	7.1	8.8	7.1	9.2
Freq. (MHz)	500.0	77.8	500.0	500.0
Limit (dB)	26.4	41.1	26.4	26.4

PASS	MAIN	SR	MAIN	SR
Worst Pair	36-12	12-36	12-36	12-36
ACR-F (dB)	16.1	16.1	17.0	16.3
Freq. (MHz)	4.3	4.3	500.0	497.0
Limit (dB)	52.7	52.7	11.3	11.3
Worst Pair	36	12	36	36
PS ACR-F (dB)	16.5	16.9	16.5	16.9
Freq. (MHz)	494.0	3.4	498.0	494.0
Limit (dB)	8.4	51.7	8.3	8.4

PASS	MAIN	SR	MAIN	SR
Worst Pair	36-45	36-45	12-36	12-36
ACR-N (dB)	16.2	16.0	34.8	37.6
Freq. (MHz)	50.8	50.8	499.0	499.0
Limit (dB)	34.2	34.2	-12.3	-12.3
Worst Pair	36	36	36	36
PS ACR-N (dB)	17.6	17.4	34.3	36.4
Freq. (MHz)	47.3	47.3	500.0	500.0
Limit (dB)	32.7	32.7	-15.3	-15.3

PASS	MAIN	SR	MAIN	SR
Worst Pair	78	78	78	78
RL (dB)	8.5	8.6	12.0	8.6
Freq. (MHz)	28.4	470.0	497.0	470.0
Limit (dB)	18.7	8.0	8.0	8.0

Compliant Network Standards:
10BASE-T 100BASE-TX 100BASE-T4
100BASE-T 10GBASE-T ATM-25
ATM-51 ATM-155 100VG-AnyLan
TR-4 TR-16 Active TR-16 Passive



LinkWare™ PC Version 9.4

Project: BMW Musterprojekt
BMW Musterprojekt.flw
Floor: Etage EG
Rack: VT23345

Site: Musterhausen
Building: Musterhaus
Telecom Room: EVT 1
Patch: HE 1

FLUKE
networks

Figure 1: Example of a class E_A permanent link measurement (Fluke DTX-1800)

Annex D: Requirements to be met by measurement technology



IDEAL INDUSTRIES, Inc. Certified - Test Report

Job Name: BMW Group
Company: GHMT AG

Report Date: Thursday, May 03, 2012 3:18 PM
Version: 1.3.1

Summary:

All Cables	Twisted Pair	Coax/Twinax	Fiber
Total: 1	Total: 1	Total: 0	Total: 0
Pass: 1	Pass: 1	Pass: 0	Pass: 0
Fail: 0	Fail: 0	Fail: 0	Fail: 0
Tot. Length: 42,8m	Tot. Length: 42,8m	Tot. Length: 0m	Tot. Length: 0m

Pass

Test Name: 9ABC
Test Limit: ISO Ea PL2 STP Perm
MFG DB:
LANTEK II-1000 [1003175/1003223]
Adapter ID: 6004, Cat 6A Chan
User Notes:

NVP: 80
Standard: ISO/IEC 11801 Am 2
Frequency Range: 1 - 500MHz
Firmware 2.012
Calibration Date: 07.09.2011 12:04:25

Test Date: 11/2/2011
Test Time: 15:12:34
Operator: H. Mustermann
Contractor: GHMT AG
Company: GHMT AG

	Worst Case Value	Pairs	Limit	Margin	Pairs	Worst Overall Value	Limit	Margin
Wiremap	N/A	N/A	N/A	N/A				
Length	N/A 42,8 m	7,8	N/A	N/A				
DC Resistance	5,4 ohms	3,6	20,6 ohms	15,2 ohms				
Propagation Delay	183,4 ns	3,6	487,0 ns	303,6 ns				
Delay Skew	4,8 ns	3,6	43,0 ns	38,2 ns				
Insertion Loss	1,7 dB @ 5,2MHz	DH 7,8	< 4,0 dB	2,3 dB	DH 3,6	17,6 dB @ 499,0MHz	< 42,0 dB	24,4 dB
Return Loss	15,5 dB @ 202,0MHz	DH 5,4	> 10,9 dB	4,6 dB	RH 3,6	15,4 dB @ 500,0MHz	> 8,0 dB	7,4 dB
NEXT	31,9 dB @ 422,0MHz	DH 3,6-1,2	> 30,8 dB	1,1 dB	DH 3,6-1,2	31,2 dB @ 500,0MHz	> 29,2 dB	2,0 dB
ACR-N	32,7 dB @ 156,0MHz	DH 3,6-5,4	>= 16,2 dB	16,5 dB	DH 3,6-1,2	13,7 dB @ 500,0MHz	>= -12,9 dB	26,6 dB
ACR-F	63,9 dB @ 6,0MHz	DH 3,6-7,8	> 49,7 dB	14,2 dB	RH 3,6-7,8	29,3 dB @ 484,0MHz	> 11,5 dB	17,8 dB
PS NEXT	28,9 dB @ 500,0MHz	RH 3,6	> 26,2 dB	2,7 dB	RH 3,6	28,9 dB @ 500,0MHz	> 26,2 dB	2,7 dB
PS ACR-N	31,6 dB @ 156,0MHz	DH 3,6	> 13,2 dB	18,4 dB	RH 3,6	11,4 dB @ 500,0MHz	> -15,9 dB	27,3 dB
PS ACR-F	63,7 dB @ 5,2MHz	DH 3,6	> 47,9 dB	15,8 dB	RH 3,6	26,6 dB @ 484,0MHz	> 8,5 dB	18,1 dB

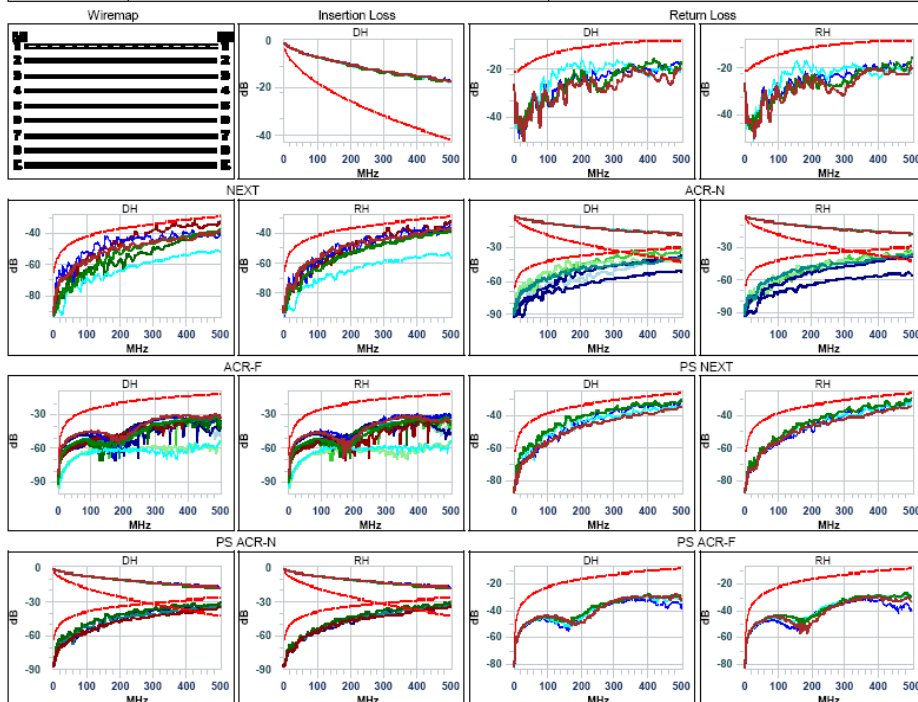


Figure 2: Example of a class E_A permanent link measurement (IDEAL Lantek II)



3 Measurements fibre optic link

3.1 General information

Contaminated connectors have a substantial impact on the measuring results obtained on a fibre-optic permanent link or channel. Top-quality connectors (that are supplied by one and) from the same manufacturer must be used to ensure a high level of measuring accuracy. Many of the faults that occur in fibre optic cabling are due to contaminated fibre-optic connector end faces. It is therefore essential to ensure that the fibre-optic connector end faces are neither contaminated nor damaged by/during the measuring process.

3.2 Acceptance measurements for fibre optic cabling

The following tests must be carried out on every fibre optic data link in order to assess the quality of fibre-optic cabling:

- Use of a videomicroscope to check the clean condition of the connector faces prior to and after the OTDR measurement (at least 200x magnification of microscope)
- Determination of the cable length on the basis of OTDR backscatter measurement
- Completion of OTDR measurement according to IEC 14763-3 to compile a backscatter graph
- Determination of the return loss and the insertion loss caused by every event on the basis of the OTDR backscatter graph (connector-coupling-connector)

The OTDR measurement is to be carried out bidirectionally at the following wavelengths:

- Single-mode: 1,310 nm and 1,550 nm
- Multi-mode: 850 nm and 1,300 nm

* The single-mode OTDR measurements must also be taken at the wavelength of 1,625 nm for MAN and WAN connections.

Comment:

Multimode fibres also require guaranteed modal excitation (encircled flux) by means of a mode controller pursuant to IEC 61280-4-1.

3.3 Checking the clean condition of the fibre-optic connector end faces

A suitable video microscope (magnification at least 200x) is to be used to check the clean condition of the fibre optic connector end faces prior to and after every OTDR measurement in accordance with IEC 14763-3 and IEC 61300-3-35. This applies in particular to the test fibres used, which are subject to a constant visual control by microscope. Contaminated connector end faces must be cleaned with suitable cleaning agents approved for use by the supplier.

Below is the relevant flow chart pursuant to IEC 61300-3-35.

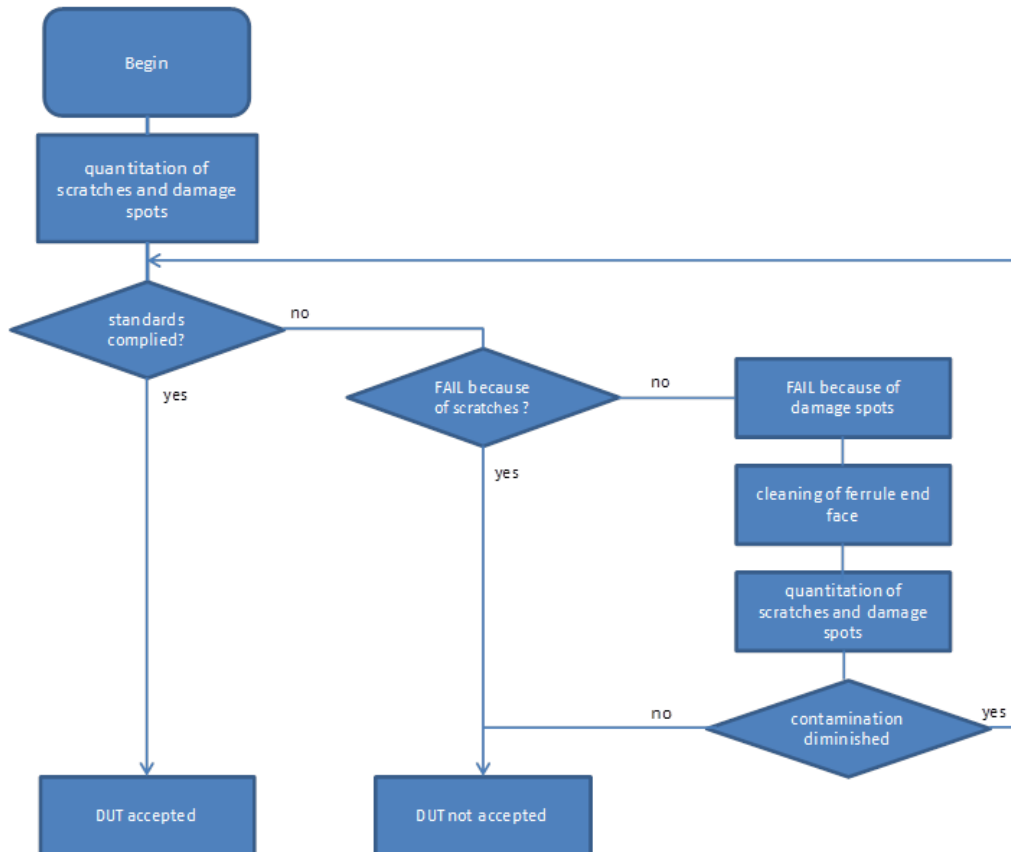


Figure 3: Flow chart pursuant to IEC 61300-3-35 for assessing fibre optic connector end faces

Annex D: Requirements to be met by measurement technology



The photomicrographs of every fibre-optic connector end face are part and parcel of the documentation and must be handed over in a well-structured layout. Only protocols that have a rating of "PASS" will be recorded.

FiberChek ^{PRO}		Fibre Inspection		JDSU
Inspection Date	03/02/2016 17:04:45			
Company Name	Mustermann Company			
Customer	Customer A			
Location	Musterland			
Operator	Max Mustermann			
Operator ID	567			
Fibre Information				
File Name	Fiber_-1-Customer A-Musterland-Max Mustermann -123-Muster-Cable-A1.pdf			
Fibre Type	Simplex			
Job ID	123			
Cable ID	Muster-Cable			
Connector ID	A1			
Fibre ID	Fiber_-1			
Comments	Test			
PASS				
Inspection Summary				
Profile Name: MM (IEC-61300-3-35 Ed. 2.0)-Benchtop Optical Setting: FVD2400-L Focus: 76				
Zone	Defects	Scratches		
Zone A (0 - 65)	PASS	PASS		
Zone B (65 - 125)	PASS	PASS		
Zone C (115 - 135)	PASS	PASS		
Zone D (135 - 250)	PASS	PASS		
Low Magnification		High Magnification		
Analysis Details				
© 2016 JDS Uniphase Corporation. All rights reserved.				
Page #1				

Figure 4: Example of assessing a fibre-optic connector end face

3.4 Cleaning fibre optic connector end faces

Fibre optic connector end faces must be cleaned according to the manufacturer's instructions and the specifications laid down in IEC/TR 62627-01.

Dry cleaning:

When slightly contaminated, the connector end face must be cleaned in accordance with the manufacturer's instructions. Suitable cleaning utensils include in particular lint-free cloths, special cleaning tapes (cartridges), or cleaning swabs. After every dry cleaning process, a microscope must be used to check whether or not the cleaning process was successful or whether cleaning must be repeated.

Wet-dry cleaning

If dry cleaning is not successful even after having been repeated two or three times, or if contamination is too severe, the connector end face must be subjected to wet-dry cleaning.

For this purpose, a solvent suited specifically for optical components (for example, ultra-pure isopropyl alcohol, > 99 %) must be applied to a lint-free cloth and must then be used to clean the connector end face according to the manufacturer's instructions. This cleaning step must be followed immediately by dry cleaning (please see above). After every wet-dry cleaning, the connector end face must also be examined in order to find out whether the cleaning process was successful or whether it has to be repeated.

If residues remain on the surface despite several wet-dry cleaning cycles, these are usually abraded particles integrated in the surface or adhesive residues that cannot be removed. In this case, the specialist planner must be consulted immediately to decide whether or not the connector end faces must be replaced.



Figure 5: Utensils permitted for cleaning optical connector end faces (selection)



- 1) **Lint-free cleansing cloths:**
Lint-free cleansing cloths in a dispenser box, specifically for the wet cleaning of fibre-optic connector end faces and glass fibres with the use of isopropyl alcohol.
- 2) **Cleaning swabs:**
Mostly for dry cleaning the end faces of connectors that are installed in couplings, adapters, device ports or patch panels. These can be supplied both for 1.25 mm and 2.5 mm ferrules.
- 3) **Isopropyl alcohol, > 99%:**
Ultra-pure alcohol for wet cleaning fibre-optic connector end faces and glass fibres using lint-free cleaning cloths (also known as 2-propanol or isopropyl alcohol (abbreviated IPA, contact causes irritation to the eyes and the mucous membranes). When handling isopropyl alcohol, care must be taken to ensure adequate ventilation.
Following the wet cleaning process with alcohol, the connector end faces must once again undergo a dry cleaning process since remaining alcohol residues act hygroscopically, which is conducive to the accumulation of dirt.
- 4) **Fibre-optic cleaning tape (for instance Reel-Cleaner, Cletop):**
Cleaning cartridge with specifically coated cleaning tape protected against contamination for dry cleaning fibre-optic connector end faces. The cleaning tape winds on automatically for every cleaning process.
- 5) **One-Click Cleaner:**
For dry cleaning end faces of fibre-optic connectors that are integrated in couplings, adapters, device ports or patch panels. The cleaning process is completed by pressing the One-Click Cleaner. Various versions are available for various connector interfaces / ferrule diameters.

3.5 OTDR measurement

OTDR backscatter measurements taken by means of an OTDR measuring instrument (OTDR: Optical Time Domain Reflectometer) provide graphic information on the entire fibre and link characteristics of the link installed.

Any fibre optic cabling laid at BMW Group (pre-assembled by the manufacturer or featuring splices) must be fully checked and documented on the basis of measurements once installation is complete.

Comment:

It is absolutely essential to comply with and apply the specifications for checking a fibre-optic cabling system in accordance with IEC 14763-3 (Implementation and operation of customer premises cabling - part 3: Testing of optical fibre cabling).

3.5.1 Selection of test equipment

To facilitate a standardised and harmonised management of the measuring results, the measurements taken on fibre optic IT cabling must be performed exclusively with test equipment that has been approved for use by BMW Group.

The following test equipment manufacturers* have been approved:

- EXFO
- Fluke
- Ideal Industries (for example, Mikro OTDR series)
- JDSU

Other test equipment is only allowed if approved by the BMW Group IT IS Function Datacenter Technology (Rechenzentrumstechnik).

** The ranking of the test equipment manufacturers listed is without bias*

3.5.2 Pulse length and measuring time

The pulse length has an impact on the time- and level-related resolution capacity of an OTDR. Short pulse lengths generate a higher spatial resolution with smaller dead zones. As the pulse length increases, range and level resolution as well as dead zones become larger. Enlarged dead zones result in reduced spatial resolution.

Measurement period:

Please see to it that the measurement period is adjusted for a sufficient duration in order to obtain a precise and noise-free result by way of averaging a large number of individual measurements:

$$t_{\text{mess}} \geq 15 \text{ s}$$

Pulse length:

Pulse length is to be chosen such as to ensure that spatial resolution is sufficiently high for assessing every connector-coupling-connector transition (including splice, if applicable) across the fibre-optic link.

The following pulse length values have been provided as a guide:

Pulse length	3 ns	10 ns
Resolution capacity	0.3 m	1 m

Table 1: Pulse width and resolution by way of example

Comment:

The OTDR must however be set (so as) to determine a noise-free curve at the shortest possible pulse length.

3.5.3 Information and requirements relating to OTDR measurements

The following specifications must be taken into account for OTDR measurements in accordance with IEC 14763-3:

- The LSA method (5-point method) must be applied to calculate the loss stages in the backscatter graph. In this connection, a straight line (1-2 or 3-4) is placed before and after the event in the OTDR curve and the straight lines are extrapolated to the location of the event. This corresponds to point (5), at which the backscatter level changes erratically. Here, fluctuations of the measured loss values are eliminated by noise effects. The distance between the two resulting points of intersection between regression lines (1-2 or 3-4) and vertical event line (5) is used to determine the resulting insertion loss.

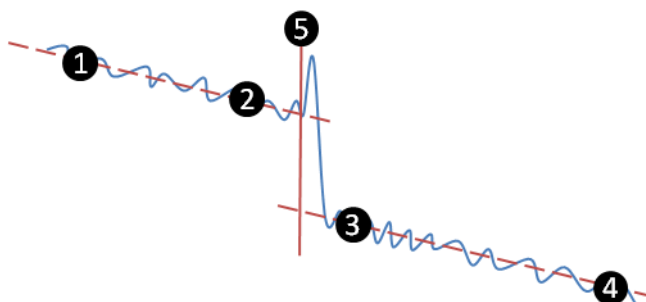


Figure 6: Example illustrating the LSA method (5-point method)



- Care must be taken to ensure that the refractive index is set for the optical fibre to be tested as specified in the manufacturer's data sheet for every wavelength.
- The backscatter graph must be plotted such as to ensure that the device being tested, including launching and trailing fibres, can be recognized and that the reflections of the releasable fibre-optic connections are not cut off.
- It is not permitted to introduce liquids into the area of the connector coupling (for example isopropyl alcohol, index-matching materials (gels and/or liquids)) for the purposes of manipulating the OTDR measuring results.
- It is also possible to use a loop for taking the measurement. In this case, a laser pointer must be used to check all fibres at the beginning for a correct 1:1 connection.

Comment:

Measurements on fibre-optic cabling must be taken with particular reference to the pertinent safety regulations regarding laser radiation. This includes among other things the accident prevention regulations BGV B2 laid down by the employer's liability insurance association for precision and electrical engineering (Berufsgenossenschaft Elektro Textil Feinmechanik) and DIN EN 60825-1.

3.5.4 Specification for reference measurements (once per measuring point)

Couplings must be used to link the launching fibre and the trailing fibre to qualify the test set-up for the OTDR measurements. To this end, a backscatter graph has to be recorded and documented prior to and after each test section. In this way the insertion loss and return loss values determined are used to examine the quality of the connectors.

These measuring results must be handed over to the specialist designer together with the OTDR test records in electronic form.

Care must be taken not to distort the backscatter graphs due to the quality of the test fibres used.

- Test fibres must have the same optical parameters as the optical fibres to be tested. No further patch cables must be placed between the launching and the trailing fibres.
- Test fibres must be subjected to a regular visual control by microscope. Contaminated connector end faces must be cleaned. If the cleaning process does not produce the desired result, the connector of the test fibre must be replaced.
- An interferometer has to be employed to test every test fibre for compliance with the geometric dimensions of the connector end faces. Proof of said analysis has to be established in the form of a test record (typically by storing the test record in the box in which the test fibre is kept).

Comment:

The fibre optic connectors of the launching or trailing fibres must be of reference quality; the maximum connector-coupling-connector attenuation must therefore not exceed the value of 0.15 dB during the reference measurement at any requisite wavelength.

3.5.5 Specifications pertaining to length measurement (once per cable)

The OTDR test equipment must therefore have at least two cursors / markers that can be set to the measurement points required. The two cursors must be placed on the rising edge of the two cable ends of the permanent link.

To determine the link length, **cursor A** must be positioned before the first event and **cursor B** before the second event (please refer to Figure 7).

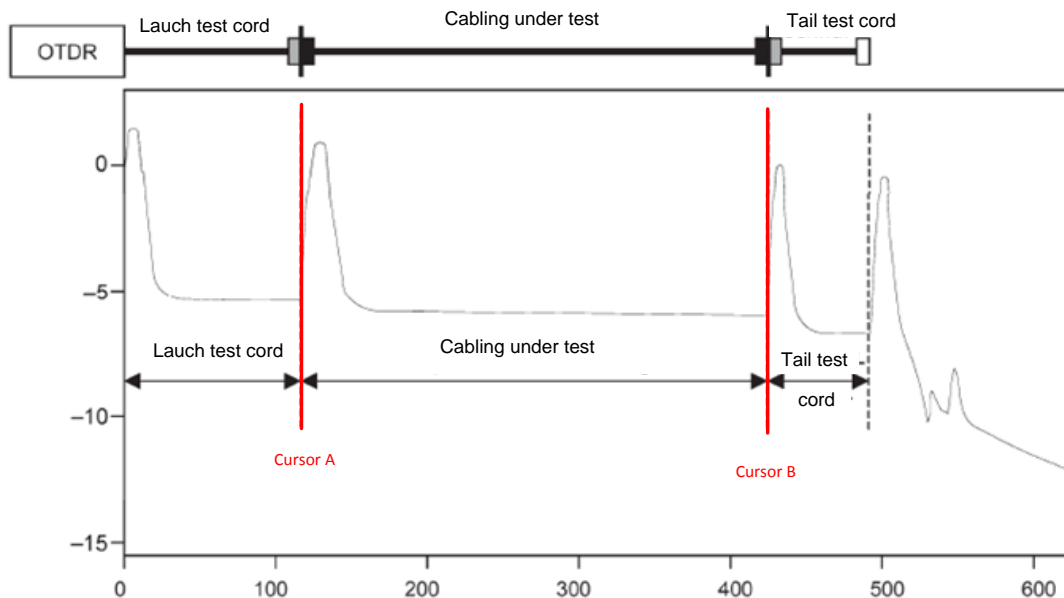


Figure 7: Positioning the cursors during length measurement

3.5.6 Specifications on bidirectional OTDR measurement including averaging

Measurements by means of OTDR must be performed in accordance with IEC 14763-3. The measurement must be taken bidirectionally for every fibre at all wavelengths and the use of a launching and a trailing fibre is mandatory.

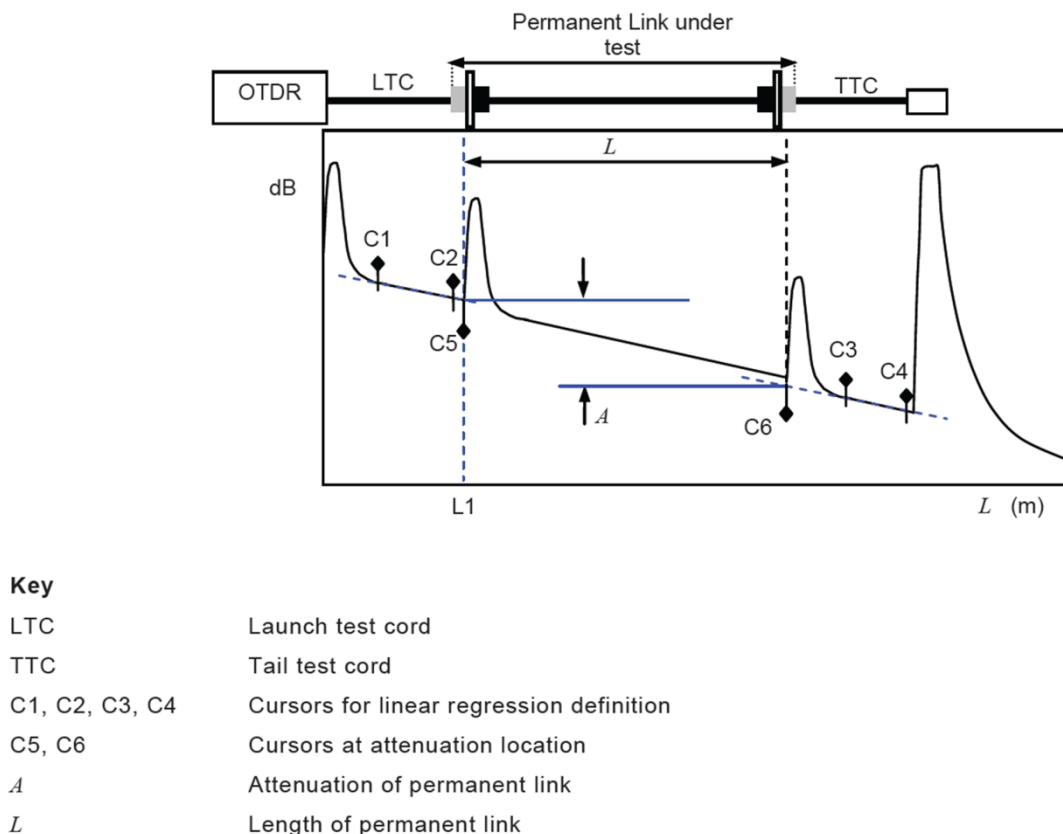


Figure 8: Graph illustrating an OTDR measurement

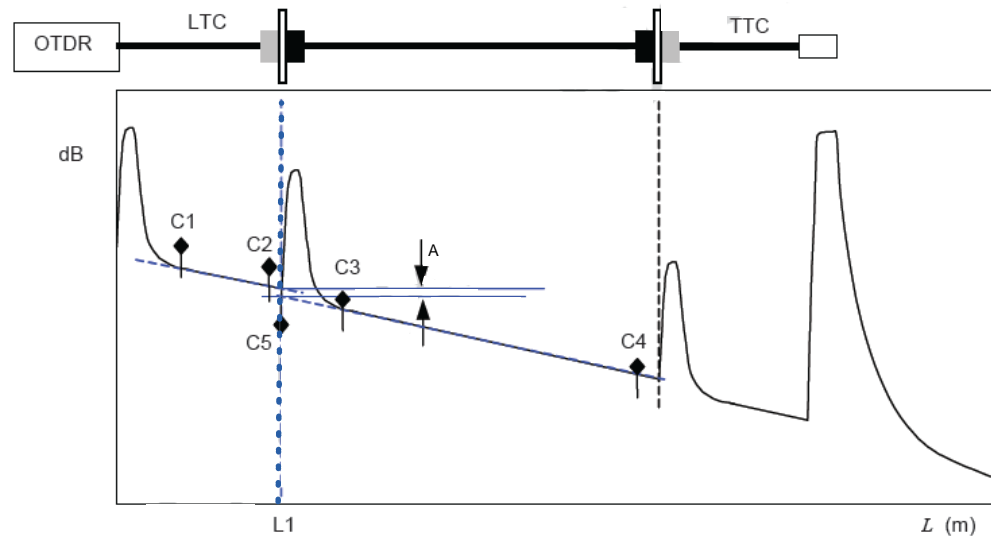
Following the measurement, evaluation software must be used to determine the average value. For the purposes of averaging, the backscatter curves created bidirectionally are mirrored.

The presentation of the superimposed backscatter curves A → B and B → A is part of the documentation.

Annex D: Requirements to be met by measurement technology



In addition, the resulting insertion loss must be determined for every event (connector-coupling-connector) by means of averaging both OTDR backscatter graphs (measuring directions A --> B and B -->A).



Key

LTC	Launch test cord
TTC	Tail test cord
C1, C2, C3, C4	Cursors for linear regression definition
C5	Cursor at attenuation location
A	Attenuation of measured connection

Figure 9: OTDR backscatter measurement of the couplings/connectors (schematic diagram)

3.5.7 Limit values

The following limit values must be complied with during the OTDR backscatter measurements:

	Singlemode/ Multimode	Insertion loss / dB
E2000™ APC (connector-coupling-connector)	Singlemode (1310 nm / 1550 nm / 1625 nm)	≤ 0,4 (incl. splice: ≤ 0.5)
LC APC (connector-coupling-connector)	Singlemode (1310 nm / 1550 nm / 1625 nm)	≤ 0,4 (incl. splice: ≤ 0.5)
LC PC (connector-coupling-connector)	Multimode (850 nm / 1300 nm)	≤ 0,4 (incl. splice: ≤ 0.5)
Splice	-	≤ 0,1
Optical fibre	-	Limit value in accordance with ISO/IEC 11801

Table 2: Insertion loss limit values

	Singlemode/ Multimode	Return loss / dB
E2000™ APC (connector-coupling-connector)	Singlemode (1310 nm / 1550 nm / 1625 nm)	≥ 60
LC APC (connector-coupling-connector)	Singlemode (1310 nm / 1550 nm / 1625 nm)	≥ 50
LC PC (connector-coupling-connector)	Multimode (850 nm / 1300 nm)	≥ 40

Table 3: Return loss limit values



3.5.8 Documentation

All OTDR measuring results (including OTDR backscatter graph and event table) must be handed over to the specialist planner in charge on data carriers (CD or DVD) in a well-structured layout and in manufacturer-specific electronic form (for instance *.sor), including viewer software.

Submitting the measuring data in PDF format or on paper only is not permitted. The installation service provider must ensure that all measurements records created by him are stored correctly without any faults in the documentation system (COMMAND).

A separate measuring record must be present for every OTDR measurement and must include at least the following data:

- Project designation
- Fibre and cable number
- Operator
- Date/time of measurement
- Device designation
- Wavelength
- Pulse width
- Recording time
- Measuring range
- Resolution
- Refractive index of fibre
- Starting and end points of the measurement (direction of measurement to be stated)
- Length of the installed optical cabling link
- Length of the launching and trailing fibres
- OTDR test curve
- Event table

In addition, the measuring results obtained in the course of the OTDR acceptance measurements must be entered in the "FiberDoc" documentation software together with the micrographs of the connector end faces and must be handed over to the specialist planner in charge in electronic form.

Comment:

The detailed requirements pertaining to "Documentation for acceptance" are specified in "Annex E: Requirements installation".

3.6 Level measurement within the framework of commissioning / fault analysis

For optical-fibre channels that must be prepared for the coupling to the active components (= link between active channels: comprises stationary optical-fibre infrastructure plus all patched work area and patch cords), the insertion loss budget must be determined.

The level measurement does not serve as a substitute for the OTDR measurement required in chapter 3.5.

The level measurement must be taken in accordance with IEC 61280-4-1, method 1 for multi-mode or in accordance with IEC 61280-4-2, method 1b for single-mode.

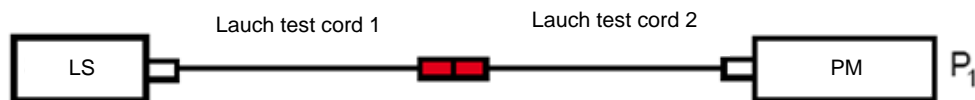


Figure 10: Zero adjustment (schematic diagram)

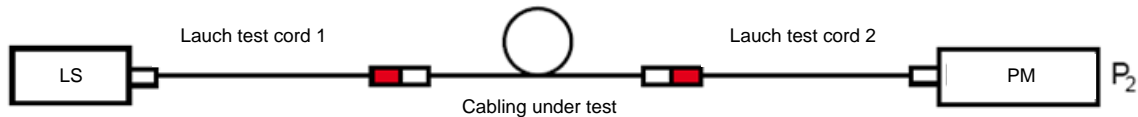


Figure 11: Level measurement test set-up (schematic diagram)

Lengths between 3 m and 5 m are permitted for test and patch cables. These test and patch cables must feature reference-quality connectors since otherwise the measuring results would be distorted.

Comment:

Multimode fibres also require guaranteed modal excitation (encircled flux) by means of a mode controller pursuant to IEC 61280-4-1.

The level measurement is to be carried out at the following wavelengths bidirectionally, followed by averaging:

- Single-mode: 1,310 nm as well as 1,550 nm
- Multi-mode: 850nm and 1,300nm

The measuring results must be handed over in a well-structured layout on disk (CD or DVD) to the specialist department in charge and must comprise the following:

- Designation of the channel
- Length of channels
- Indication of fibre type
- max. CIL¹ for the corresponding network application
- Measurement data
- Measuring results for measurement direction A --> B
- Measuring results for measurement direction B -->A
- Averaging from measurement directions A --> B and B -->A

¹ CIL = is the maximum channel insertion loss (or of the optical power budget, if applicable), as defined in the network application standard.

Annex D: Requirements to be met by measurement technology



The installation service provider must ensure that any measurement records created by him are stored correctly in the documentation system (COMMAND).

Fibre-no. / Link-no.	optical fibre	network applications	max. CIL (dB)	CIL A -> B (dB)	CIL B -> A (dB)	Average A -> B; B -> A (dB)
Server xxxx to VT 12345_fibre 1	SM_OS2	16G fibre channel	6,40	1,50	1,30	1,40
Server xxxx to VT 12345_fibre 2	SM_OS2	16G fibre channel	6,40	1,30	1,80	1,55
Server xxxx to VT 12345_fibre 3	SM_OS2	16G fibre channel	6,40	2,20	1,80	2,00
Server xxxx to VT 12345_fibre 4	SM_OS2	16G fibre channel	6,40	1,90	1,50	1,70
.....

Table 4: Documentation of the results from a level measurement by way of example



Figure 12: Level measurement equipment by way of example

COMMENTS:

The maximum insertion loss values of the channel, depending on the network application, are listed in chapter 4.

The detailed requirements pertaining to "Documentation for acceptance" are specified in "Annex E: Requirements installation".

4 Optical network applications

4.1 Single-mode

In accordance with DIN EN 50173-1:2011, the insertion loss or, as the case may be, the overall length of the channel for single-mode (OS2) must not exceed the following values, depending on the wavelength (excerpt):

Network application Single-mode	Maximum insertion loss of channel for OS2	Class / maximum channel length for OS2
ATM at 51.84 Mbps	10.0 dB (1,310 nm)	OF-10000 / 20,000 m
ATM at 155.52 Mbps	7.0 dB (1,310 nm)	OF-10000 / 12,500 m
ATM at 622.08 Mbps	7.0 dB (1,310 nm)	OF-10000 / 12,500 m
DIS 14165-111: fibre channel (FC-PH) at 266 Mbps	6.0 dB (1,310 nm)	OF-10000 / 10,000 m
DIS 14165-111: fibre channel (FC-PH) at 531 Mbps	14.0 dB (1,310 nm)	OF-10000 / 30,000 m
DIS 14165-111: fibre channel (FC-PH) at 1062 Mbps	6.0 dB (1,310 nm)	OF-10000 / 10,000 m
1 Gbps FC (1.0625 GBd)	7.8 dB (1,310 nm)	OF-10000 / 10,000 m
2 Gbps FC (2.125 GBd)	7.8 dB (1,310 nm)	OF-10000 / 10,000 m
4 Gbps FC (4.25 GBd)	7.8 dB (1,310 nm)	OF-10000 / 10,000 m
8 Gbps FC (8.5 GBd)	6.4 dB (1,310 nm)	OF-10000 / 10,000 m
16 Gbps FC (14,025 GBd)	6.4 dB (1,310 nm)	OF-10000 / 10,000 m
ISO/IEC 802.3ae: 1000Base-LX	4.56 dB (1,310 nm)	OF-5000 / 5,000 m
ISO/IEC 9314-4: FDDI SMF-PMD	10.0 dB (1,310 nm)	OF-10000 / 20,000 m
IEEE 802.3: 10GBase-LX4	6.2 dB (1,310 nm)	OF-10000 / 10,000 m
IEEE 802.3: 10GBase-LR/LW	6.2 dB (1,310 nm)	OF-10000 / 10,000 m
IEEE 802.3: 10GBase-ER/EW	10.9 dB (1,550 nm)	OF-10000 / 22,250 m
IEEE 802.3: 40GBase-LR4	6.7 dB (1,310 nm)	OF-10000 / 10,000 m
IEEE 802.3: 100GBase-LR4	8.3 dB (1,310 nm)	OF-10000 / 10,000 m
IEEE 802.3: 100GBase-ER4	18.0 dB (1,550 nm)	OF-10000 / 40,000 m

Table 5: Supported network applications for single-mode cabling (OS2)



4.2 Multi-mode

In accordance with DIN EN 50173-1, the insertion loss of the channel for multi-mode (OM3/OM4) must not exceed the following values, depending on the wavelength (excerpt):

Network application Multi-mode	Maximum insertion loss of channel for OM3/OM4	Class / max. channel length for OM3/OM4
DIS 14165-111: fibre channel (FC-PH) at 266 Mbps	12.0 dB (850 nm) 5.5 dB (1,300 nm)	OF-2000 / 2,000 m
DIS 14165-111: fibre channel (FC-PH) at 531 Mbps	8.0 dB (850 nm)	OF-500 / 1,000 m
DIS 14165-111: fibre channel (FC-PH) at 1,062 Mbps	4.0 dB (850 nm)	OF-500 / 500 m
1 Gbps FC (1.0625 GBd)	2.62 dB (850 nm)	OF-500 / 500 m
2 Gbps FC (2.125 GBd)	3.31 dB (850 nm)	OF-300 / 300 m
4 Gbps FC (4.25 GBd)	2,28 dB (850 nm) ¹ 3,02 dB (850 nm) ²	OF-300 / 380 m OF-300 / 420 m
8 Gbps FC (8.5 GBd)	2,19 dB (850 nm) ¹ 2,22 dB (850 nm) ²	OF-100 / 150 m ¹ OF-100 / 190 m ²
16 Gbps FC (14,025 GBd)	1,95 dB (850 nm) ¹ 1,97 dB (850 nm) ²	OF-100 / 100 m OF-100 / 125 m
100Base-FX	6.3 dB (1,300 nm)	OF-2000 / 2,000 m
1000Base-SX	3.56 dB (850 nm)	OF-500 / 550 m
1000Base-LX	2.35 dB (1,300 nm)	OF-500 / 550 m
10GBase-SR/SW	2.60 dB (850 nm)	OF-300 / 300 m
10GBase-LX4	2.0 dB (1,300 nm)	OF-300 / 300 m
40GBase-SR4	1.9 dB (850 nm) ¹ 1.5 dB (850 nm) ²	OF-100 / 100 m OF-100 / 150 m
100GBase-SR10	1,9 dB (850 nm) ¹ 1,5 dB (850 nm) ²	OF-100 / 100 m OF-100 / 150 m

Table 6: Supported network applications for fibre-optic multi-mode cabling
(OM3/OM4)

¹ with OM3

² with OM4