

AB Micropol Fiberoptic  
313 50 ÅLED

## Test of Optical Connectors with reference to 1056-A160

(9 appendices)

### Introduction

Fiber connectors of the SC/UPC type, mounted on 2 and 3 m long patchcords of G652 fiber, have been evaluated with respect to requirements set by TeliaSonera/Skanova in document 1056 – A 160 “Optical Connector and Adaptor type SC/PC for Single Mode Fibre”. The tests has been performed during 2 different intervals, in 2011 and in 2015, as specified below. The result is that the connectors and adapters from Micropol fulfil the requirement on all parameters as specified in the document.

### Identification

Objects to test (DUTs)	15 connectorized 2 m long G652 fiber patchcords, with SC/UPC connectors on both ends, ID.numbered SCU <sub>P</sub> C <sub>i</sub> , where i runs from 01 to 30 (2011) from Micropol. 20 connectorized 3 m long G652 fiber patchcords with SC/UPC connectors on both ends, ID.numbered j, where j runs from 01 to 40 (2015) from Micropol
Supporting objects	20 SC/SC adapters from Micropol 10 connectorized 3 m long G652 fiber patchcords from Supplier A with SC/UPC connectors on both ends* 10 connectorized 3 m long G652 fiber patchcords from Supplier B with SC/UPC connectors on both ends* 10 SC/SC adapters from Supplier A* 10 SC/SC adapters from Supplier B* * Skanova supplied patchcords and adapters from two Suppliers, noted A and B, already approved according to Skanova requirement. The request to test intermateability to two other suppliers leads to some changes in sample selection, as described below in the report
Object state	Upon arrival the objects had no visual damages. All fiber patchcords where individually packed, new from production.
Received date	2011-12-07 and 2015-01-26
Measurement place	Borås
Measurement dates	2011-12-07 to 2011-12-22 and 2015-01-28 to 2015-07-13

### Measurement methods and procedures

The objects where measured according to the instructions in TeliaSonera/Skanova specification 1056-A 160 “Optical Connector and Adaptor type SC/PC for Single Mode Fibre”. The tests 4.1 Visual Inspection, 4.3.2 Attenuation of random mated connectors, 4.4 Return Loss of random mated connectors, 4.5 Bending moment, 4.6 Cable pulling and 4.7

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#### SP Technical Research Institute of Sweden

Postal address  
SP  
Box 857  
SE-501 15 BORÅS  
Sweden

Office location  
Västeråsen  
Brinellgatan 4  
SE-504 62 BORÅS

Phone / Fax / E-mail  
+46 10 516 50 00  
+46 33 13 55 02  
info@sp.se

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Torsion were performed in 2011. The tests 4.8 Strength of coupling mechanism, 4.9 Drop (impact), 4.10 Static side load test, 4.11 Mechanical endurance, 4.12 Vibration, 4.13 Change of temperature, 4.14 Dry heat, 4.15 Damp heat (steady state), 4.16 Cold, 4.17 Damp heat (cycling), 4.18 Corrosive atmosphere, 4.19 Condensation test and 4.20 Intermateability were performed in 2015. The results are compared with the requirements below, and detailed measurement data is attached in appendices. Optical measurements are at wavelength 1550 nm, unless otherwise specified.

#### **4.1 Visual Inspection , 4.1.2 Inspection of end face**

The end face of the connectors were inspected to be free from residues of glue. Study in fiber microscope to look for scratches or break out glass pieces on the fiber face.

Sample size: 20 connectors, 10 adapters all from Micropol.

Requirement: No residue, no scratches or break out glass pieces on fiber face

#### **4.3 Attenuation, 4.3.2 Attenuation of random mated connectors**

Setup and measurement according to IEC 61300-3-34, method 1. The used adaptors are previously verified to fulfil requirements, and are not covered by this study.

Sample size: 20 connectors, 10 adapters all from Micropol.

Requirement: mean  $\leq 0,25$  dB, max  $\leq 0,50$  dB

#### **4.4 Return Loss, 4.4.1 Coupler Method**

The measurement equipment operates according to IEC 61300-3-6 §4.1 method B. The reference return loss is achieved from attenuating the light through the fiber, enabling measurements up to 60 dB.

Sample size: 20 connectors, 10 adapters all from Micropol.

Requirement: RL  $\geq 50$  dB, all connector matings

#### **4.5 Bending Moment**

Measurement according to IEC 61300-2-7, applying 10 N at a position 25 mm from the center line defined by the optical interface. Full load applied for  $>10$  s

Sample size: 5 connector sets (one sided test: 5 connectors tested in 5 adapters) from Micropol.

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### **4.6 Cable Pulling**

Measurements according to IEC 61300-2-4, applying 5 N at a position 0,3 m from the end face of the connector. Full load applied for 60 s.

Sample size: 5 connector sets from Micropol.

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### **4.7 Torsion**

Measurement according to IEC 61300-2-5, applying 2 N at a position 0,2 m from the end face of the connector. Keeping the connector fixed and turning the cable  $\pm 180$  degrees in 25 cycles.

Sample size: 5 connector sets (assumed, not specified in document) from Micropol

Requirement: allowable attenuation variation  $\leq 0,20$  dB,

#### 4.8 Strength of Coupling Mechanism

Measurement according to IEC 61300-2-6, applying 40 N at a position 0,3 m from the end face of the connector. Fiber spooled on mandrel with 60 mm diameter and 40 N was slowly applied while attenuation was measured. Return Loss was measured before, during and after load.

Sample size: 5 connector sets from Micropol

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.9 Drop

Measurement according to IEC 61300-2-12 method 2. Each device was dropped 5 times from 1.5 m height, hitting a steel plate at impact. Attenuation and return loss was measured before tests and after each drop.

Sample size: 5 connector sets from Micropol

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.10 Static side load test

Measurement according to IEC 61300-2-42. Each device was loaded with 1 N for 60 minutes in 1 direction. Attenuation was measured before, during and after the test.

Sample size: 5 connector sets (assumed, not specified in document) from Micropol

Requirement: allowable attenuation variation  $\leq 0,20$  dB

#### 4.11 Mechanical endurance

Measurement according to IEC 61300-2-2. Each device was disconnected and reconnected 500 times. Attenuation and return loss was measured at least every 100 reconnection. Cleaning was performed when necessary, never less than 10 mating cycles inbetween.

Sample size: 5 connector sets from Micropol

Measurement wavelength:  $1310 \pm 30$  nm

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.12 Vibration

Measurement and test according to IEC 61300-2-1, vibration according to IEC60068-2-6 test Fc. Parameter adjustments compared to specifying document due to inconsistency. Attenuation measured before, during and after each axis. Return loss measured before and after each axis.

Frequency range:	10 – 55 Hz
Endurance duration / axis:	30 min
Number of axes:	3 orthogonal
Number of cycles (10 – 55 – 10):	6 at default sweep rate specified in standard
Vibration amplitude:	0,75 mm

Sample size: 10 connector sets (20 connectors and 10 adapters) from Micropol

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.13 Change of Temperature

Measurement and test according to IEC 61300-2-22, test method according to IEC60068-2-14 test Nb. Attenuation was measured before, during and after the test. Return loss was measured before and after the test. During the test, return loss was measured multiple times at both extreme temperatures.

High temperature:	+ 70 °C
Low temperature:	- 40 °C
Duration at extreme temperatures:	1 hour
Temperature rate of change:	1°C/min
Number of cycles:	12
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 10 connector sets from Micropol  
Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.14 Dry Heat

Measurement and test according to IEC 61300-2-18, test method according to IEC60068-2-2 test Bb. Attenuation was measured before, during and after the test. Return loss was measured before and after the test. During the test, return loss was measured multiple times.

Temperature:	+ 70 °C
Duration of exposure:	96 hours
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 10 connector sets from Micropol  
Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB, strength of coupling mechanism as specified in §4.8.

#### 4.15 Damp Heat

Measurement and test according to IEC 61300-2-19, test method according to IEC60068-2-3 test Ca. Attenuation was measured before, during and after the test. Return loss was measured before and after the test. During the test, return loss was measured multiple times.

Temperature:	+ 40 °C
Relative humidity:	93 $\pm$ 2%
Duration of exposure:	96 hours
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 10 connector sets from Micropol  
Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB.

#### 4.16 Cold

Measurement and test according to IEC 61300-2-17, test method according to IEC60068-2-1 test Ab. Attenuation was measured before, during and after the test. Return loss was measured before and after the test. During the test, return loss was measured multiple times.

Temperature:	- 40 °C
Duration of exposure:	96 hours
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 10 connector sets from Micropol  
Requirement: allowable attenuation variation  $\leq 0,20$  dB.

#### 4.17 Damp Heat (Cycling)

Measurement and test method according to IEC60068-2-30 test Db variant 2. Attenuation was measured before, during and after the test. Return loss was measured before and after the test. During the test, return loss was measured multiple times at both extreme temperatures.

High temperature:	+ 55 °C
Low temperature:	+ 25 °C
Relative humidity:	93 ± 2% (as specified in standard)
Duration at extreme temperatures:	24 hours
Temperature rate of change:	1 °C/min
Number of cycles:	6
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 10 connector sets from Micropol

Requirement: allowable attenuation variation ≤ 0,20 dB, allowable return loss ≥ 50 dB

#### 4.18 Corrosive atmosphere (salt mist)

Measurement and test according to IEC 61300-2-26, test method according to IEC60068-2-11 test Ka. Attenuation and return loss was measured before and after the test.

This test was performed after 4.19, to avoid salt contamination of climate chamber.

Atmosphere:	5% NaCl, pH 6.5 – 7.2
Temperature:	+ 35 °C
Duration of test:	96 hours
Pre-conditioning and recovery:	2 hours at normal ambient conditions.

Sample size: 10 connector sets

Requirement: allowable attenuation variation ≤ 0,20 dB, allowable return loss ≥ 50 dB

#### 4.19 Condensation test

Measurement and test according to IEC 61300-2-21, test method according to IEC60068-2-38 test Z/AD. Document specifies IEC60068-2-28, however this standard is no longer valid, replaced with -38. Attenuation and return loss was measured before, during and after the test.

High temperature:	+ 65 °C
Low temperature:	- 10 °C
Relative humidity:	93 ± 2%
Profile:	Z/AD
Number of cycles:	10
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 10 connector sets from Micropol

Requirement: allowable attenuation variation ≤ 0,20 dB, allowable return loss ≥ 50 dB

#### 4.20 Intermateability

##### 4.20.1 Attenuation measurements

Setup and measurement according to IEC 61300-3-34, method 1.

Sample size: 10 connectors from Micropol, 5 connectors from Supplier A, 5 connectors from Supplier B. 4 adapters from Micropol, 3 adapters from Supplier A, 3 adapters from supplier B.

Requirement: mean ≤ 0,25 dB, max ≤ 0,50 dB

#### 4.20.2 Return Loss measurements

The measurement equipment operates according to IEC 61300-3-6 §4.1 method B.

Sample size: 10 connectors from Micropol, 5 connectors from Supplier A, 5 connectors from Supplier B. 4 adapters from Micropol, 3 adapters from Supplier A, 3 adapters from supplier B.

Requirement:  $RL \geq 50$  dB, all connector matings

#### 4.20.3 Change of Temperature

Measurement and test according to IEC 61300-2-22, test method according to IEC60068-2-14 test Nb. Attenuation was measured before, during and after the test. Return loss was measured before and after the test. During the test, return loss was measured multiple times at both extreme temperatures.

High temperature:	+ 70 °C
Low temperature:	- 40 °C
Duration at extreme temperatures:	1 hour
Temperature rate of change:	1°C/min
Number of cycles:	12
Pre-conditioning and recovery:	2 hours at normal ambient conditions

Sample size: 8 connectors from Micropol, 4 connectors from Supplier A, 4 connectors from Supplier B. Adapters were 4 from M, 2 from A and 2 from B

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.20.4 Mechanical endurance

Measurement according to IEC 61300-2-2. Each device was disconnected and reconnected 500 times. Attenuation and return loss was measured at least every 100 reconnection. Cleaning was performed when necessary, never less than 10 mating cycles inbetween.

Sample size: 4 connectors from Micropol, 2 connectors from Supplier A, 2 connectors from Supplier B. Adapters were 4 from M, 2 from A and 2 from B

Measurement wavelength:  $1310 \pm 30$  nm

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

#### 4.20.5 Strength of Coupling Mechanism

Measurement according to IEC 61300-2-6, applying 40 N at a position 0,3 m from the end face of the connector. Fiber spooled on mandrel with 60 mm diameter and 40 N was slowly applied while attenuation was measured. Return Loss was measured before, during and after load.

Sample size: 8 connectors from Micropol, 4 connectors from Supplier A, 4 connectors from Supplier B. Adapters were 4 from M, 2 from A and 2 from B

Requirement: allowable attenuation variation  $\leq 0,20$  dB, allowable return loss  $\geq 50$  dB

Test	DUTs	Results	Conclusion
4.1 Visual Inspection 4.1.2 Inspection of end face	SCUPC01 to 20	No residues of glue, no scratches or break out glass pieces were found.	<b>Pass</b>
4.3 Attenuation 4.3.2 Random mated connectors	SCUPC01 to 20	Mean attenuation = 0,11 dB Max attenuation = 0,45 dB	<b>Pass</b>
4.4 Return Loss 4.4.1 Coupler Method	SCUPC01-20	All connector mating experienced $\geq 60$ dB	<b>Pass</b>
4.5 Bending moment	SCUPC23-26. 29-30	Max atten variation = 0,01 dB RL $\geq 60$ dB at all times	<b>Pass</b>
4.6 Cable Pulling	SCUPC21 – 26	Max atten variation = 0,01 dB RL $\geq 60$ dB at all times	<b>Pass</b>
4.7 Torsion	SCUPC23 – 26, 29	Max atten variation = 0,02 dB RL $\geq 60$ dB at all times	<b>Pass</b>
4.8 Strength of Coupling Mechanism	9-13	Max atten variation = 0,04 dB RL $\geq 60$ dB at all times	<b>Pass</b>
4.9 Drop	9-13	Max atten variation = 0,02 dB RL $\geq 60$ dB at all times	<b>Pass</b>
4.10 Static side Load Test	9-13	Max atten variation = 0,04 dB RL $\geq 53$ dB at all times	<b>Pass</b>
4.11 Mechanical Endurance	9-10. 12-14	Max atten variation = 0,13 dB RL $\geq 60$ dB at all times	<b>Pass</b>
4.12 Vibration (sinusoidal)	1-6, 10-11, 13-24	Max total att var = 0,1 dB RL $> 50$ dB at all times	<b>Pass</b>
4.13 Change of Temperature	1-6, 10-11, 13-24	Max atten variation $< 0,08$ dB RL $> 60$ dB at all times	<b>Pass</b>
4.14 Dry Heat	1-6, 10-11, 13-24	Max total att var = 0,11 dB RL $> 60$ dB at all times Strength of coupling mechanism verified	<b>Pass</b>
4.15 Damp Heat	1-6, 10-11, 13-24	Max total att var = 0,2 dB RL $> 60$ dB at all times	<b>Pass</b>
4.16 Cold	1-6, 10-11, 13-24	Max total att var = 0,12 dB RL $> 60$ dB at all times	<b>Pass</b>
4.17 Damp Heat (Cycling)	1-6, 10-11, 13-24	Max total att var = 0,22 dB, estimated $< 0,04$ dB/DUT RL $> 60$ dB at all times	<b>Pass</b>
4.18 Corrosive atmosphere (Salt Mist)	1-6, 9-24	Max total att var = 1,0 dB, estimated $< 0,2$ dB/DUT RL $> 55$ dB at all times	<b>Pass</b>
4.19 Condensation test	1-6, 10-11, 13-24	Max total att var = 0,22 dB, estimated $< 0,04$ dB/DUT RL $> 60$ dB at all times	<b>Pass</b>

4.20 Intermateability			
4.20.1 Attenuation	25-34	Mean attenuation = 0,12 dB Max attenuation = 0,38 dB	<b>Pass</b>
4.20.2 Return Loss	25-34	Return Loss > 60 dB, all mating combinations	<b>Pass</b>
4.20.3 Change of Temperature	25-32	Max atten variation < 0,08 dB RL > 60 dB at all times	<b>Pass</b>
4.20.4 Mechanical Endurance	25-28	Max attenuation = 0,18 dB Max variation = 0,03 dB RL > 52 dB all matings	<b>Pass</b>
4.20.5 Strength of Coupling Mechanism	25-32	Max att var = 0,05 dB RL > 60 dB at all times	<b>Pass</b>
<b>Conclusion</b>		<b>All requirements</b>	<b>Pass</b>

The results relate only to the objects, which are specified in this document.

### Measurement conditions

Room temperature      23 ±1 °C  
 Instruments              Turned on > 1 hour before measurements  
 Wavelength              1550 nm, unless specified other.

### Conclusion

The measurements verify that the connectors evaluated in this study fulfils the requirement of all parameters, as specified in the TeliaSonera/Skanova document 1056-A160.

### Measurement uncertainty

Attenuation: ± 0.01 dB

Wavelength: ± 0,5 nm

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k = 2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty has been determined in accordance with EA Publication EA-4/02 (formerly EAL-R2). The long term stability of the calibrated object is not included in the reported expanded uncertainty of measurement.

### Traceability

SP is National Laboratory for photometric and optical radiometric quantities by appointment of the Swedish government. The unit for the quantity radiant flux is realized at wavelengths of different laser lines from the definition of electrical voltage and electric resistance by use of a cryogenic electrical substitution radiometer. All used standards and instruments are calibrated regularly.



## Equipment

Optical Return Loss Meter:	JDSU cORL-A1, SN: BN2298/23
Multifunction Loss Tester:	EXFO FOT-930, SN: 478437
Optical Power Meter:	JDSU MP-60, SN: J0914S-7380-044
OTDR:	EXFO FTB-200-S1, SN: 476795

## SP Technical Research Institute of Sweden Measurement Technology - Communication

Performed by

Per Olof Hedekvist

## Appendices

Appendix 1:	Data from measurements in 4.3 to 4.7
Appendix 2:	Data from measurements in 4.8 to 4.11
Appendix 3:	Data from measurements in 4.12
Appendix 4:	Data from measurements 4.13 to 4.17, and. 4.20.3
Appendix 5:	Data from measurements 4.18
Appendix 6:	Data from measurements 4.19
Appendix 7:	Data from measurements 4.20
Appendix 8:	Report 5P00506, Vibration Test
Appendix 9:	Report 5P03627 Neutral Salt Spray (NSS) test of connectors

Appendix 1

**Data from measurements in 4.3 to 4.7**

Connectors in top row are SPUPCi [1=1..20]

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SCUPC1			9	10	4	14	15	16	28	13	12	16	17	19	14	10	4	16	6	3
SCUPC2			25	16	13	1	11	18	10	25	1	6	11	4	19	3	12	16	13	16
SCUPC3					1	5	10	15	20	8	20	8	11	19	9	3	20	0	6	10
SCUPC4					14	15	17	15	45	21	4	6	13	20	20	17	9	3	0	4
SCUPC5							2	1	19	15	18	18	1	7	3	5	16	19	15	11
SCUPC6							8	3	33	16	4	7	0	8	10	5	10	2	9	7
SCUPC7									44	18	4	9	16	9	5	5	1	19	8	5
SCUPC8									45	20	7	16	11	12	24	9	19	22	15	5
SCUPC9											4	8	12	7	11	1	9	18	12	11
SCUPC10											8	5	3	11	13	8	16	11	11	4
SCUPC11													15	9	18	7	7	19	12	9
SCUPC12													18	8	13	3	16	19	19	15
SCUPC13															2	9	10	1	3	10
SCUPC14															13	3	1	8	3	3
SCUPC15																	8	0	5	3
SCUPC16																	8	4	3	5
SCUPC17																			11	1
SCUPC18																			12	11
SCUPC19																				
SCUPC20																		Average	0,110056	
																		Max	0,45	

All measured data are in 0,01 dB for clarity, Average and Max values are given in dB

RL are > 60 dB in all datapoints

Torsion	Before	During	After	Mating connector
SCUPC23	0	0	0	SCUPC29
SCUPC24	0	0	0	SCUPC29
SCUPC25	0	0	0	SCUPC29
SCUPC26	0	2	2	SCUPC29
SCUPC29	0	0	0	SCUPC25
SCUPC30				
Bending	During	after = during or less		
SCUPC23	0			SCUPC25
SCUPC24	0			SCUPC26
SCUPC25	1			SCUPC23
SCUPC26	0			SCUPC24
SCUPC29	0			SCUPC23
SCUPC30	0			SCUPC23
Pulling	SCUPC23	SCUPC24	SCUPC25	SCUPC26
SCUPC21	0	1	0	0
SCUPC22	0	1	0	0
SCUPC23			0	0
SCUPC24			1	0
	During	after = during or less		

Appendix 2

**Data from measurements in 4.8 to 4.11**

**4.8 Strength of Coupling Mechanism**

Test according to IEC 61300-2-6

Fiber adapter is mounted in vertical fixture and DUT is connected from below. Fiber is spooled on figure 8 mandrel with 60 mm diameter and 40 N load is slowly applied. Set for 120 s. Maximum attenuation and minimum Return Loss are noted during test. All values in dB, “high” corresponds to Return Loss > 60 dB

connector	Att before	RL before	Att during	RL during	Att after	RL after	Variation
9	0	high	0,01	high	0	high	0,01
10	0	high	0,04	high	0,02	high	0,04
11	0,13	high	0,15	high	0,13	high	0,02
12	0,07	high	0,09	high	0,09	high	0,02
13	0,05	high	0,07	high	0,06	high	0,02

**4.9 Drop**

Test according to IEC 61300-2-12 method 2

Fiber connector is mounted in horizontal fixture and loose end dropped from 1,5 m height, onto 10 mm thick steel plate. Connector cleaned after each drop. All values in dB, “high” corresponds to Return Loss > 60 dB

Connector	9		10		11		12		13	
Drop Nr	Att	RL	Att	RL	Att	RL	Att	RL	Att	RL
<b>before</b>	0,06	high	0,07	high	0,05	high	0,12	high	0,06	high
1	0,06	high	0,07	high	0,05	high	0,13	high	0,07	high
2	0,07	high	0,07	high	0,04	high	0,12	high	0,06	high
3	0,06	high	0,07	high	0,06	high	0,13	high	0,06	high
4	0,07	high	0,07	high	0,04	high	0,13	high	0,07	high
5	0,06	high	0,08	high	0,05	high	0,12	high	0,08	high
<b>Max var</b>	0,01	0	0,01	0	0,02	0	0,01	0	0,02	0

**4.10 Static side load test**

Test according to IEC 61300-2-42

Fiber connector is mounted in horizontal fixture and a vertical force of 1 N is applied. Attenuation and return loss is measured before, during and after test. Worst values during the test is shown in table.

Connector	Att before	RL before	Att during	RL during	Att after	RL after	Att vari
9	0,06	high	0,09	high	0,07	high	0,03
10	0,02	high	0,03	high	0,03	high	0,01
11	0,12	high	0,16	53,65	0,14	53,65	0,04
12	0,05	high	0,06	high	0,06	high	0,01
13	0,02	high	0,03	high	0,03	high	0,01

Appendix 2

**4.11 Mechanical endurance**

Test according to IEC 61300-2-2

Fiber is mounted in horizontal fixture and the mating connector is disconnected and reconnected while attenuation and return loss is observed. Maximum and minimum attenuation, and minimum Return Loss, is noted for every 50 mating cycles. All values in dB, return loss = “high” corresponds to > 60 dB.

Connector	9			10			12			13			14		
M cycle	Min att	Max att	RL	Min att	Max att	RL	Min att	Max att	RL	Min att	Max att	RL	Min att	Max att	RL
<b>0</b>	0,01	0,01	high	0,03	0,03	high	0,1	0,1	55	0,12	0,12	high	0,07	0,07	high
<b>50</b>	0	0,02	high	0,02	0,05	high	0,09	0,11	55	0,11	0,14	high	0,06	0,09	high
<b>100</b>	0	0,03	high	0,01	0,05	high	0,06	0,11	high	0,07	0,11	high	0,06	0,1	high
<b>150</b>	0,01	0,04	high	0,02	0,05	high	0,07	0,12	55	0,07	0,14	high	0,06	0,12	high
<b>200</b>	0,01	0,05	high	0,02	0,06	high	0,06	0,12	55	0,01	0,09	high	0,07	0,1	high
<b>250</b>	0,01	0,05	high	0,03	0,07	high	0,07	0,13	55	0,01	0,08	high	0,07	0,09	high
<b>300</b>	0,01	0,05	high	0,02	0,07	high	0,07	0,13	55	0,01	0,07	high	0,09	0,12	high
<b>350</b>	0,02	0,06	high	0,02	0,06	high	0,06	0,12	55	0,01	0,06	high	0,11	0,13	high
<b>400</b>	0,02	0,05	high	0,01	0,07	high	0,07	0,13	55	0,02	0,06	high	0,09	0,11	high
<b>450</b>	0,01	0,06	high	0,02	0,06	high	0,07	0,13	55	0,01	0,08	high	0,1	0,12	high
<b>500</b>	0,02	0,06	high	0,03	0,07	high	0,07	0,14	55	0,01	0,08	high	0,11	0,14	high
<b>Att var</b>		<b>0,06</b>			<b>0,06</b>			<b>0,08</b>			<b>0,13</b>			<b>0,08</b>	

## Appendix 3

**Data from measurements in 4.12**

Setup and vibration test as specified in report 5P00506.

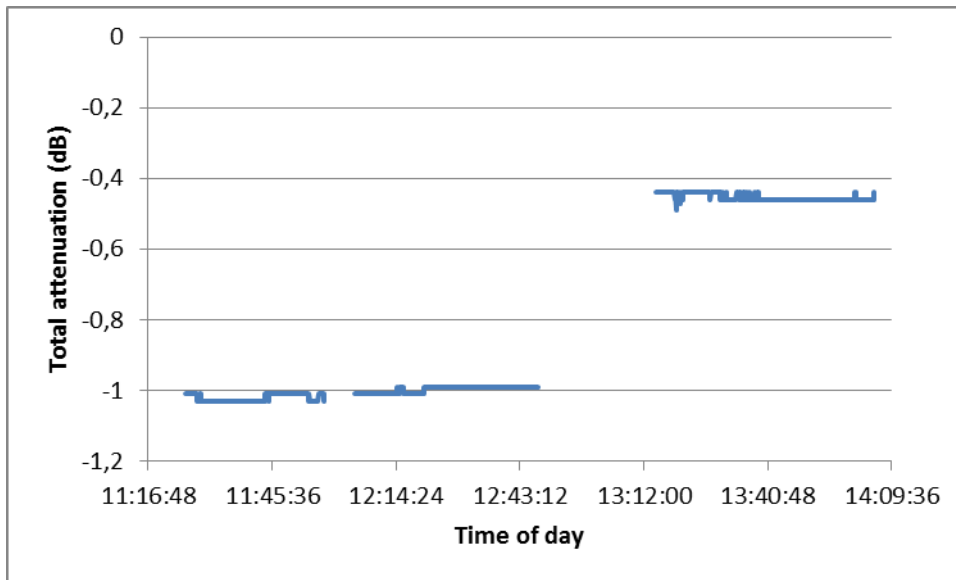
Note parameter anomaly: IEC 60068-2-6 test Fc, standard sweep rate is 1 octave/min.

6 sweep cycles (10-55-10) is 29 minutes 30 seconds.

**Optical measurements:**

10 DUTs connected in series. OTDR measurement verifies even distributed loss in chain of connector interfaces.

Total attenuation measured during test.



First two sequences are measured during vibration in X and Y direction. Total attenuation of < 1,1 dB corresponds to average of 0,01 dB/DUT. OTDR measurements verify no DUT exceeds 0,5 dB. Combined estimate gives maximum attenuation <0,02 dB. Variation < 0,1 dB of all DUTs in series.

Last sequence measured after additional cleaning of first and last connector. Total attenuation 0,46 dB. Variation < 0,1 dB of all DUTs in series.

Return Loss measured between each test. RL > 50 dB of all DUTs in series.

## Appendix 4

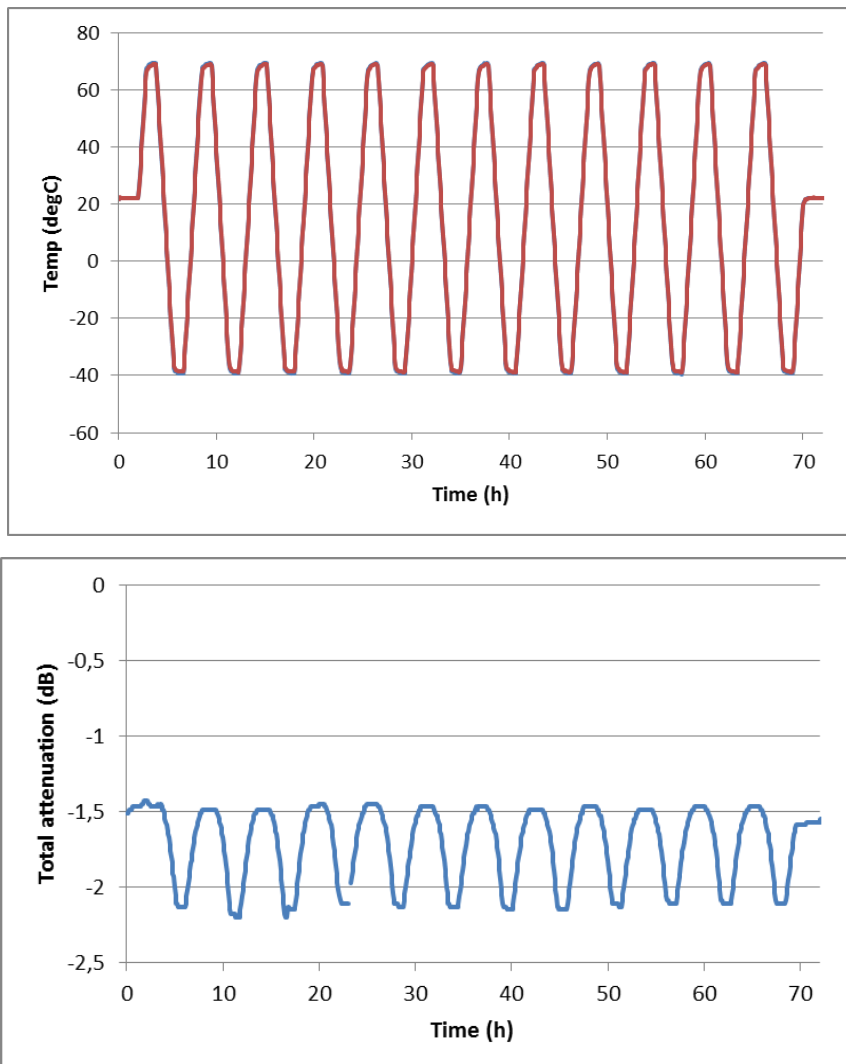
**Data from measurements 4.13 to 4.17, and. 4.20.3****4.13 and 4.20.3 Change of Temperature**

Setup of climate chamber in accordance with IEC 60068-2-14 test Nb

Test 4.13, 10 DUTs connected in series, concatenated with test 4.20.3, 4 DUT connected with intermediate reference connectors from SUPPLIER A and Supplier B. In total 18 connectors in series.

Measured RL > 50,5 dB before test.

OTDR measurement confirms even distribution of attenuation in each connector. Total attenuation = 1,51 dB, estimated to maximum attenuation in worst splice < 0,17 dB (2\*average attenuation).



Data from 2 thermosensors during test (top) and total attenuation through 18 connectors (bottom).

Lack of data corresponds to time for OTDR measurement, verifying evenly distributed attenuation in all connector interfaces. Max total variation is 0,7 dB, estimated to < 0,08 dB / DUT. Measurement of return loss at -40°C shows > 60 dB

Appendix 4

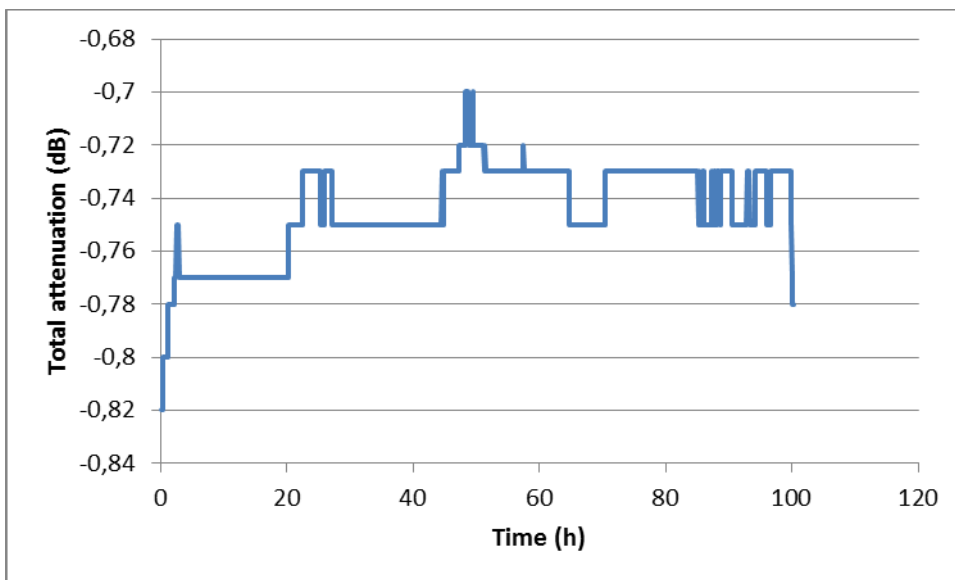
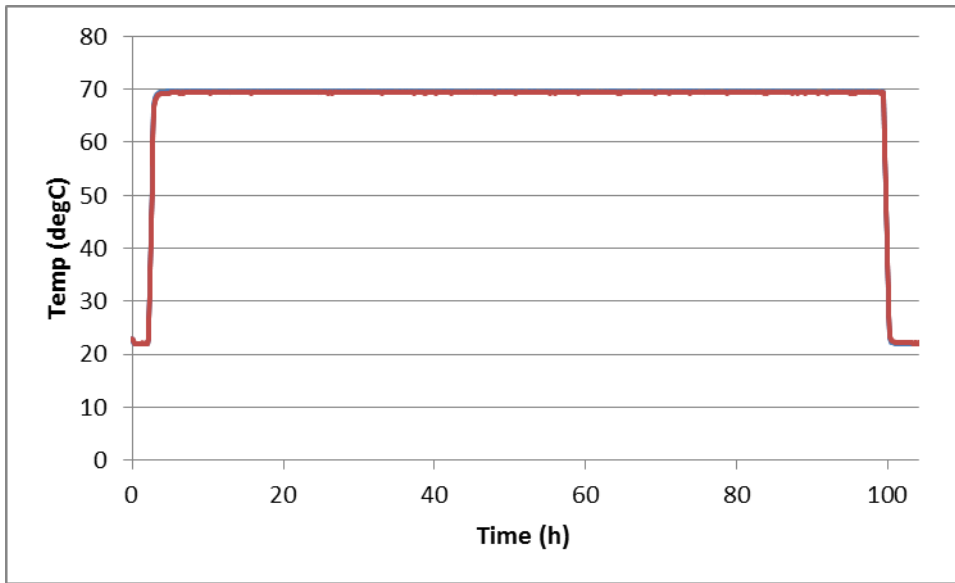
**4.14 Dry Heat**

Setup of climate chamber in accordance with IEC 60068-2-2 test Bb

10 DUTs connected in series.

Measured RL > 50,5 dB before test.

OTDR measurement confirms even distribution of attenuation in each connector. Total attenuation = 0,78 dB, estimated to maximum attenuation in worst splice < 0,16 dB (2\*average attenuation).



Data from 2 thermosensors during test (top) and total attenuation through 10 connectors (bottom).

Max total variation is 0,11 dB, estimated to < 0,02 dB / DUT. Strength of coupling mechanism is verified after test.

Appendix 4

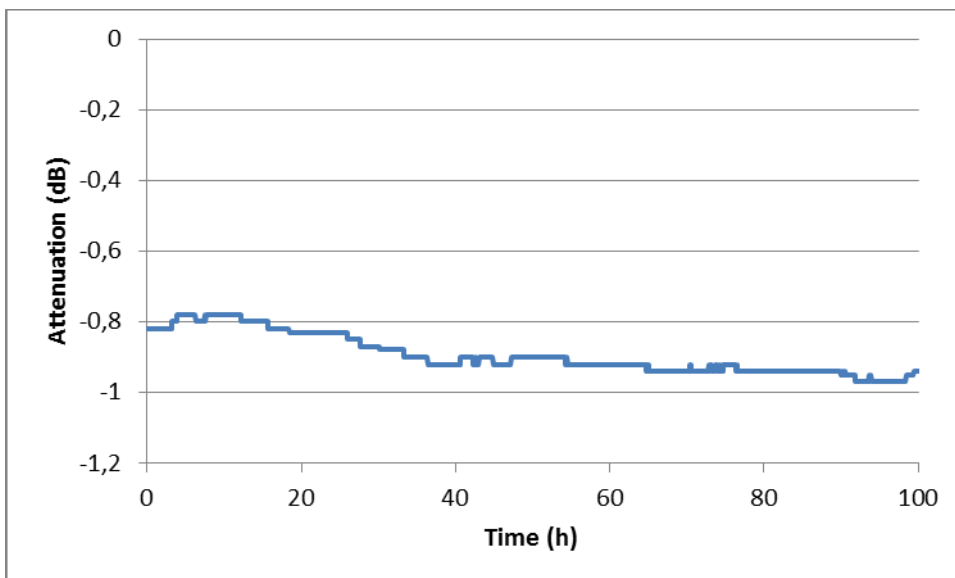
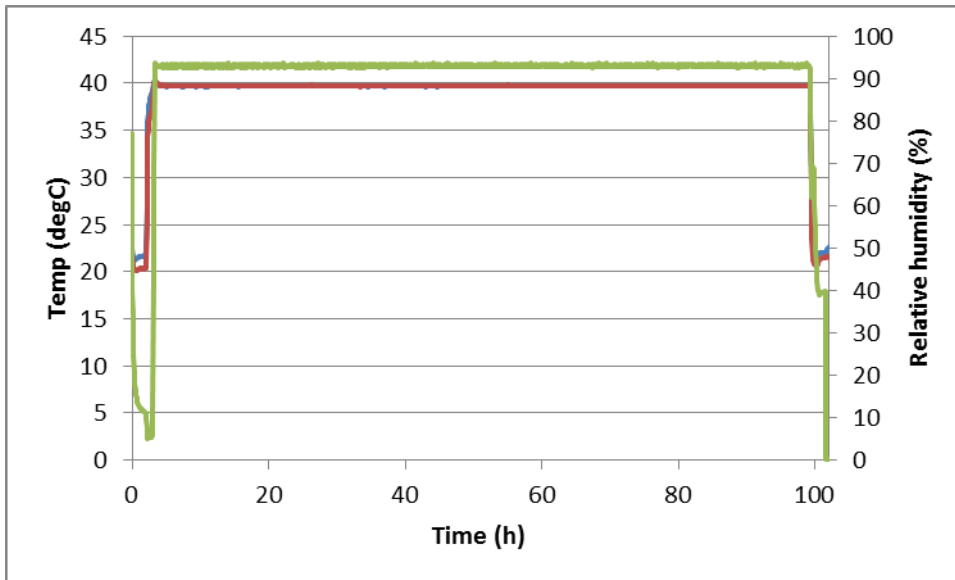
**4.15 Damp Heat (steady state)**

Setup of climate chamber in accordance with IEC 60068-2-3 test Ca

10 DUTs connected in series.

Measured RL > 60 dB before test.

OTDR measurement confirms even distribution of attenuation in each connector. Total attenuation = 0,80 dB, estimated to maximum attenuation in worst splice < 0,16 dB (2\*average attenuation).



Data from 2 thermosensors and one humidity sensor during test (top) and total attenuation through 10 connectors (bottom).

Max total variation is 0,2 dB, estimated to < 0,04 dB / DUT. Return loss after test >60 dB



Appendix 4

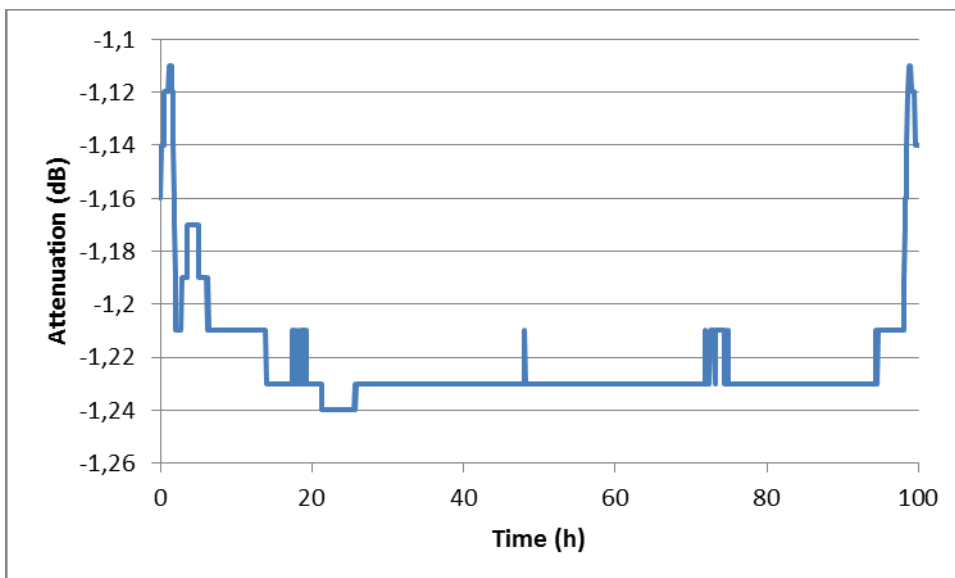
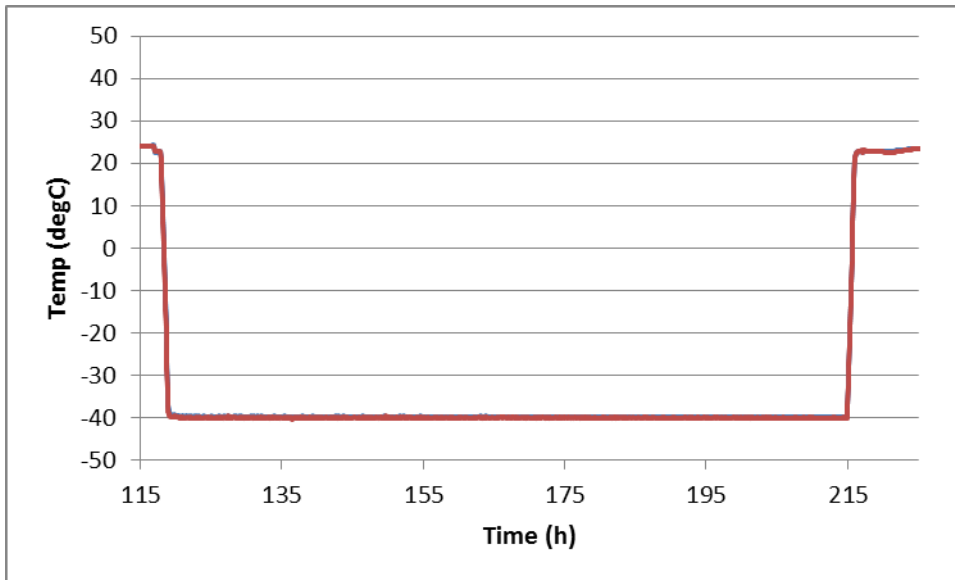
**4.16 Cold**

Setup of climate chamber in accordance with IEC 60068-2-1 test Ab

10 DUTs connected in series.

Measured RL > 60 dB before test.

OTDR measurement confirms even distribution of attenuation in each connector. Total attenuation = 1,16 dB, estimated to maximum attenuation in worst splice < 0,23 dB (2\*average attenuation).



Data from 2 thermosensors during test (top) and total attenuation through 10 connectors (bottom). Time scale on top graph includes 115 hours offset.

Max total variation is 0,12 dB, estimated to < 0,02 dB / DUT. Return loss after test >60 dB

Appendix 4

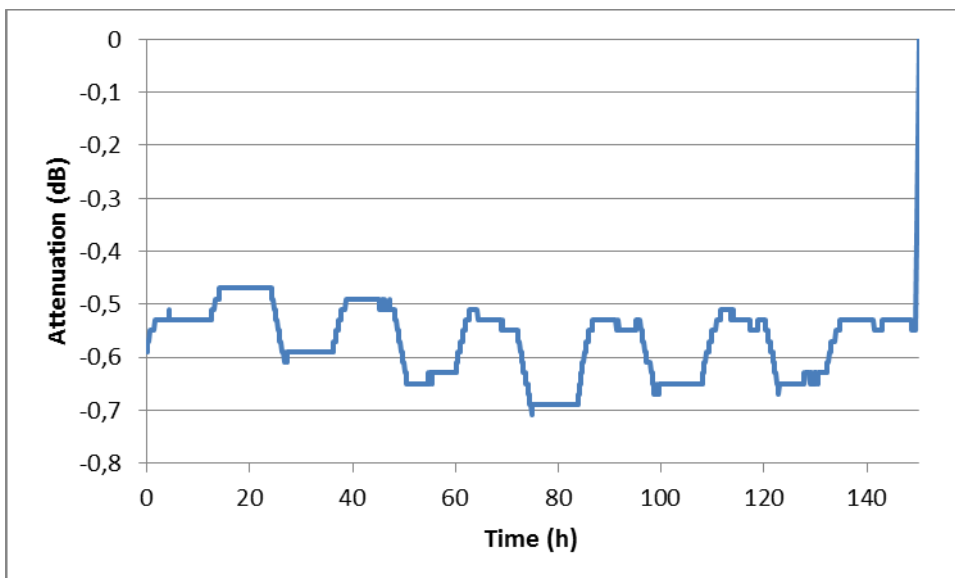
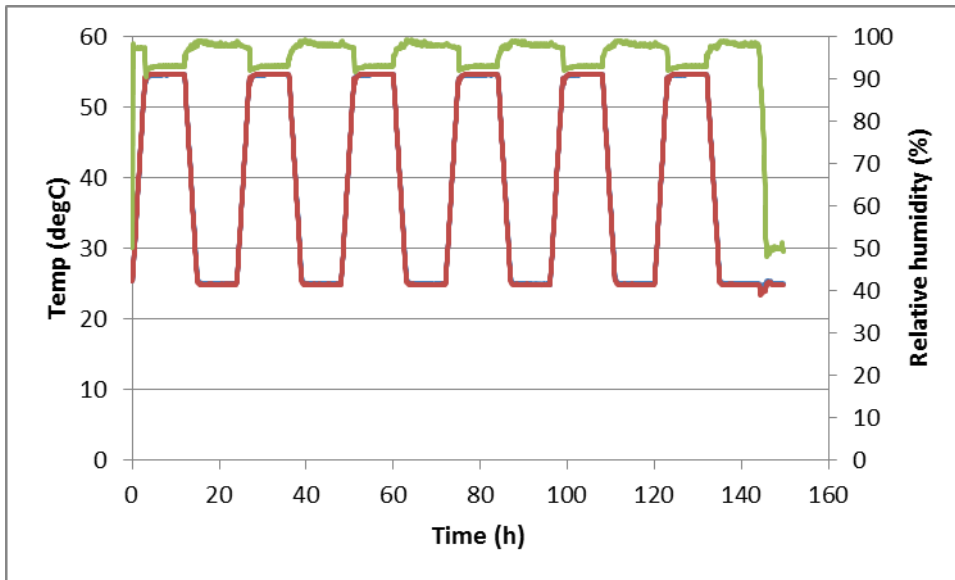
**4.17 Damp Heat (Cycling)**

Setup of climate chamber in accordance with IEC 60068-2-30 test Db, variant 2

10 DUTs connected in series.

Measured RL > 60 dB before test.

OTDR measurement confirms even distribution of attenuation in each connector. Total attenuation = 0,60 dB, estimated to maximum attenuation in worst splice < 0,12 dB (2\*average attenuation).



Data from 2 thermosensors and one humidity sensor during test (top) and total attenuation through 10 connectors (bottom).

Max total variation is 0,22 dB, estimated to < 0,04 dB / DUT. Return loss after test >60 dB

## Appendix 5

### Data from measurements 4.18

#### 4.18 Corrosive Atmosphere (Salt Mist)

Setup of corrosive atmosphere chamber according to IEC60068-2-11 test Ka. Details of atmosphere as specified in report 5P03627

Measurement before test: Total attenuation 0,08 dB, Return Loss > 60 dB

Measurement after test: Total attenuation 1,18 dB, Return Loss 55 dB

Estimated max attenuation < 0,25 dB/DUT, and max attenuation variation < 0,2 dB based on OTDR measurement and attenuation

Appendix 6

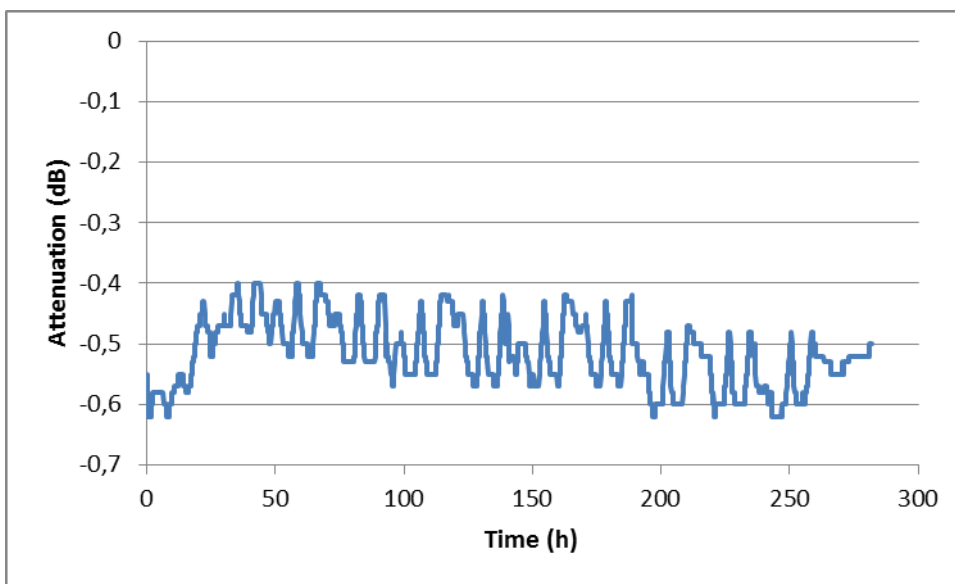
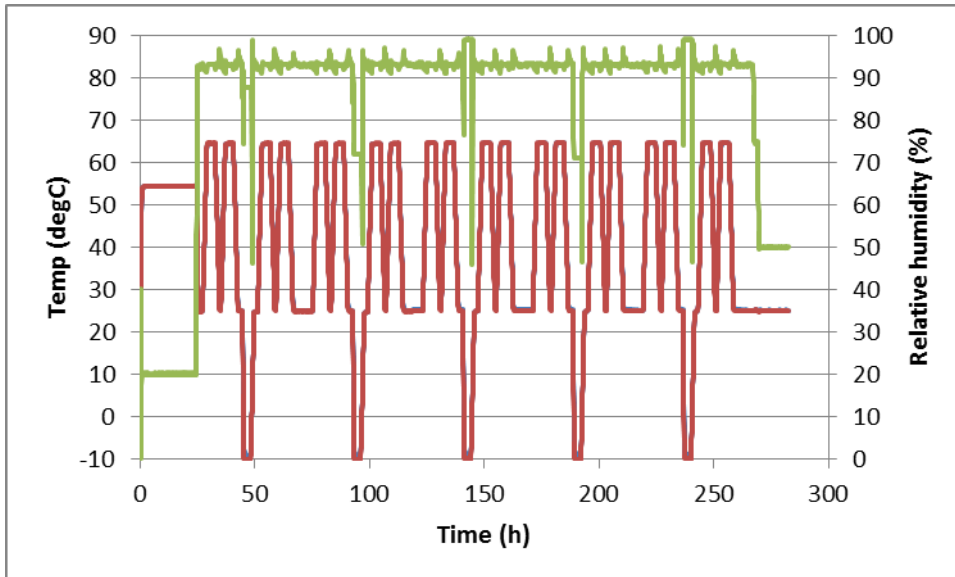
**Data from measurements 4.19 Condensation test**

Setup of climate chamber in accordance with IEC 60068-2-38 test Z/AD, (-10°C to + 65°C, 10 cycles).

Note: IEC 60068-2-28, as specified in document 1056-A160 is no longer valid. Has been replaced with IEC 60068-2-38.

10 DUTs connected in series.

Measured RL > 60 dB before test. OTDR measurement confirms even distribution of attenuation in each connector. Total attenuation = 0,60 dB, estimated to maximum attenuation in worst connector interface < 0,12 dB (2\*average attenuation).



Data from 2 thermosensors and one humidity sensor during test (top) and total attenuation through 10 connectors (bottom). Max total variation is 0,22 dB, estimated to < 0,04 dB / DUT. Return loss after test >60 dB.

Appendix 7

**Data from measurements 4.20**

**4.20.1 Attenuation measurement and 4.20.2 Return Loss**

Tests are performed based on Second Source Plugs and adapters. Method as described by IEC61300-3-34

Individual measurement of 10 connectors from Micropol (M) mated to 5 connectors from Supplier B, and 5 connectors from Supplier A, all combinations. Used adapters are 4 from Micropol (M), 3 from Supplier A (A) and 3 from supplier B (B). Discrepancy from Skanova specification, sample size, due to request to test intermateability to two suppliers.

Return Loss measured, RL > 60 dB, at each mating combination

Connector	26	25	33	34	30	29	31	32	27	28
Adapter	M	M	M	M	A	N	A	N	A	N
A1	0,18	0,22	0,33	0,31	0,29	0,37	0,31	0,35	0,38	0,3
A2	0,2	0,24	0,17	0,14	0,27	0,12	0,26	0,2	0,08	0,25
A3	0,06	0,06	0,1	0,09	0,11	0,14	0,18	0,14	0,15	0,17
A4	0,02	0,13	0,11	0,04	0,08	0,05	0,08	0,11	0,05	0,15
A5	0,07	0,15	0,05	0,01	0,05	0	0,08	0,16	0,09	0,06
B1	0,1	0,09	0,09	0,09	0,1	0,1	0,12	0,16	0,02	0,1
B2	0,02	0,03	0,07	0,01	0,1	0,03	0,11	0,11	0,12	0,16
B3	0,08	0,07	0,08	0,05	0,07	0,12	0,12	0,15	0,11	0,08
B4	0,06	0,06	0,05	0	0,05	0,08	0,08	0,09	0,12	0,11
B5	0,06	0,06	0,04	0,13	0,08	0,1	0,05	0,09	0,04	0,13
							<b>Mean</b>	<b>0,1185</b>	<b>Max</b>	<b>0,38</b>

**4.20.3 Change of Temperature**

Test performed together with test 4.13. See appendix 4

**4.20.4 Mechanical Endurance**

Test according to IEC 61300-2-2. Connectors cleaned when necessary.

Fiber adapter is mounted in horizontal fixture and the DUT is disconnected and reconnected while attenuation and return loss is observed. Maximum attenuation, and minimum Return Loss, is noted for every 100 mating cycles. All values in dB, return loss = "high" corresponds to > 60 dB. Mating adapter is Micropol (M), Supplier A or Supplier B, and mating connector is Supplier A or Supplier B.

Connector		26		25		27		28	
# of cycles	Mate	B		B		A		A	
	Adap	M		B		M		A	
0		0,01	high	0	high	0,12	high	0,15	high
100		0,03	high	0,03	high	0,09	high	0,17	high
200		0,03	high	0,03	high	0,08	high	0,17	high
300		0,01	high	0,02	high	0,05	high	0,18	high
400		0,01	high	0,03	52	0,08	high	0,17	high
500		0	high	0,02	57	0,09	high	0,17	high

Max attenuation =0,18 dB, max variation 0,03 dB, RL > 52 dB.

Appendix 7

**4.20.5 Strength of Coupling Mechanism**

Test according to IEC 61300-2-6

Fiber adapter is mounted in vertical fixture and DUT is mounted from below. Fiber adapter and mating connector are from Micropol (M), Supplier A or Supplier B. Fiber is spooled on figure 8 mandrel with 60 mm diameter and 40 N load is slowly applied. Set for 120 s. Maximum attenuation and minimum Return Loss are noted during test. All values in dB, “high” corresponds to Return Loss > 60 dB.

Connector	Mate	Adap	before		during		after	
28	A	M	0,07	high	0,08	high	0,07	high
27	A	M	0,03	high	0,04	high	0,03	high
29	A	A	0	high	0,01	high	0	high
30	A	A	0,06	high	0,11	high	0,06	high
25	B	M	0,04	high	0,08	high	0,04	high
26	B	M	0,01	high	0,02	high	0,01	high
32	B	B	0,03	high	0,05	high	0,03	high
31	B	B	0,04	high	0,06	high	0,04	high

Max attenuation variation = 0,05 dB, Return Loss > 60 dB, all matings



## Appendix 8

### **Report 5P00506 Vibration test**

Report (7 pages) attached



## Appendix 9

### **Report 5P03627 Neutral Salt Spray (NSS) test of connectors**

Report (5 pages) attached