To: Mr. Hassan Refaat
El Sewedy Cables Ltd.
16 Baghdad Street,
Kourba, Heliopolis,
P.O. Box: 288 Helioplolis.
Cairo, Egypt

KINECTRICS

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Kinectrics International Inc. Report: K-422180-RC-0001-R00
March 21, 2006

C.J. Pon, M.J. Kastelein, M. Colbert, G. Hale
Transmission and Distribution Technologies Business

A series of twenty-four (24) tests were performed for El Sewedy Cables Ltd. on a 14.5 mm diameter, 48 fibre optical ground wire (OPGW) cable. The OPGW cable was manufactured by El Sewedy Cables Ltd. and is designated AA/ACS 79/33-14kA/0.5s. The end user of the cable is the Egyptian Electricity Egyptian Company. Eighteen (18) of the twenty-four (24) tests were performed at the Kinectrics Laboratory in Canada. These tests were performed in accordance to IEEE Std. 1138-1994, IEC 60794-1-2, ASTM B117 and Kinectrics methodology. This document is a compilation of all the individual test reports. The reports are assembled in the following order.

	TEST	TEST DATE	TEST STANDARD (IEEE Std. 1138-1994)
1.	Water Ingress Test	March 8-9, 2006	Paragraph 4.1.1.1
2.	Seepage of Flooding Compound	March 8-9, 2006	Paragraph 4.1.1.2
3.	Short Circuit Test	March 16, 2006	Paragraph 4.1.1.3
4.	Aeolian Vibration Test	February 28-March 20, 2006	Paragraph 4.1.1.4
5.	Galloping Test	March 8-9, 2006	Paragraph 4.1.1.5
6.	Sheave Test	March 10, 2006	Paragraph 4.1.1.6
7.	Crush Test	March 10, 2006	Paragraph 4.1.1.7
8.	Impact Test	March 10, 2006	Paragraph 4.1.1.7
9.	Stress-Strain/Fibre-Strain Test	March 9, 2006	Paragraphs 4.1.1.9 and 4.1.1.11
10/11.	Strain Margin Test and Tensile Performance Test	March 9, 2006	Paragraph 4.1.1.10
12.	Temperature Cycle Test	March 8-10, 2006	Paragraph 4.1.1.13
13.	Short Term and Long Term Minimum Bending Radius	March 8, 2006	IEC60794-1-2, Method E11A,E11B
14.	Salt Spray Corrosion Test	February 1-March 15, 2006	ASTM B117
15.	Lightning Arc Test	March 17, 2006	IEC 60794-1-2, Section 38
16.	DC Resistance Test	March 9, 2006	Kinectrics Method
17.	Cable Cut-off Wavelength	March 8, 2006	Paragraph 4.1.1.12
18.	Creep Test	January 31-March 14, 2006	Paragraph 4.1.1.8

Each individual test report is self-contained with dedicated figures and separate pagination. The three (3) appendices located at the back of this document are common to each test report.

Six (6) of the twenty-four (24) tests were performed at the Underwriters Laboratory in the U.S.A. These tests were performed in accordance to TIA-455-78-B/IEC 60793-1-40, TIA-455-173, TIA-455-175-B/IEC 60793-1-42, and TIA-455-176-A/IEC 60793-1-20. All tests are assembled in the following order in Appendix D.

	TEST	TEST DATE	TEST STANDARD
19.	Chromatic Dispersion	March 13, 2006	TIA-455-175-B / IEC 60793-1-42
20.	Concentricity Error	March 13, 2006	TIA-455-176-A / IEC 60793-1-20
21.	Cladding Diameter	March 13, 2006	TIA-455-176-A / IEC 60793-1-20
22.	Cladding Non-Circularity	March 13, 2006	TIA-455-176-A / IEC 60793-1-20
23.	Coating Diameter	March 13, 2006	TIA-455-173
24.	Attenuation Coefficient	March 13, 2006	TIA-455-78-B, Part 1-42

ACKNOWLEDGEMENTS

The assistance of Ms. J. Levine and Mr. G. Gouliaras for the Lightning Arc Test is greatly appreciated. Mr. C. Maurice and Mr. G. Lau performed the Short Circuit Test.

Prepared by:

C.J. Pon
Principal Engineer
Transmission and Distribution Technologies Business

M. J. Kastelein
Technologist
Transmission and Distribution Technologies Business

M. Colbert
Technologist
Transmission and Distribution Technologies Business

G. Hale
Technologist
Transmission and Distribution Technologies Business

Approved by:

Dr. J. Kuffel
General Manager
Transmission and Distribution Technologies Business

CJP:MJK:MC:GH:JC

DISCLAIMER

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**WATER INGRESS TEST**
Test Date:	March 8-9, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not Applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Water Ingress Test is to observe whether water passes through the open end of a horizontal, one (1) metre fluid-blocked optical core when the other end is subjected to a one (1) metre head of water.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.1 and EIA/TIA 455-82B-1992.

TEST SET-UP

The set-up for the Water Ingress Test is shown in Figures 1a and 1b.

Test Apparatus

A one (1) m section of OPGW cable was prepared for this test. All components of the cable were removed from the fluid-blocked stainless steel tube.

The stainless steel tube containing the optical fibres was positioned horizontally with one end attached to a vertically-aligned, clear plastic tube using a water-tight fitting. The fitting did not restrict the water from entering the stainless steel tube. A collection dish was placed under the open end of the optical unit to collect any water that may pass through it.

Optical Network

Optical measurements were not required for this test.

Instrumentation and Data Acquisition

The optical unit and collection dish were visually checked for water. The start and completion times were manually recorded. No electronic measurements were required for this test.

TEST PROCEDURE

The clear plastic tube was filled with 1.0 metre ±0.1 metre of water. The water was maintained at this level for twenty-four (24) hours. During and at the conclusion of twenty-four (24) hours, the open end of the optical unit was visually checked for water.

TEST RESULTS

The start and completion times of the test and the observations are shown in the table below.

Sample	Start Date/Time	Completion Date/Time	Observation
SS Tube with no Stripe	March 8, 2006 @10:42 AM	March 9, 2006 @11:16	No water was observed at end of the tube or in the collection dish.

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.1, no water shall leak through the open end of the one (1) metre stainless steel tube.

CONCLUSION

The cable, as tested, met the requirements for the Water Ingress Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.11 and EIA/TIA 455-82B-1992.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

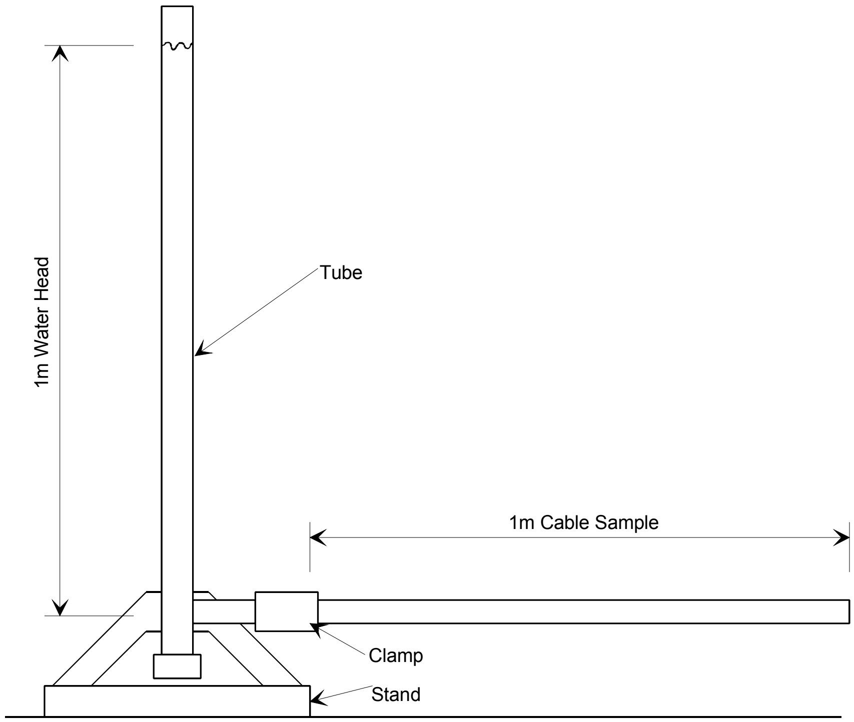


Figure 1a Set-up for Water Ingress Test (Schematic)

Figure 1b Set-up for Water Ingress Test

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**SEEPAGE OF FLOODING COMPOUND TEST**
Test Date:	March 8-9, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Seepage of Flooding Compound Test is to verify that no more than a specified amount of flooding compound seeps out of a vertically-aligned, prepared cable sample when subjected to an elevated temperature.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.2 and EIA/TIA 455-81A-1991.

TEST SET-UP

The set-up for the Seepage of Flooding Compound Test is shown in Figures 1a and 1b.

Test Apparatus

Five (5) OPGW samples, each 30.0 cm ± 0.5 cm in total length were prepared. All the outer layer metallic strands were cut back 13.0 cm ± 0.25 cm from one end. All the inner layer strands were cut back 8.0 cm ± 0.25 cm from the same end to expose the two (2) fluid-blocked optical units. The sample ends were not blocked or sealed.

The samples were suspended vertically from a support frame. Small, lightweight collection dishes were placed directly under each sample to collect any fluid-blocking compound that may drip from the optical unit.

A 1m x 1m x 1m environmental chamber was used to control the temperature.

Optical Network

Optical measurements were not required for this test.

Instrumentation and Data Acquisition

A scale having an accuracy of at least ±0.001 g was used to measure the weight of the dishes. The weights of the dishes were manually recorded.

The temperature in the chamber was measured by a thermocouple placed near the support frame close to the samples.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The environmental chamber was preheated to at least 65°C.

The five (5) dishes were weighed and recorded. The samples were shielded from air circulation in the chamber with a plexiglass cylindrical cover. The support frame, with the covered samples, was placed in the chamber.

After a one (1) hour preconditioning period, the samples were removed from the chamber and the dishes weighed and recorded. The dishes were placed back under the samples and were returned into the chamber. After 23 additional hours (24 hours total), the samples were again removed from the chamber and the dishes weighed and recorded.

TEST RESULTS

The weights of the five (5) dishes are recorded in Table 1 below. As per Clause 5.6 in EIA/TIA - 455-81A, measured changes in weight equal to or less than 0.005 g are reported as “No Flow”.

Sample No.	Dish No.	Initial Weight (g)	After 1 hr (g)	Net Change (g)	Dish No.	Initial Weight (g)	After 24 hrs (g)	Net Change (g)
1	1	1.379	1.376	-0.003	1	1.376	1.378	+0.002
2	2	1.374	1.371	-0.003	2	1.371	1.372	+0.001
3	3	1.374	1.371	-0.003	3	1.371	1.372	+0.001
4	4	1.357	1.353	-0.004	4	1.353	1.354	+0.001
5	5	1.380	1.378	-0.002	5	1.378	1.379	+0.001

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.2, after the preconditioning period (1 hr) there shall be less than 0.5 g of the flooding compound in the dish. After 24 hrs, there shall be less than 0.05 g of flooding compound in the dish.

CONCLUSION

The cable, as tested, met the requirements for the Seepage of Flooding Compound Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.2 and EIA/TIA 455-81A-1991.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

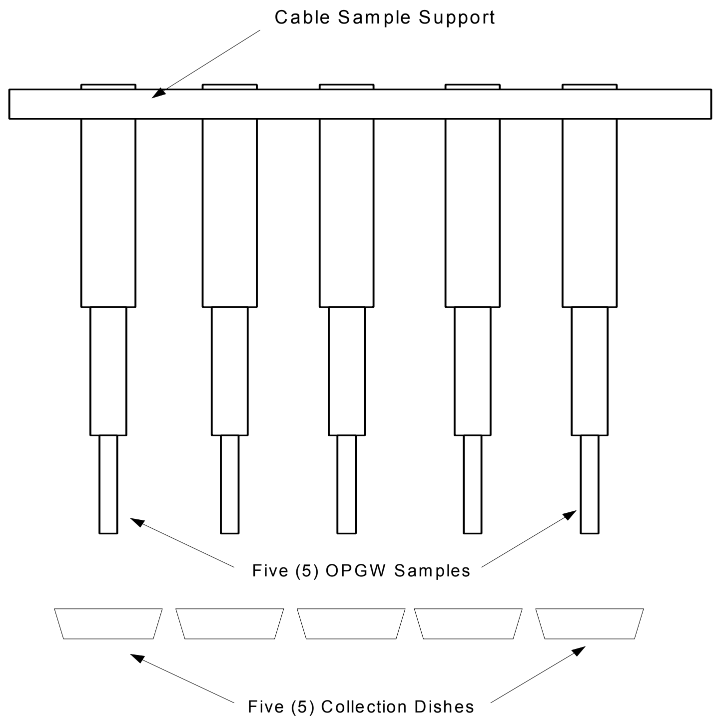


Figure 1a Set-up for the Seepage of Flooding Compound Test (Schematic)

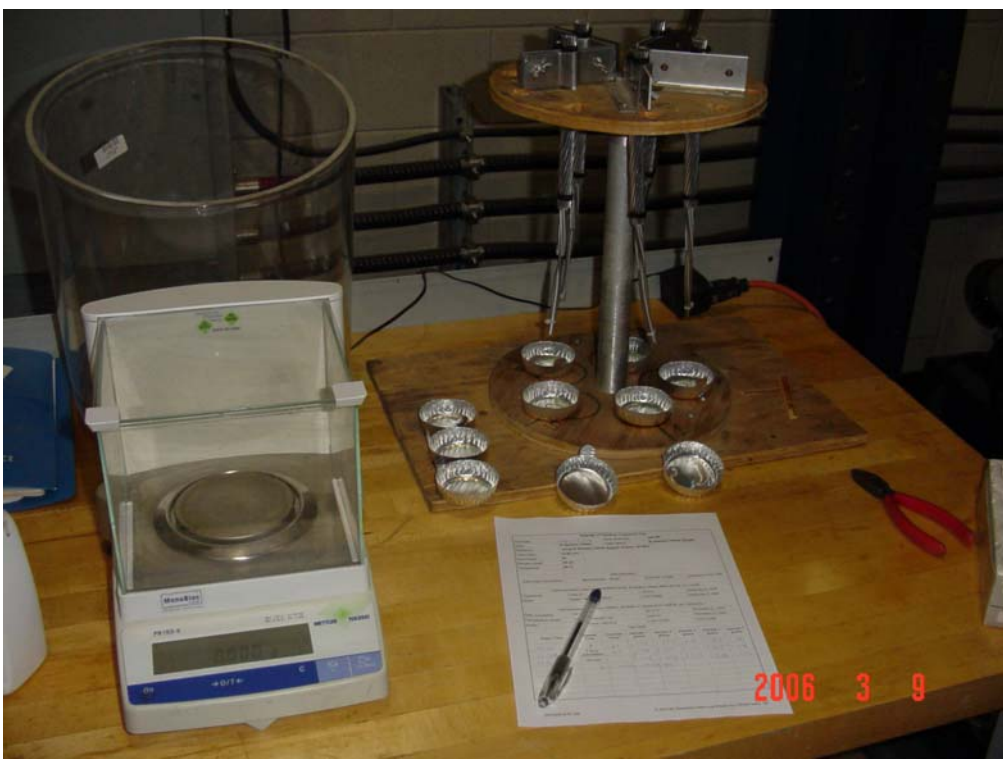


Figure 1b Set-up for the Seepage of Flooding Compound Test

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**SHORT CIRCUIT TEST**
Test Date:	**March 16, 2006**
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 5S4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	SEFAG EXPORT AG Dead-end P/N: 182 929-568
Kinectrics Staff:	Mr. Craig Pon Mr. Claude Maurice Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Short Circuit Test is to verify that the OPGW can withstand repeated short circuit applications without exceeding optical, physical or thermal requirements.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.3.

TEST SET-UP

The Short Circuit Test was carried out at Kinectrics' Indoor High Current Test Facility. A schematic of the electrical circuit is shown in Figure 1. The set-up for the test is shown in Figures 2a and 2b.

Test Apparatus

Two (2) OPGW samples were used for this test. One sample was used to monitor the performance of the optical fibres and to observe any physical damage that might occur during the test. The other sample was used only to measure the temperature at several points in the cross-section of the cable. The cables were positioned about 1 m apart and about 1.5 m above the ground.

The cables were electrically connected in series so that they would be subjected to the same short circuit current. The short circuit current was provided by a high level current transformer. A separate low-level transformer was also connected to the test span. It provided a current of several hundred amperes to maintain the cable temperature to at least 40ºC between short circuit applications.

<u>Optical Sample</u>

The cable and fibre terminations and the method to measure optical attenuation are described in Appendix B.

The length of cable between the current injection points was 10.2 m. The optical fibres were terminated beyond each dead-end clamp. A turnbuckle was used to tension the cable to the required value. A dynamometer was used to measure the tension. The optical sample was tensioned to about 933 kgf at 40ºC. This is about 15% of the rated tensile strength of the cable (6,220 kgf).

<u>Temperature Sample</u>

The temperature in this sample was measured at three (3) locations using three (3) fast responding thermocouples. They were spaced approximately one (1) m apart at the following locations.

Thermocouple #1 – Between two (2) aluminum alloy wires
Thermocouple #2 – Between two (2) aluminum-clad steel wires
Thermocouple #3 – Inside one SSLT optical unit

The thermocouples were optically isolated from other instrumentation to prevent electrical interference. A turnbuckle was used to tension the cable to nominally the same value as the optical sample. A thermocouple installation is shown in Figure 3.

Optical Network

<u>Optical Sample</u>

For power attenuation measurements, twenty-four (24) of forty-eight (48) fibres were spliced producing a total fibre length under test of 244.8 m (24 fibres x 10.2 m).

Temperature Sample

Optical signals were not measured in this cable sample.

Instrumentation and Data Acquisition

For each short circuit application, or “shot”, a high-speed data acquisition system recorded the short circuit current at 10,000 samples/second. The optical power readings from the optical sample were recorded at 500 samples/second. The thermocouple readings from the temperature sample were recorded at 200 samples/second. The optical readings and the temperature from thermocouple #1 were also recorded once every two (2) seconds. This provided a “digital strip chart” of the entire test.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The cable was first subjected to one (1) low-level calibration shot and then ten (10) “official” shots. The purpose of the calibration shot was to ensure that the current level was correct. For the “official” shots, the target values for the electrical parameters were:

Parameter	Target Value
Energy	Minimum 104.5 kA^2-sec
Fault Current	14.45 kA
Duration	0.5 sec
Asymmetry	Maximum possible

To ensure the optical signals were stable, the power meters were powered on and operating for at least one hour before the first shot.

The normalized optical measurement was reset to zero before the first official shot.

For each shot, the fault current and duration may vary slightly from the target values. The objective was to achieve the minimum energy level for each shot.

The cables were visually inspected for birdcaging or other damage during the test.

The optical and temperature data were acquired for about one (1) hour after the tenth shot. The cable was maintained at 40°C during this hold period.

TEST RESULTS

The temperature, current and optical attenuation data for the ten (10) shots is summarized in the "Data Monitoring Summary" sheet. The data for each shot is shown in the figures labeled Shot #1 to Shot #10. The optical attenuation during the short circuit applications never increased more than 0.14 dB/km at 1550 nm.

The cable temperature, optical attenuation and short circuit data for the tem (10) "official" shots are summarized in the "Data Monitoring Summary" sheet. The top panel displays the cable temperature for the duration of the test as measured by Thermocouple #1. The second panel displays the optical attenuation for the duration of the test. All data are summarized in the table at the bottom of the page.

The maximum absolute temperature reached was 226ºC (184+42), and was measured during Shot #4 on Thermocouple #1 (between two aluminum alloy wires). The maximum absolute temperature reached inside the SS optical unit (as measured by Thermocouple #3 during Shot #6) was 151ºC (110+41).

The optical sample was dissected at the following locations after the test and visually examined for damage.

Cable Component	North Dead-end	South Dead-end	Midpoint
Aluminum Alloy Wires	No damage	No damage	No damage
Aluminum-Clad Steel Wires	No damage	No damage	No damage
Stainless Steel Loose Tubes	No damage	No damage	No damage
Fibres	No damage	No damage	No damage
Binders	No damage	No damage	No damage
Gel Compound	No damage	No damage	No damage

The dissected components from the midpoint of the span are shown in Figure 4.

ACCEPTANCE CRITERIA

According to IEEE, the attenuation increase during the test shall be no greater than 1.0 dB/km. Birdcaging or breaking of the cable strands during the test shall constitute failure. The cable and hardware shall be dissected after the test and visually examined for damage at each dead-end assembly and at the midpoint of the span. Each separable component of the cable shall be inspected and inspected for excessive wear, discoloration, deformation or other signs of breakdown.

CONCLUSION

The cable, as tested, met the requirements for the Short Circuit Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.3.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

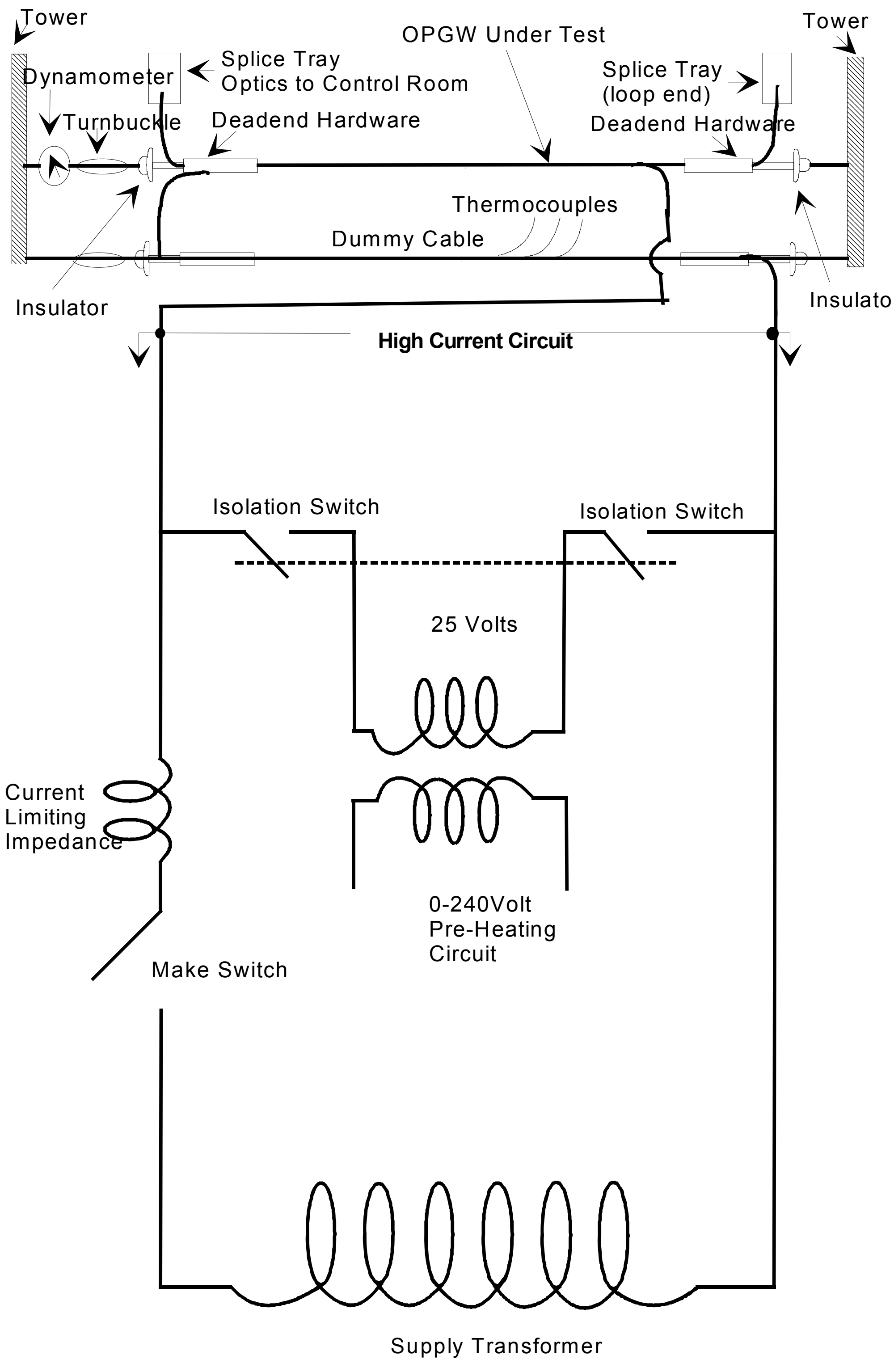


Figure 1 Electrical Circuit for Short Circuit Test

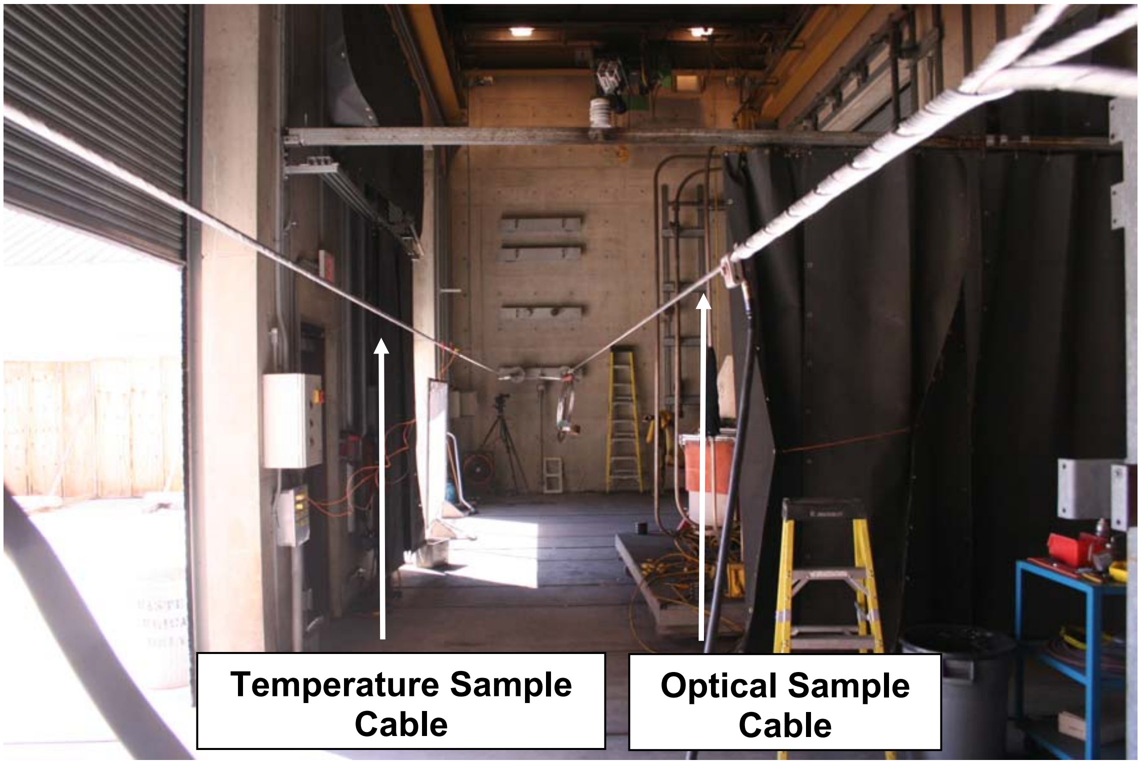


Figure 2a Set-up for Short Circuit Test in High Current Yard

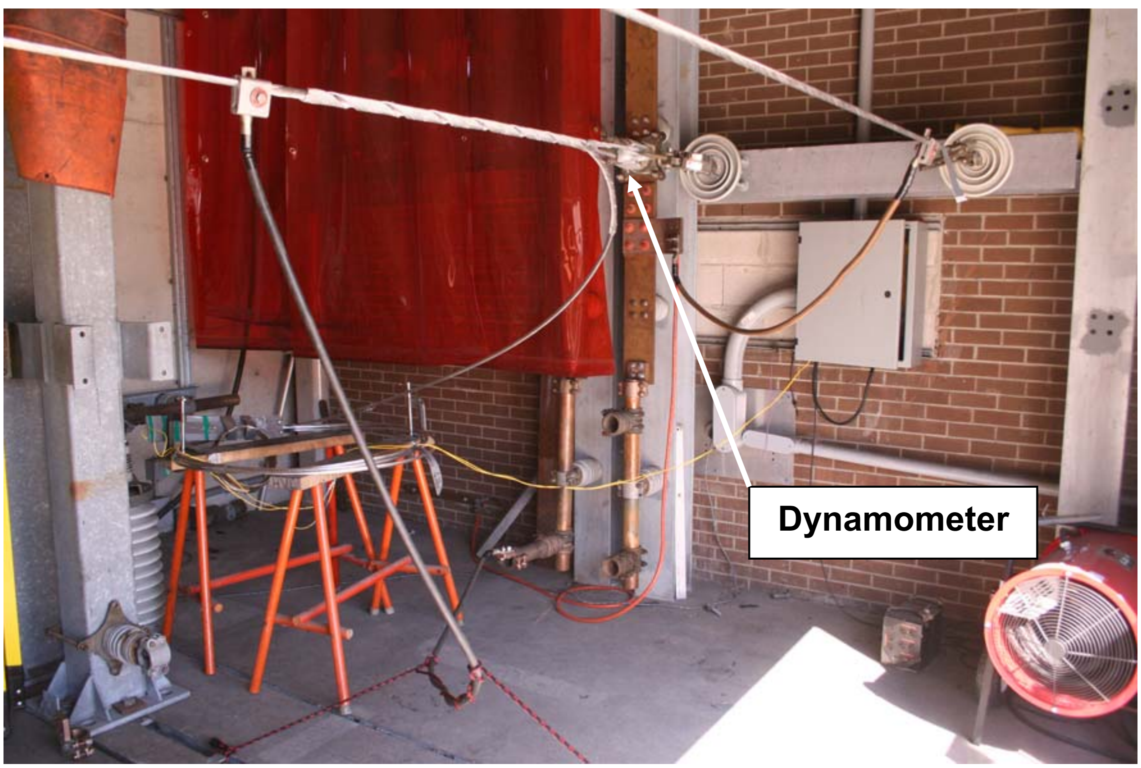


Figure 2b Set-up for Short Circuit Test in High Current Yard

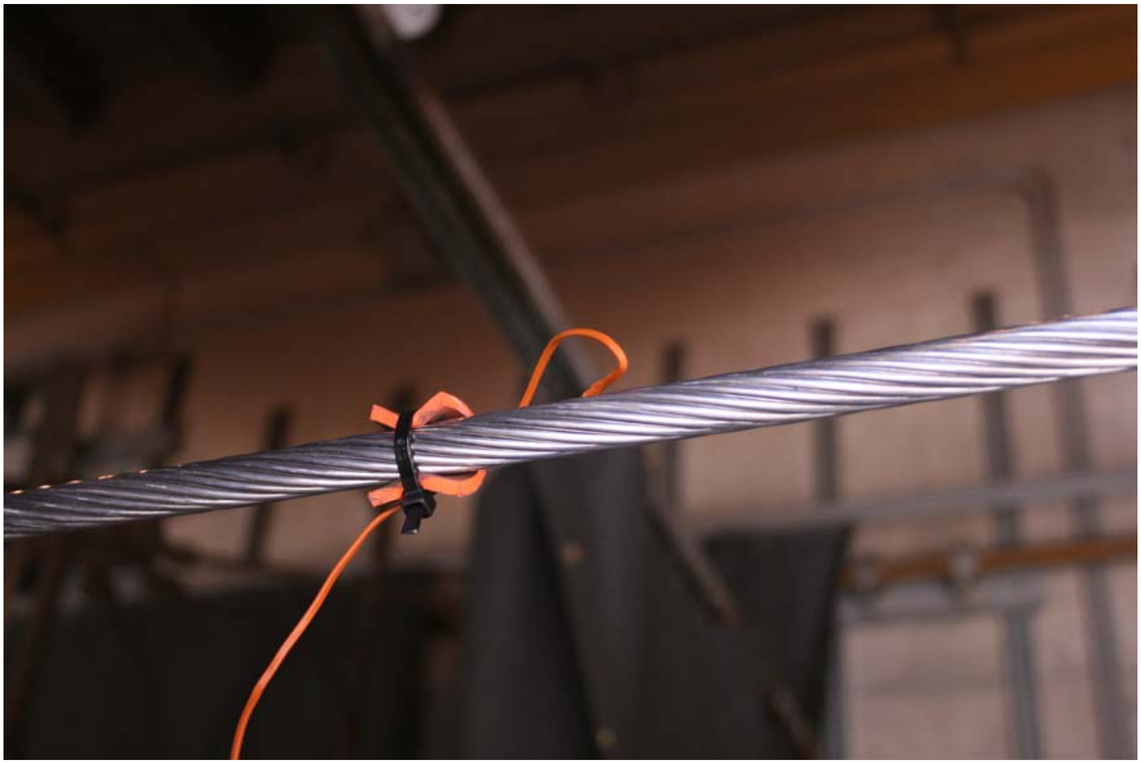


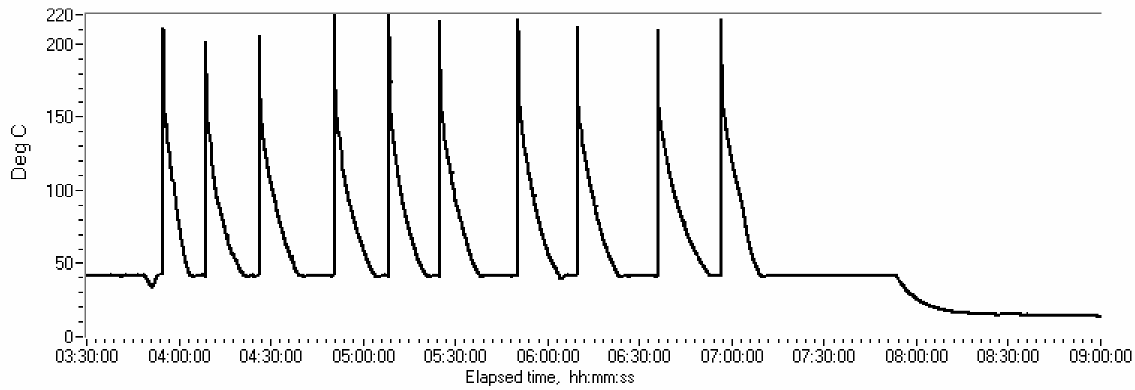
Figure 3   Installation of Thermocouple on Temperature Sample

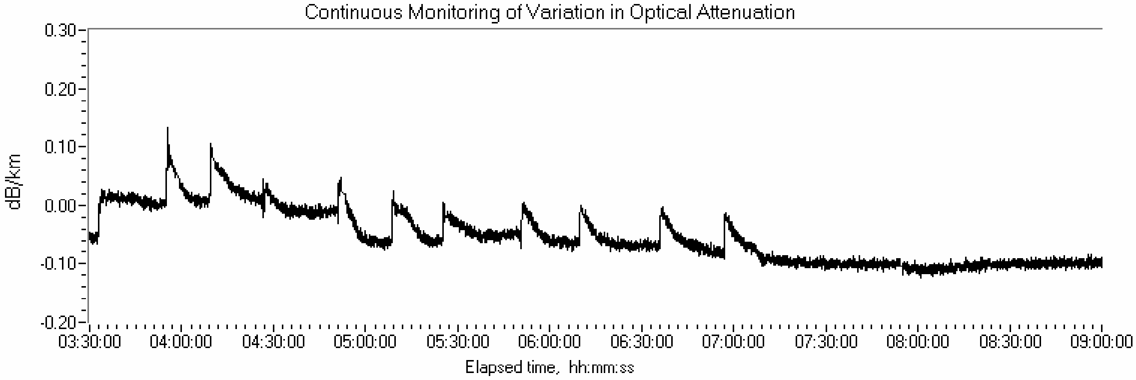
Figure 4 Dissected Components from Midpoint of Span

Data Monitoring Summary

El Sewedy Cables

Fault current test on OPGW, 14.5 mm, 48 fibres.
Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s





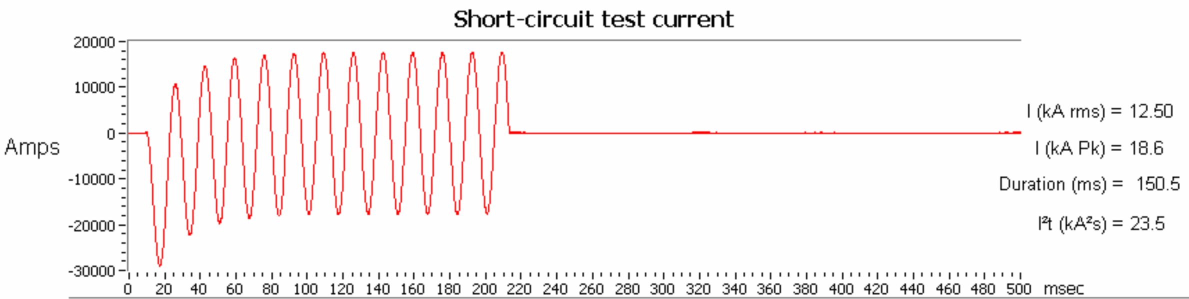
					Maximum Temperature Rise				
	Test #	I rms (kA)	Duration (ms)	I^t (kA²s)	Therm. #1	Therm. #2	Therm. #3	Therm. #4	Init. T
Calib.	06-975	13.0	204	34.5	56°	35°	34°	–	41°
Shot #1	06-977	14.06	503	99.5	174	110	99	–	41
Shot #2	06-978	14.07	502	99.5	173	110	99	–	41
Shot #3	06-979	14.08	503	99.6	175	123	100	–	43
Shot #4	06-980	14.43	503	104.7	184	151	102	–	42
Shot #5	06-981	14.42	503	104.6	183	112	99	–	40
Shot #6	06-982	14.42	503	104.6	183	115	110	–	41
Shot #7	06-983	14.39	503	104.1	182	114	96	–	40
Shot #8	06-984	14.40	503	104.2	181	114	87	–	37
Shot #9	06-985	14.42	503	104.6	181	115	80	–	41
Shot #10	06-986	14.46	503	105.1	183	122	92	–	42
Shot #11									
Shot #12									
Shot #13									
Shot #14									

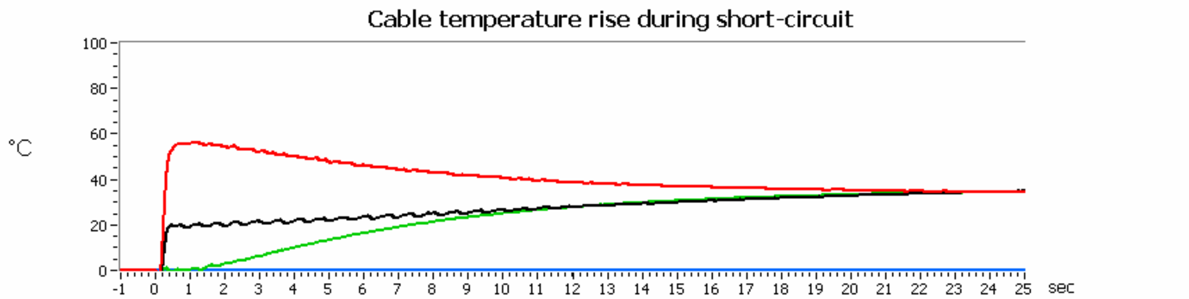
Therm. #1: Between two AA wires
Therm. #2: Between two ACS wires
Therm. #3: Inside optical tube
Therm. #4: not used

March 16, 2006
High Current Laboratory
WO: K-422180

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-975		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	**Fault current test on OPGW, 14.5 mm, 24 fibres.** **Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s** **Cal shot**

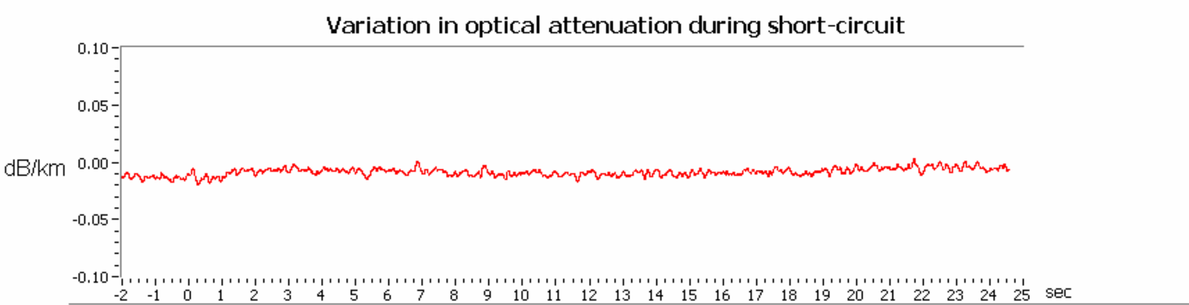




Average cable temperature before fault: 41 °C

Maximum temperature rise

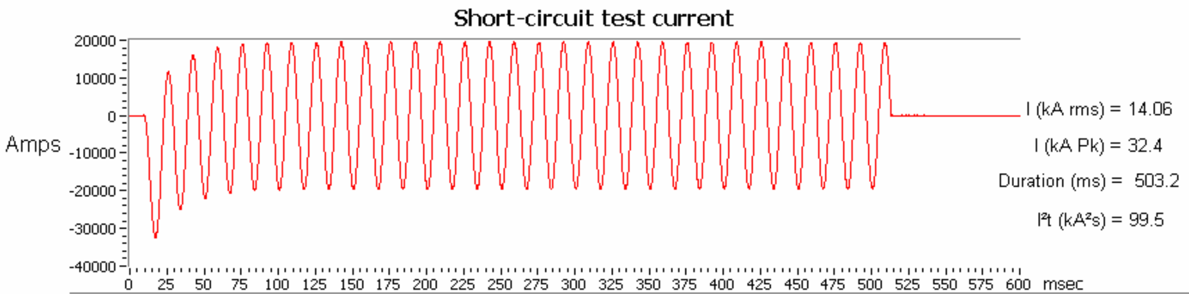
Between two AA wires	56°C
Between two ACS wires	35°C
Inside optical tube	34°C
	0°C

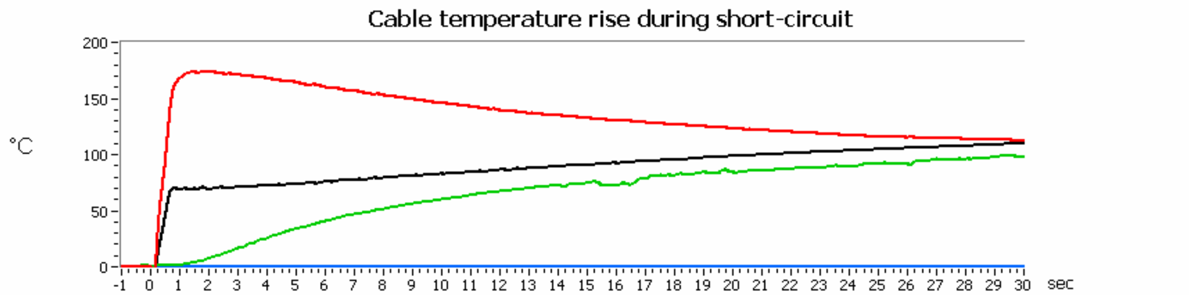


# of spliced fibres = 24
Test Cable length (m) = 10.2
Total test fibre length (m) = 244.8

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-977		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	Fault current test on OPGW, 14.5 mm, 24 fibres. Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s Shot #1

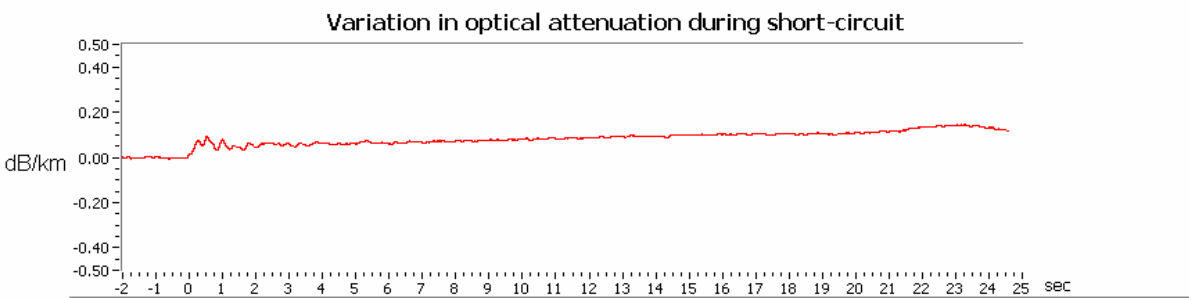




Average cable temperature
before fault:
41 °C

Maximum temperature rise

Between two AA wires	174°C
Between two ACS wires	110°C
Inside optical tube	99°C
	0°C



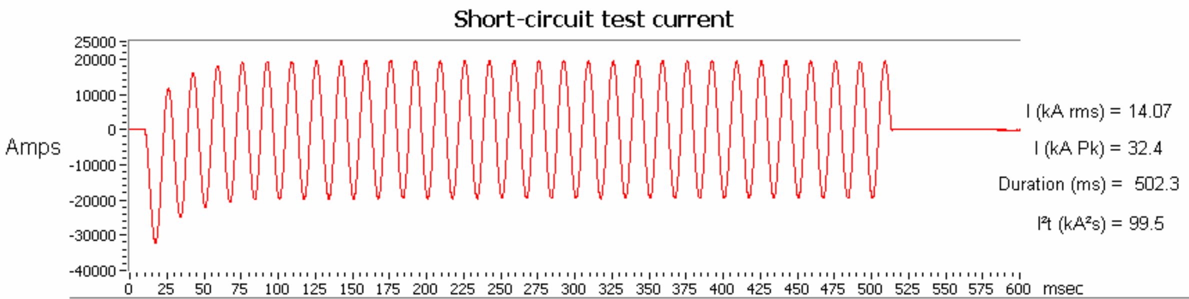
# of spliced fibres = 24

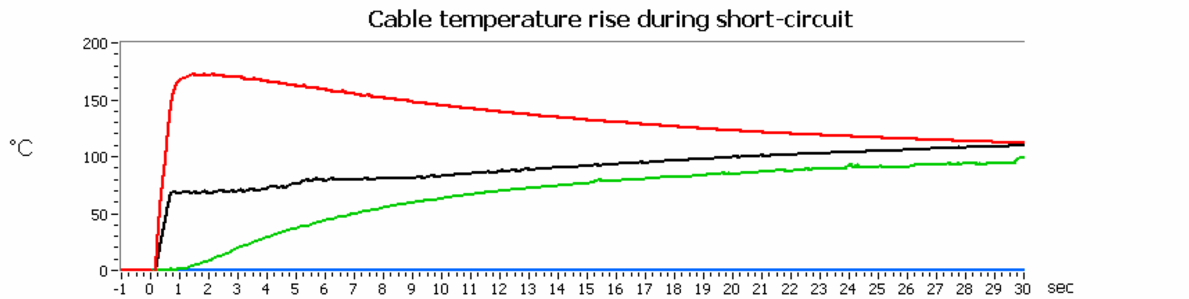
Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-978		
WO#: K-422180		

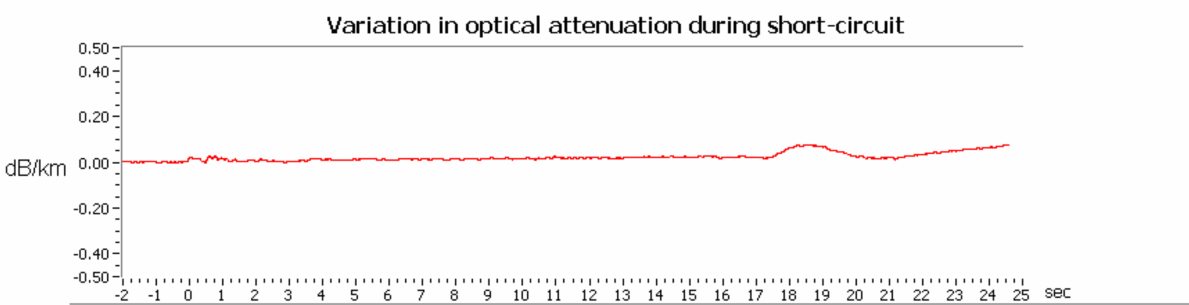
Client:	Description:
El Sewedy Cables	**Fault current test on OPGW, 14.5 mm, 24 fibres.** **Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s** **Shot #2**





Average cable temperature before fault: 41 °C

Maximum temperature rise	
Between two AA wires	173°C
Between two ACS wires	110°C
Inside optical tube	99°C
	0°C



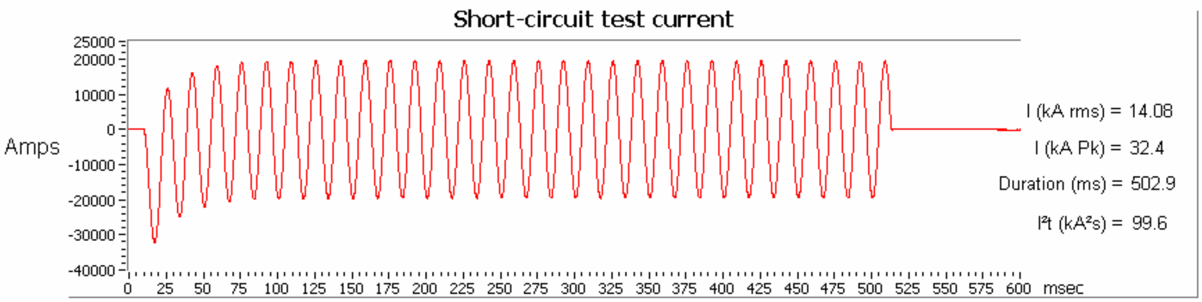
# of spliced fibres = 24

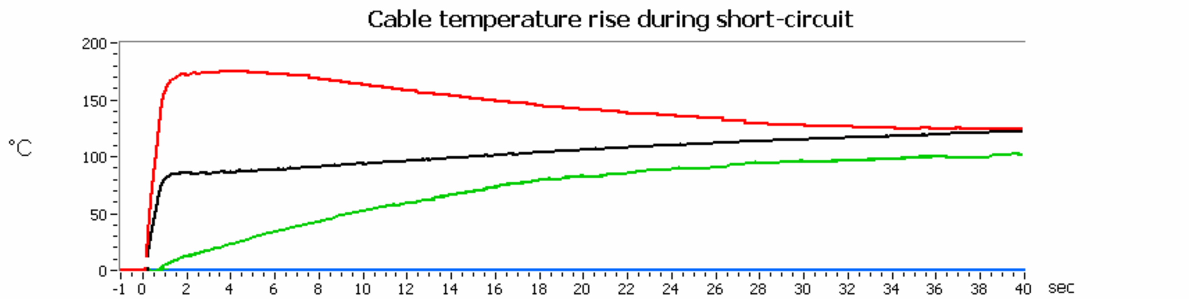
Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-979		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	Fault current test on OPGW, 14.5 mm, 24 fibres. Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s Shot #3

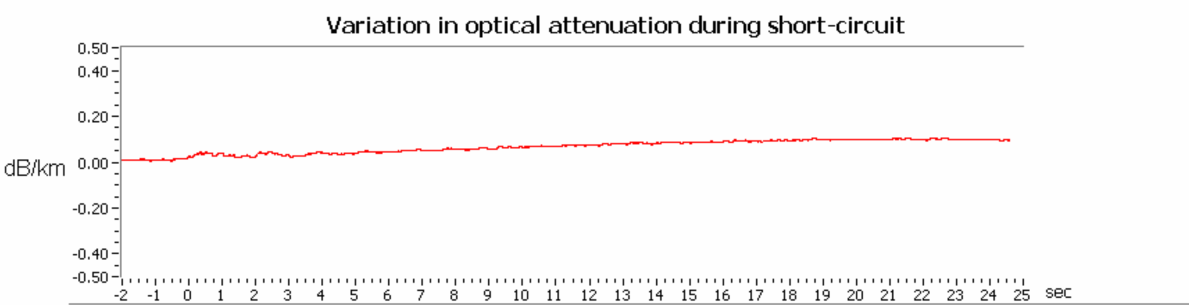




Average cable temperature before fault: 43 °C

Maximum temperature rise

Between two AA wires	175°C
Between two ACS wires	123°C
Inside optical tube	100°C
	0°C



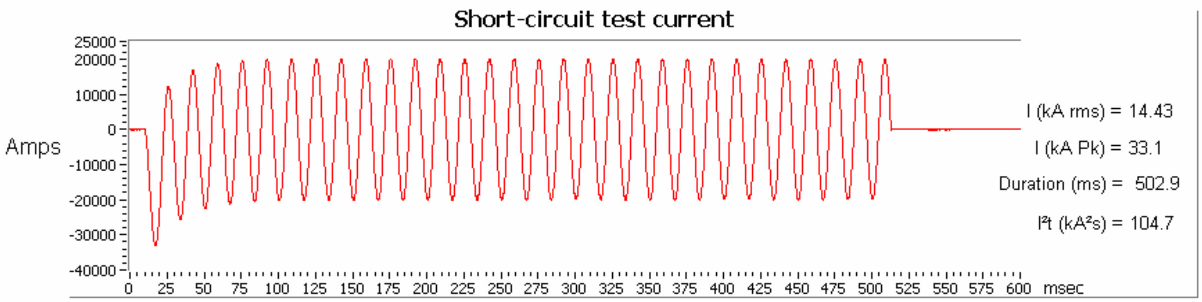
# of spliced fibres = 24

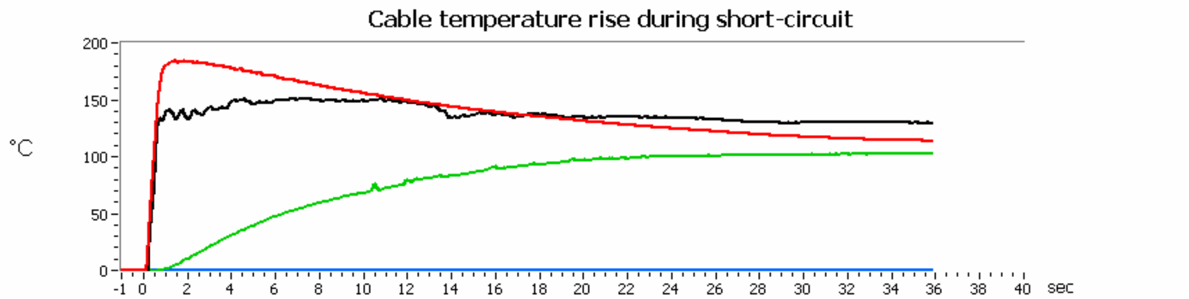
Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

Mar 16, 2006	**High Current Test Laboratory** **Kinectrics Inc.** **Test Sheet**	KINECTRICS
Test # 2006-980		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	**Fault current test on OPGW, 14.5 mm, 24 fibres.** **Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s** **Shot #4**

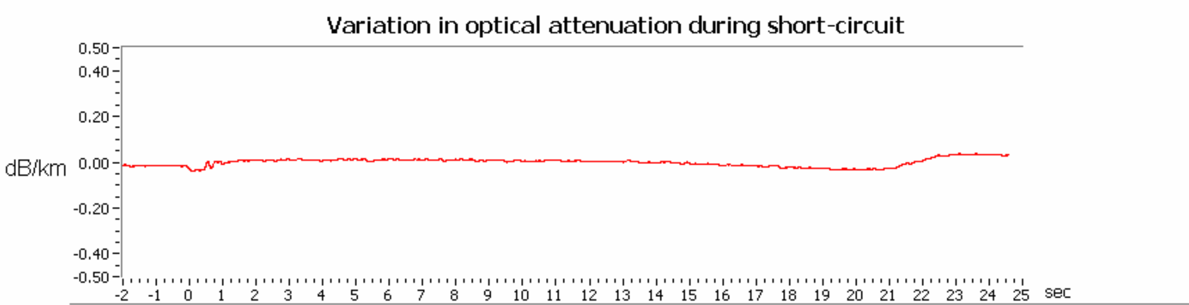




Average cable temperature before fault:
42 °C

Maximum temperature rise

Between two AA wires	184°C
Between two ACS wires	151°C
Inside optical tube	103°C
	0°C



# of spliced fibres = 24

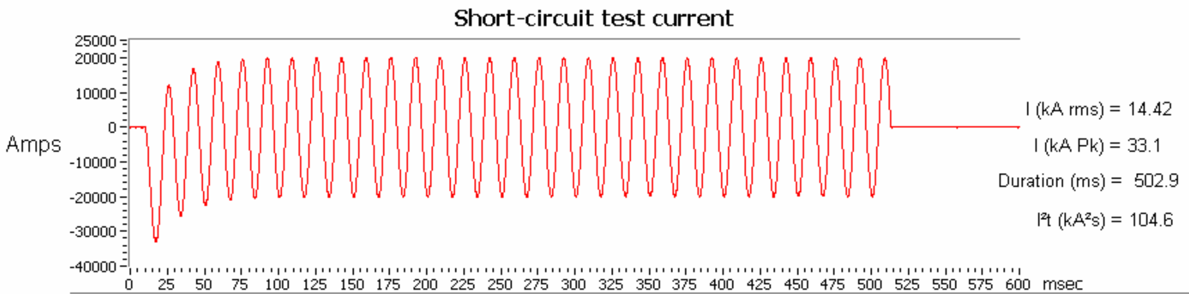
Test Cable length (m) = 10.2

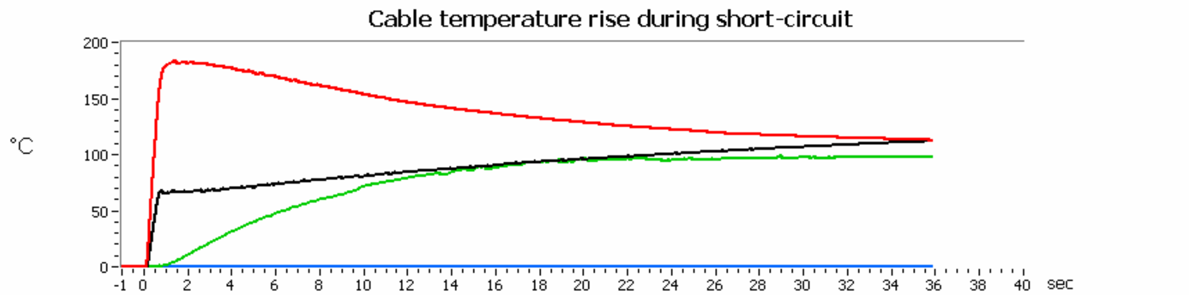
Total test fibre length (m) = 244.8

PRIVATE INFORMATION, This test data shall not be disclosed or distributed without permission of the client.

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-981		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	Fault current test on OPGW, 14.5 mm, 24 fibres. Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s Shot #5

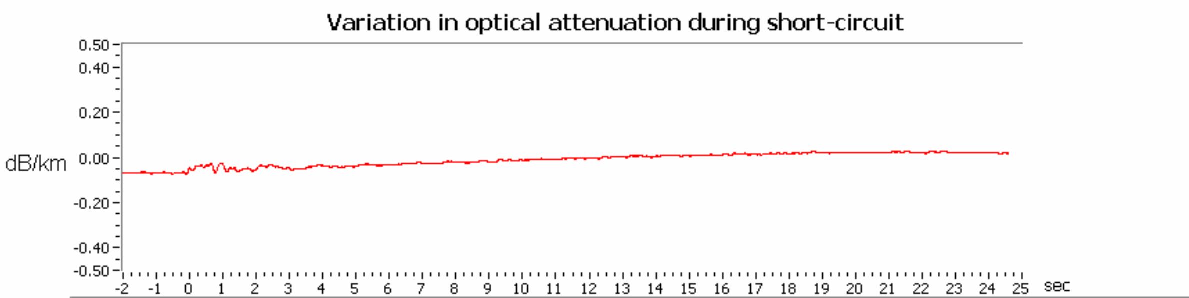




Average cable temperature before fault: 40 ºC

Maximum temperature rise

Between two AA wires	183°C
Between two ACS wires	112°C
Inside optical tube	98°C
	0°C



# of spliced fibres = 24

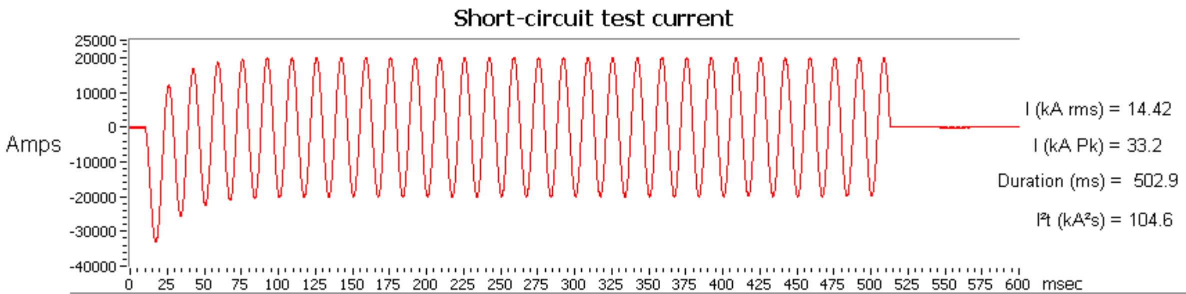
Test Cable length (m) = 10.2

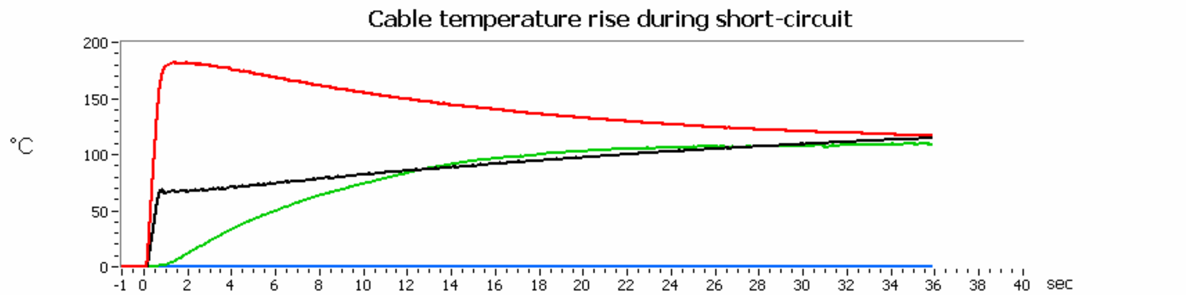
Total test fibre length (m) = 244.8

PRIVATE INFORMATION, This test data shall not be disclosed or distributed without permission of the client.

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-982		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	**Fault current test on OPGW, 14.5 mm, 24 fibres.** **Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s** **Shot #6**

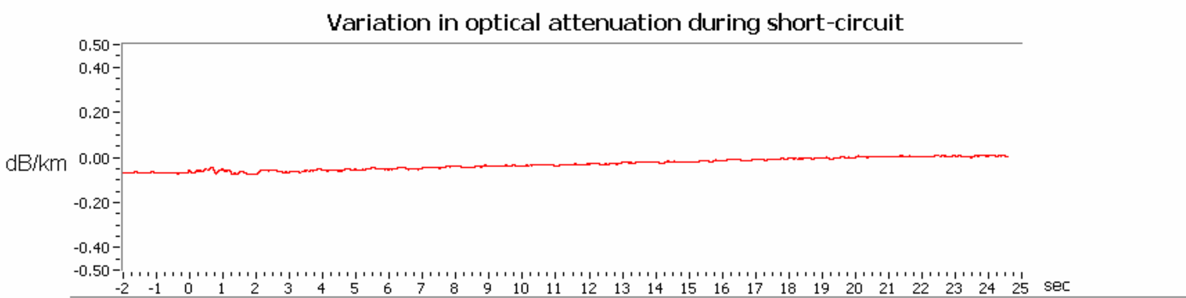




Average cable temperature before fault: 41 °C

Maximum temperature rise

Between two AA wires	183°C
Between two ACS wires	114°C
Inside optical tube	110°C
	0°C



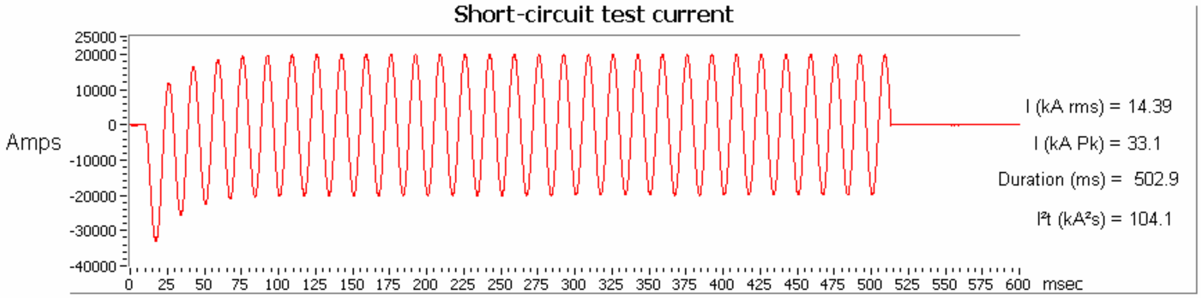
# of spliced fibres = 24

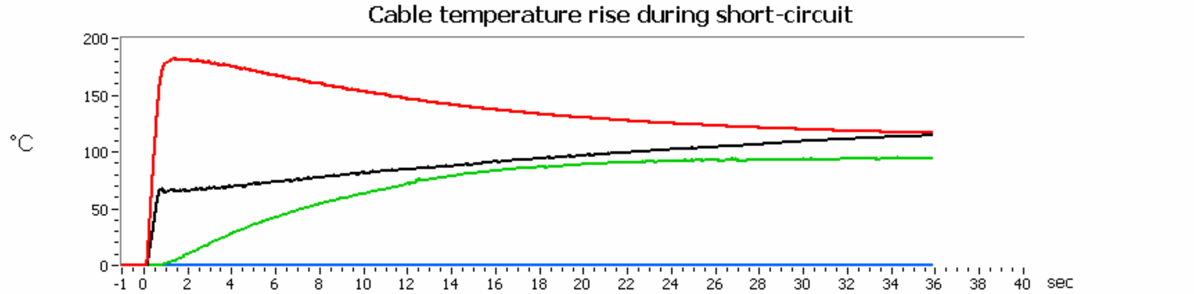
Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-983		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	Fault current test on OPGW, 14.5 mm, 24 fibres. Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s Shot #7

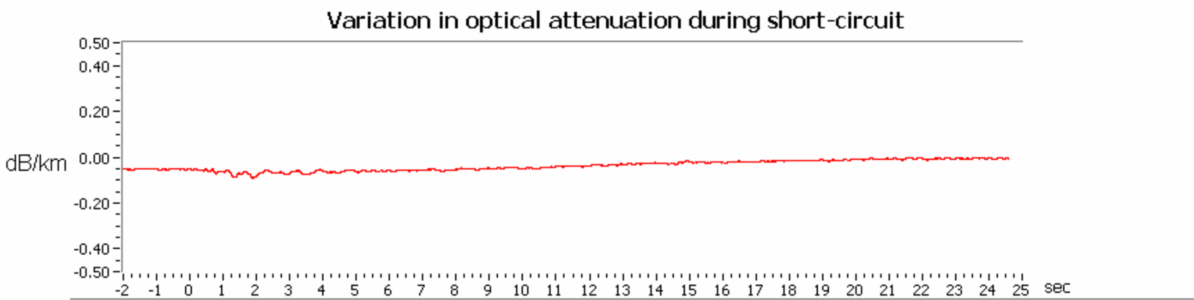




Average cable temperature before fault: 40 °C

Maximum temperature rise

Between two AA wires	182°C
Between two ACS wires	114°C
Inside optical tube	96°C
	0°C



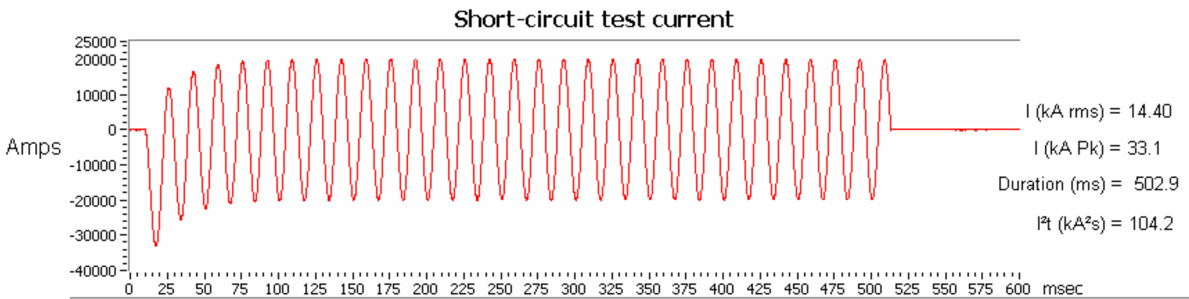
# of spliced fibres = 24

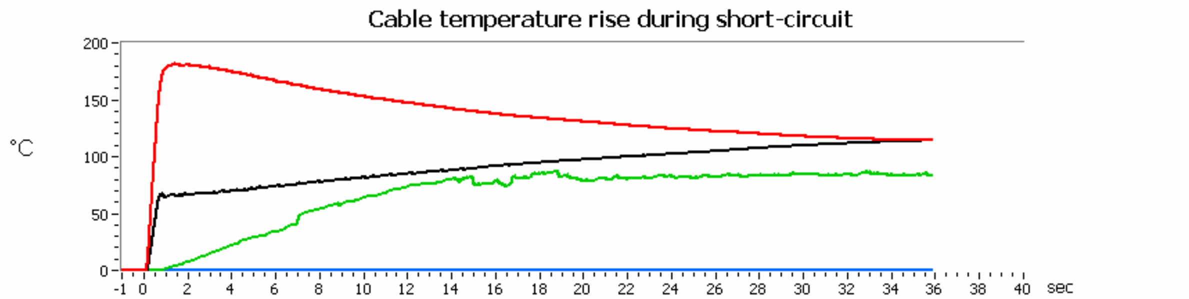
Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

Mar 16, 2006	**High Current Test Laboratory** **Kinectrics Inc.** **Test Sheet**	KINECTRICS
Test # 2006-984		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	**Fault current test on OPGW, 14.5 mm, 24 fibres.** **Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s** **Shot #8**

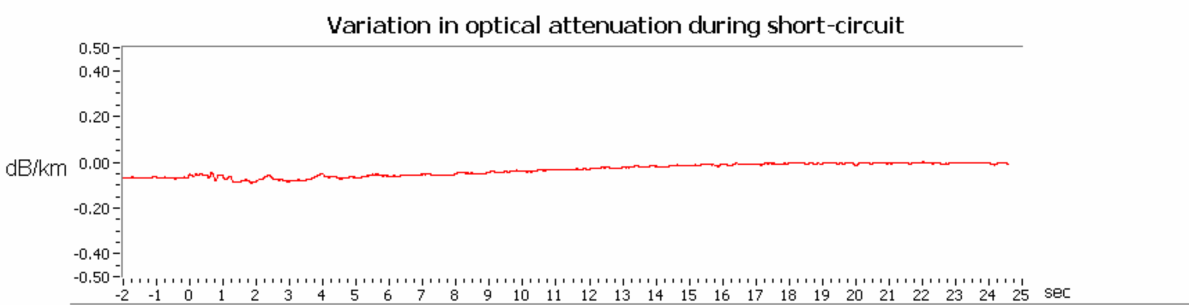




Average cable temperature before fault:
37 °C

Maximum temperature rise

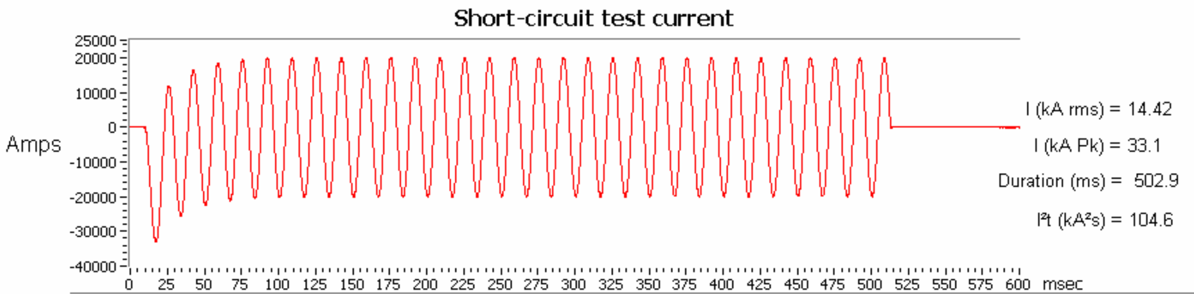
Between two AA wires	181°C
Between two ACS wires	114°C
Inside optical tube	87°C
	0°C

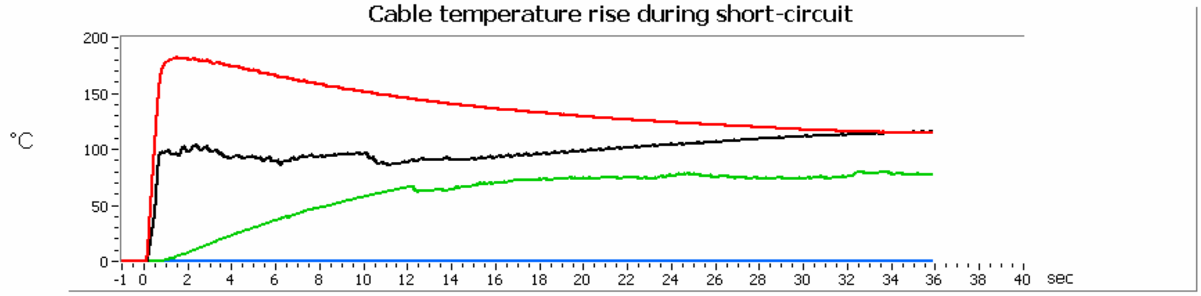


# of spliced fibres = 24
Test Cable length (m) = 10.2
Total test fibre length (m) = 244.8

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-985		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	Fault current test on OPGW, 14.5 mm, 48 fibres. Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s Shot #9

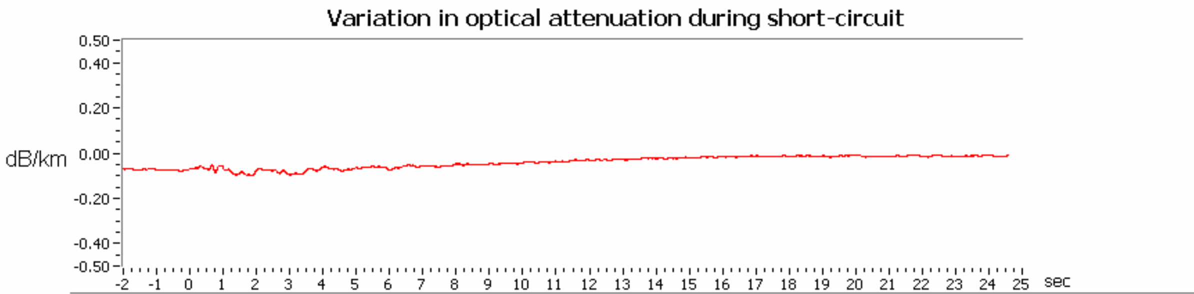




Average cable temperature before fault: 41 ºC

Maximum temperature rise

Between two AA wires	181°C
Between two ACS wires	115°C
Inside optical tube	80°C
	0°C



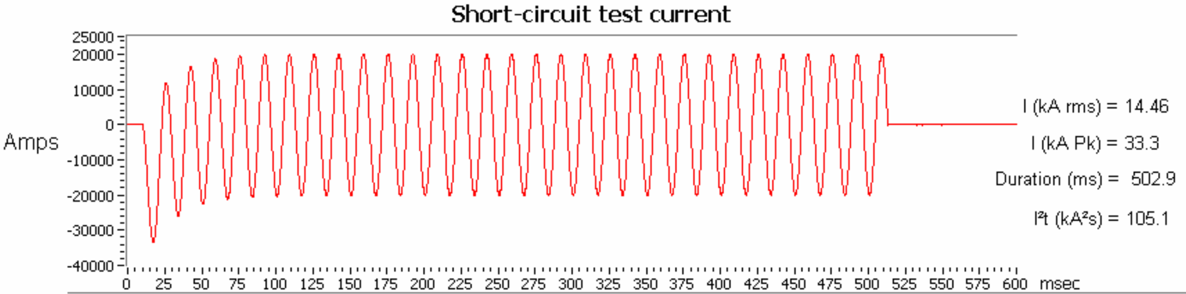
# of spliced fibres = 24

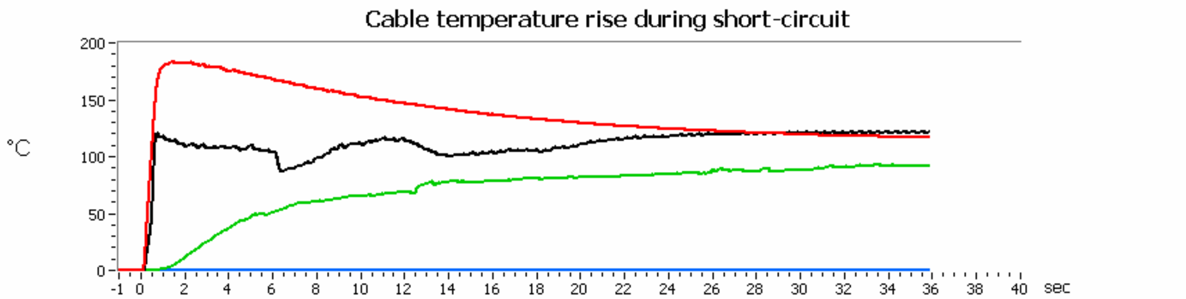
Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

Mar 16, 2006	High Current Test Laboratory Kinectrics Inc. Test Sheet	KINECTRICS
Test # 2006-986		
WO#: K-422180		

Client:	Description:
El Sewedy Cables	Fault current test on OPGW, 14.5 mm, 48 fibres. Test: 14.45 kA @ 0.5 seconds = 104.5.0 kA²s Shot #10

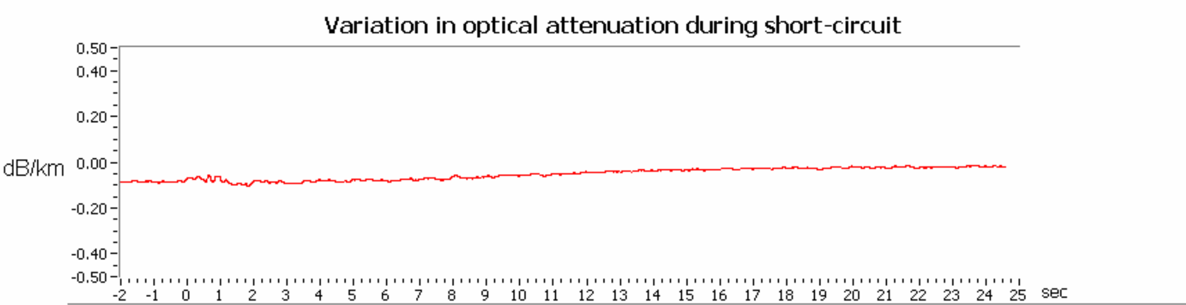




Average cable temperature before fault:
42 ºC

Maximum temperature rise

Between two AA wires	183°C
Between two ACS wires	122°C
Inside optical tube	92°C
	0°C



# of spliced fibres = 24

Test Cable length (m) = 10.2

Total test fibre length (m) = 244.8

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**AEOLIAN VIBRATION TEST**
Test Date:	February 27- March 20, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessores:	SEFAG EXPORT AG Dead-end P/N: 182 929-568 Suspension P/N: 182 913-728
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Aeolian Vibration Test is to assess the fatigue performance of the fibre optic ground wire and the optical characteristics of the fibres under typical aeolian vibrations.

TEST STANDARD

The test was performed in accordance with IEEE 1138-1994, Paragraph 4.1.1.4.

TEST SETUP

The set-up for the Aeolian Vibration Test is shown in Figures 1a, 1b, and 1c. The test was performed on the span designated “North”.

Test Apparatus

The OPGW was contained between two intermediate abutments. The active span cable length was 26.15 m and the passive span cable length was 11.85 m for a total cable length of 38.0 m between the loading points of the dead-end clamps. Fixed end abutments were used to load and maintain tension in the fibre optic cable. The initial target tension of 1,555 kgf is 25% of the cable's RTS (6,220 kgf). This was applied using a cantilever weight arm on one of the end abutments.

The dead-end assemblies were installed between the intermediate abutments. The suspension assembly was supported at a height such that the static sag angle of the cable to horizontal was 1.8 degrees in the active span and 3.7 degrees in the passive span.

The free loop antinode amplitude of the cable was measured at the first free loop from the suspension assembly towards the shaker.

An electronically controlled shaker was used to excite the cable in the vertical plane. The shaker armature was securely fastened to the cable so that it was perpendicular to the cable in the vertical plane. The shaker was located in the span to allow a minimum of six vibration loops between the suspension assembly and the shaker.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Twenty-four (24) of the forty-eight (48) fibres were spliced to make a total fibre length under test of 912 m (24 x 38.0 m). The test sample was terminated beyond both dead-ends such that the optical fibres could not move relative to the OPGW. The cable and fibre terminations and the optical power measurement method are described in Appendix B.

Instrumentation and Data Acquisition

Optical power meters were used to measure the optical attenuation in the test fibres. A laser micrometer was used to measure the free loop antinode amplitude. A load cell was used to measure the cable tension. A hand-held digital protractor was used to measure the exit angle of the cable from the suspension clamp. A thermocouple was used to measure the air temperature.

The optical power signals, peak-to-peak free loop amplitude, vibration frequency, number of cycles, cable tension and air temperature were recorded every five (5) minutes by a digital data logging system.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The OPGW was pretensioned to 124 kgf and an initial optical measurement was taken. The OPGW was then tensioned to 1,555 kgf or 25% of the cable RTS and the exit angles of the cable from the suspension clamp were measured.

The initial target vibration frequency was 57.2 cps, which is the frequency produced by a 4.5 m/s wind (i.e., frequency = 830 ÷ diameter of the OPGW in mm). The actual vibration frequency was the system resonance that was nearest to the target frequency and also provided good system stability.

The target free loop peak-to-peak antinode amplitude was 4.83 mm or one third of the OPGW diameter. This amplitude was maintained at this level in the first free loop from the suspension assembly towards the shaker. The amplitudes in the passive span and the section between the shaker and the dead-end in the active span were maintained at levels no greater than one third of the cable diameter.

The number of vibration loops were counted, and their average loop lengths were calculated for each of the two (2) sections of the OPGW in the active span. The two sections are i) between the dead-end and shaker, and ii) between the shaker and suspension.

The OPGW was subjected to 100 million vibration cycles.

Optical measurements were taken for two (2) hours after the completion of the vibration cycles.

TEST RESULTS

The average values of all the data recorded are listed in Table 1. The average vibration loop length is the average of the free vibration loops only, excluding the vibration loops next to the dead-ends, shaker, or suspension. A plot of peak-to-peak free loop antinode amplitude versus vibration cycles is shown in Figure 2.

Table 1: Average Values of Results

Parameter	Average Value
OPGW Tension	1,583 kgf
Vibration Frequency	61.45 cps
Peak-to-peak Amplitude	4.83 mm
Vibration Loop Length – Active Span, Dead-end to Shaker	1.40 m
Vibration Loop Length – Active Span, Shaker to Suspension	1.45 m
Vibration Loops – Active Span, Dead-end to Shaker	5 free loops
Vibration Loops – Active Span, Shaker to Suspension	12 free loops

Optical

A plot of optical attenuation amplitude versus vibration cycles is shown in Figure 2. The maximum temporary attenuation increase measured during the test was 0.30 dB/km. The permanent attenuation measured at the end of the test (after 2 hour hold) was 0.24 dB/km.

Dissection

After completion of 100 million cycles, the cable was dissected and visually examined. Photos of the dissected suspension, active-span dead-end and passive-span dead-end are shown in Figures 3a, 3b, 3c, and 3d respectively.

Active Dead-end -	There were no visible signs of breaks, cracks, failure or discoloration of any components of the OPGW.
Passive Dead-end -	There were no visible signs of breaks, cracks, failure or discoloration of any components of the OPGW.
Suspension -	There were no visible signs of breaks, cracks, failure or discoloration of any components of the OPGW.

ACCEPTANCE CRITERIA

As specified in IEEE 1138-1994, Paragraph 4.1.1.4, the maximum allowable temporary or permanent attenuation is ≤ 1.0 dB/km. Any significant damage to any component of the cable shall constitute failure.

CONCLUSION

The cable, as tested, met the requirements for the Aeolian Vibration Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.4.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

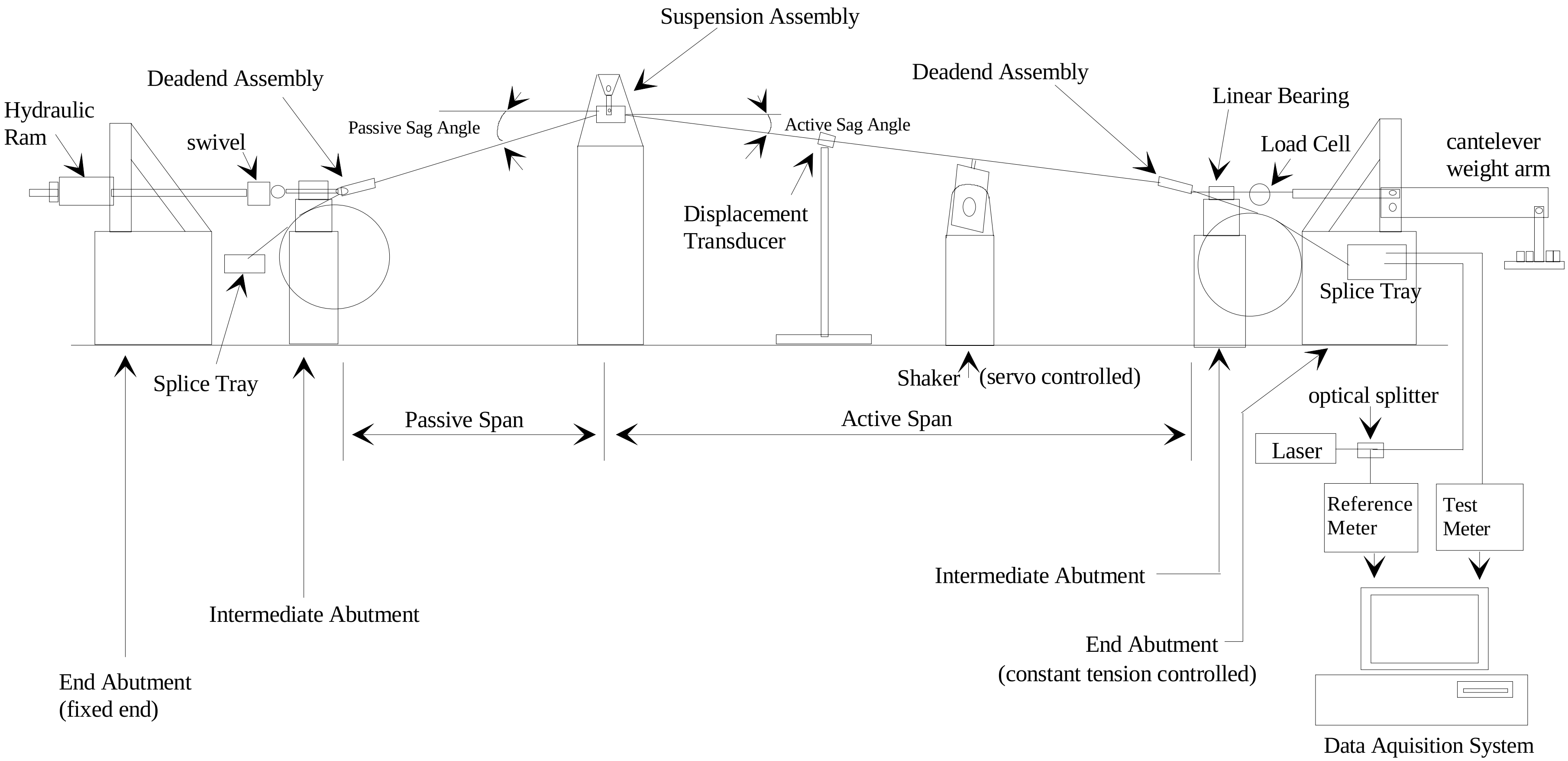


Figure 1a Set-Up for Aeolian Vibration Test (Schematic)

Figure 1b Test Setup for Aeolian Vibration Test (Suspension and Active Span)

Figure 1c Test Setup for Aeolian Vibration Test (Suspension and Passive Span)

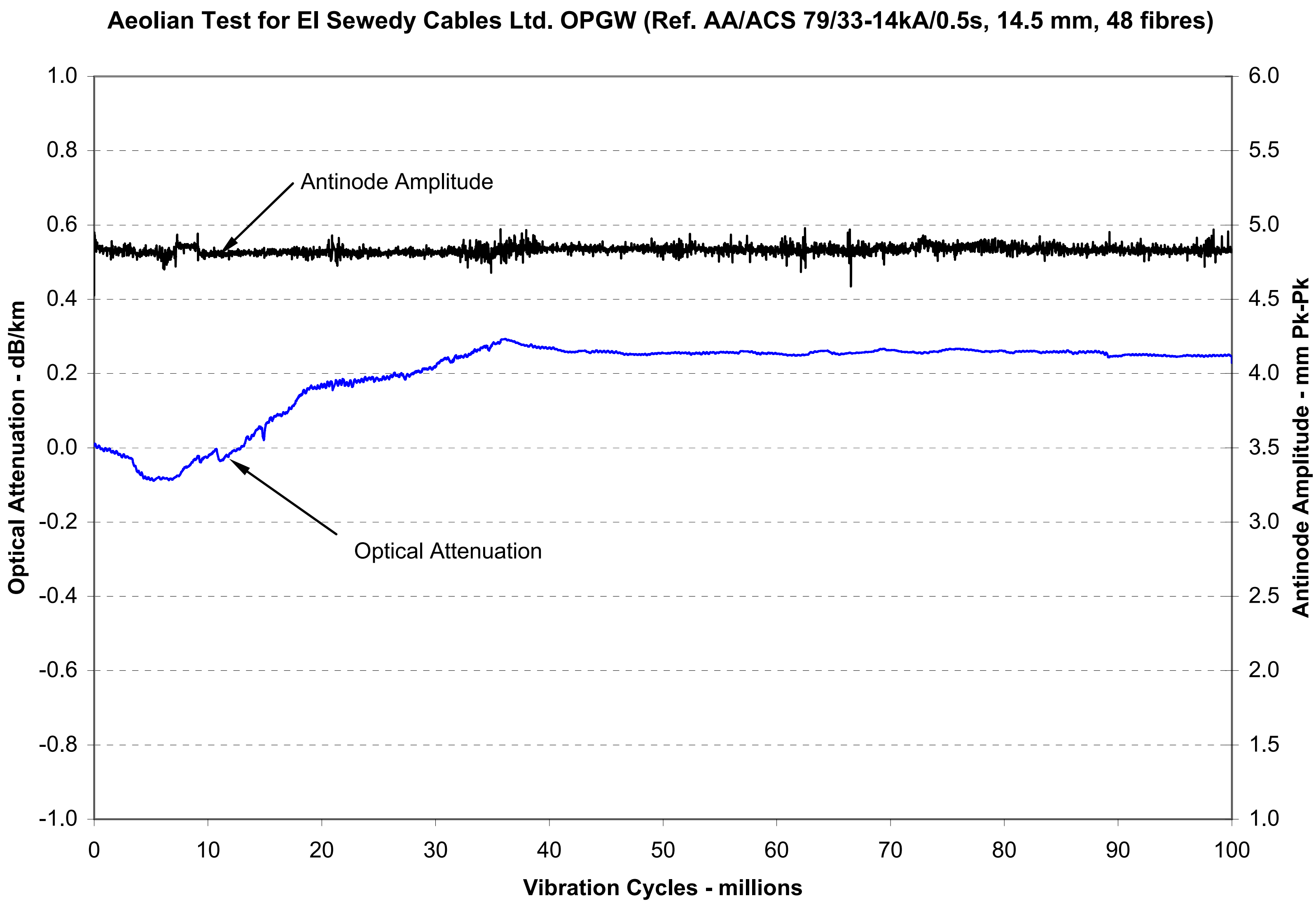


Figure 2 Aeolian Vibration Test Results (Optical Attenuation versus Vibration Cycles)

Figure 3a Dissected Components from Aeolian Vibration Test (Under Active Dead-end)

Figure 3b Dissected Components from Aeolian Vibration Test (Under Passive Dead-end)

Figure 3c Dissected Components from Aeolian Vibration Test (Suspension)

Figure 3d Dissected Components from Aeolian Vibration Test (Suspension)

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name: **GALLOPING TEST**

Test Date: March 8-9, 2006

Test Laboratory: Kinectrics International Inc.
800 Kipling Avenue
Toronto, Ontario M8Z 6C4
CANADA

Cable Manufacturer: El Sewedy Cables Ltd.

End-User: Egyptian Electricity Transmission Company

Cable Designation: AA/ACS 79/33-14kA/0.5s

Accessories: SEFAG EXPORT AG
Dead-end P/N: 182 929-568
Suspension P/N: 182 913-728

Kinectrics Staff: Mr. Craig Pon
Mr. Mike Kastelein
Mr. Mike Colbert
Mr. Gord Hale

Witnesses: Mr. Hassan Refaat – El Seedy Cables
Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Galloping Test is to assess the fatigue performance of the fibre optic ground wire and the optical characteristics of the fibres under typical galloping conditions.

TEST STANDARD

The test was performed in accordance with IEEE Standard 1138-1994, Paragraph 4.1.1.5.

TEST SET-UP

The set-up for the Galloping Test is shown in Figures 1a, 1b, and 1c.

Test Apparatus

The test section was contained between two intermediate abutments. The active span cable length was 20 m and the passive span cable length was 20 m for a total cable length of 40 m between the loading points of the dead-end clamps. Fixed end abutments were used to load and maintain tension in the fibre optic cable. The initial target tension was 124 kgf or 2% of the cable RTS (6,220 kgf). This was applied using a cantilever weight arm on one of the end abutments and a sheave wheel and counter weight at the other end abutment. The end abutments allowed horizontal motion of the test sample by way of linear bearings.

The dead-end assemblies were installed between the intermediate abutments. The suspension assembly was supported at a height such that the static sag angle of the cable to horizontal was less than 1^{o} in the active span.

The free loop antinode amplitude was measured at a point midway between the suspension assembly and the dead-end. This was achieved by manually observing a graduated scale supported next to the cable.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Twenty-six (26) of the forty-eight (48) fibres were spliced together to form one continuous loop. This provided a total fibre length under test of 1040 m (26 x 40 m). The test sample was terminated beyond both dead-ends such that the optical fibres could not move relative to the OPGW. The cable and fibre terminations and the optical power measurement method are described in Appendix B.

Instrumentation and Data Acquisition

Optical power meters were used to measure the optical attenuation in the test fibres. A load cell was used to measure the cable tension. A hand-held digital protractor was used to measure the exit angle of the cable from the suspension clamp. A thermocouple was used to measure the air temperature.

The optical power signals, tension, number of cycles and temperature were monitored and recorded every 5 minutes by a digital data logging system. The free loop peak-to-peak antinode amplitude and frequency were recorded manually.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

An initial optical measurement was taken one hour prior to starting the test. The difference between the reference and test signals for the initial measurement provided an initial base reading. The change in this difference during the test indicated the change in the attenuation of the test fibre.

The cable was subjected to 100,000 galloping cycles in the single loop mode. The free loop peak-to-peak antinode amplitude was maintained at a minimum of about 0.8 m or 1/25th of the distance from the dead-end to the suspension clamp length (i.e. 20 m).

Optical measurements were taken for an additional two (2) hours after the completion of the galloping test.

TEST RESULTS

The galloping frequency throughout the test was 1.15 cps. The free loop antinode amplitude in the active (driven) span was maintained at 0.8 m. The free loop antinode amplitude in the passive span was about 0.4 m during the test. The tension in the cable fluctuated between 90 to 133 kgf as the cable galloped.

Optical

A plot of optical attenuation amplitude versus galloping cycles is shown in Figure 2. The maximum temporary attenuation increase measured during the test was 0.02 dB/km. The permanent attenuation measured at the end of the test (after 2 hour hold) was 0.01 dB/km.

Dissection

After completion of 100,000 cycles, the cable was dissected and visually examined. Figures 3a and 3b show the dissected components of the suspension assembly.

Active Dead-end -	There were no visible signs of breaks, cracks, failure or discoloration of any components of the OPGW.
Passive Dead-end -	There were no visible signs of breaks, cracks, failure or discoloration of any components of the OPGW.
Suspension -	There were no visible signs of breaks, cracks, failure or discoloration of any components of the OPGW.

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.5, the maximum allowable temporary or permanent attenuation is 1.0 dB/km. Any significant damage to any component of the cable shall constitute failure.

CONCLUSION

The cable, as tested, met the requirements for the Galloping Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.5.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

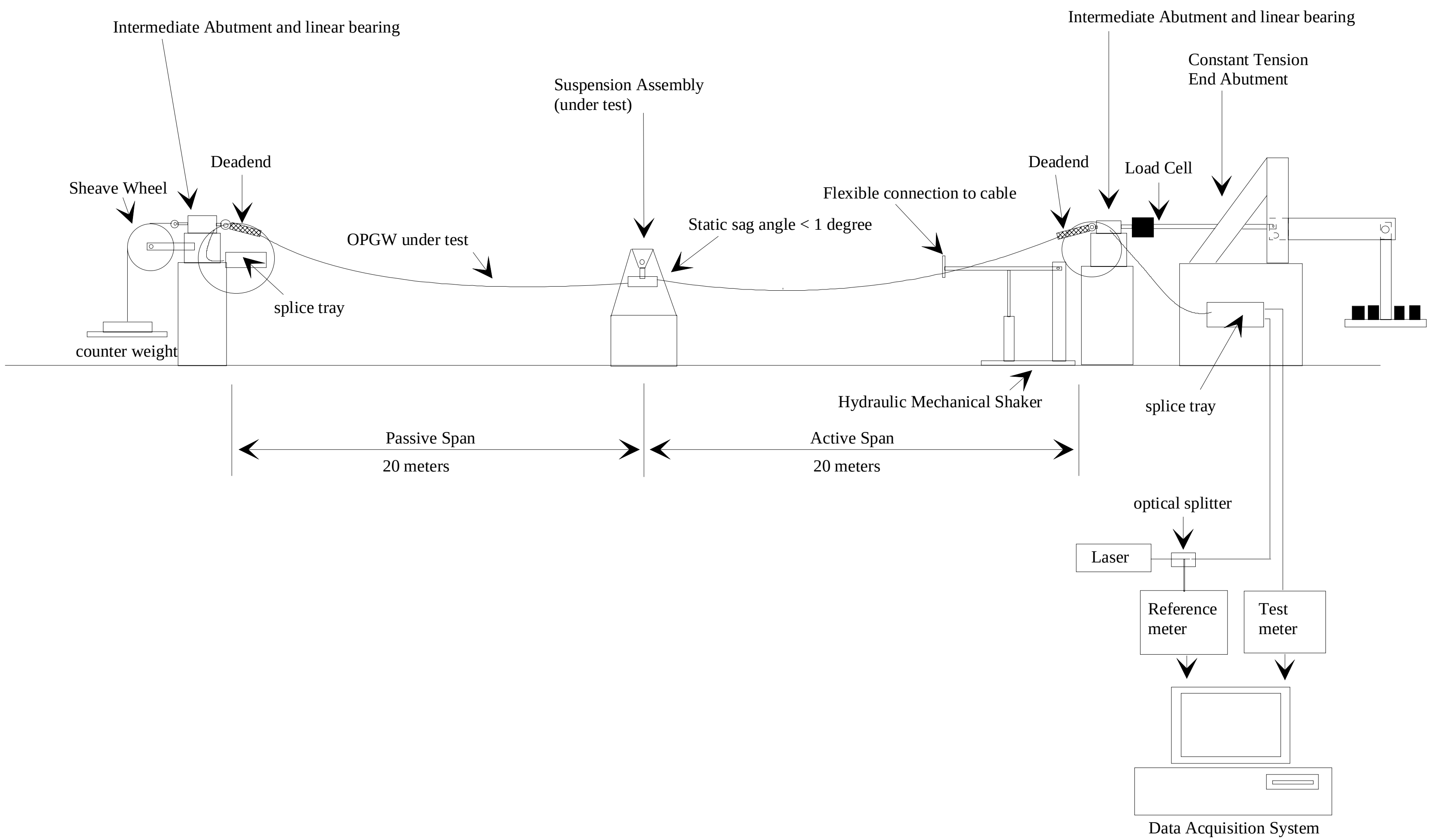


Figure 1a Test Set-up for Galloping Test (Schematic)

Figure 1b Test Setup for Galloping Test (Active Span)

Figure 1c Test Setup for Galloping Test (Suspension)

Galloping Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

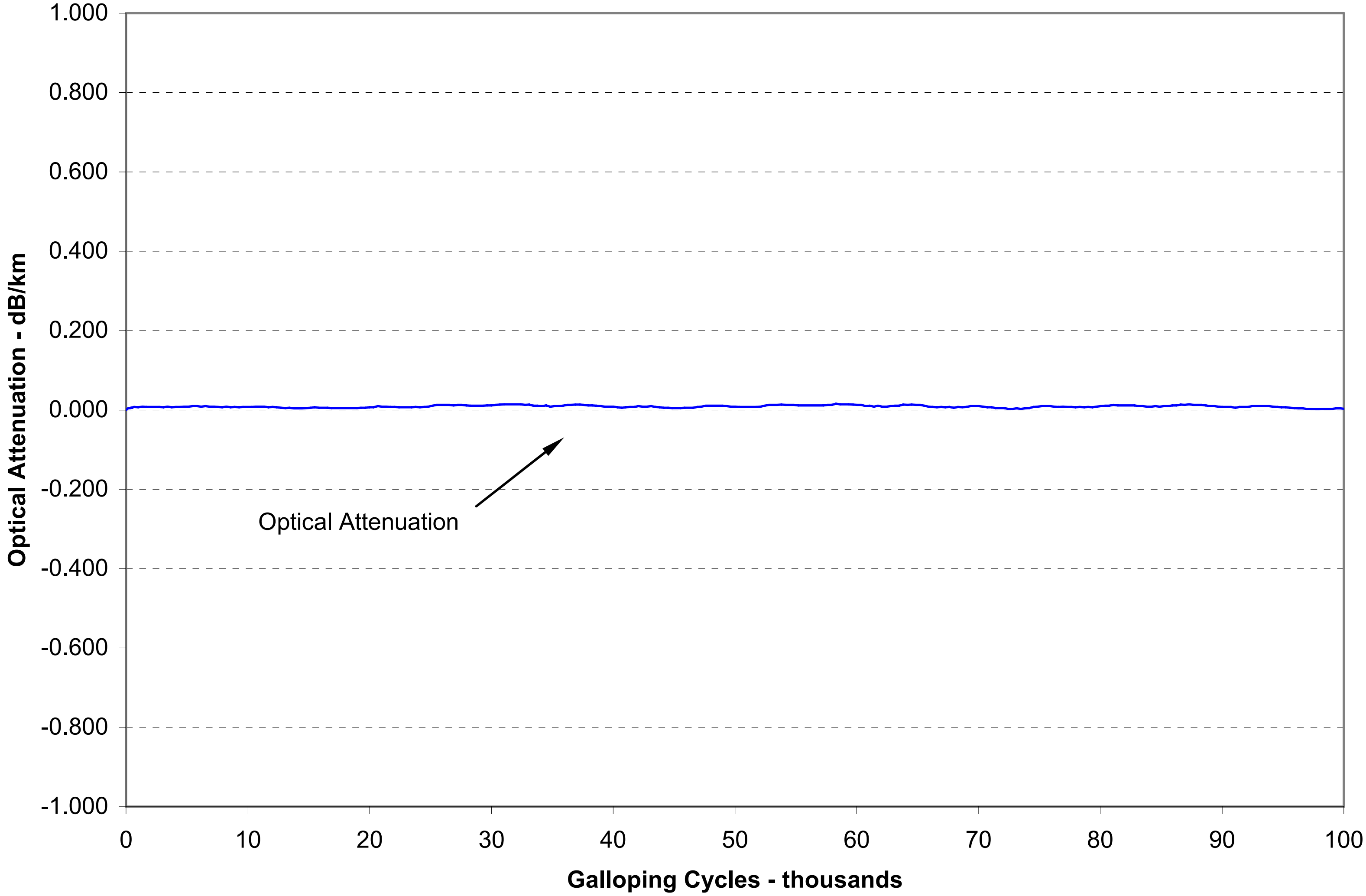


Figure 2 Optical Attenuation vs. Galloping Cycles

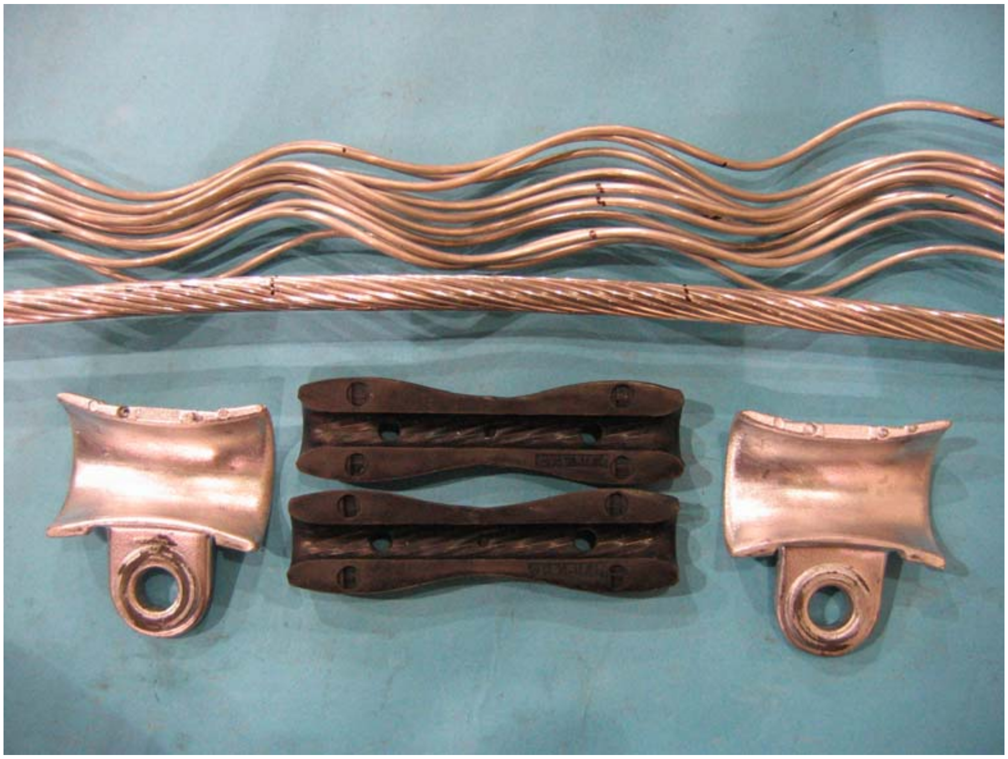


Figure 3a Dissected Components from Galloping Suspension Test

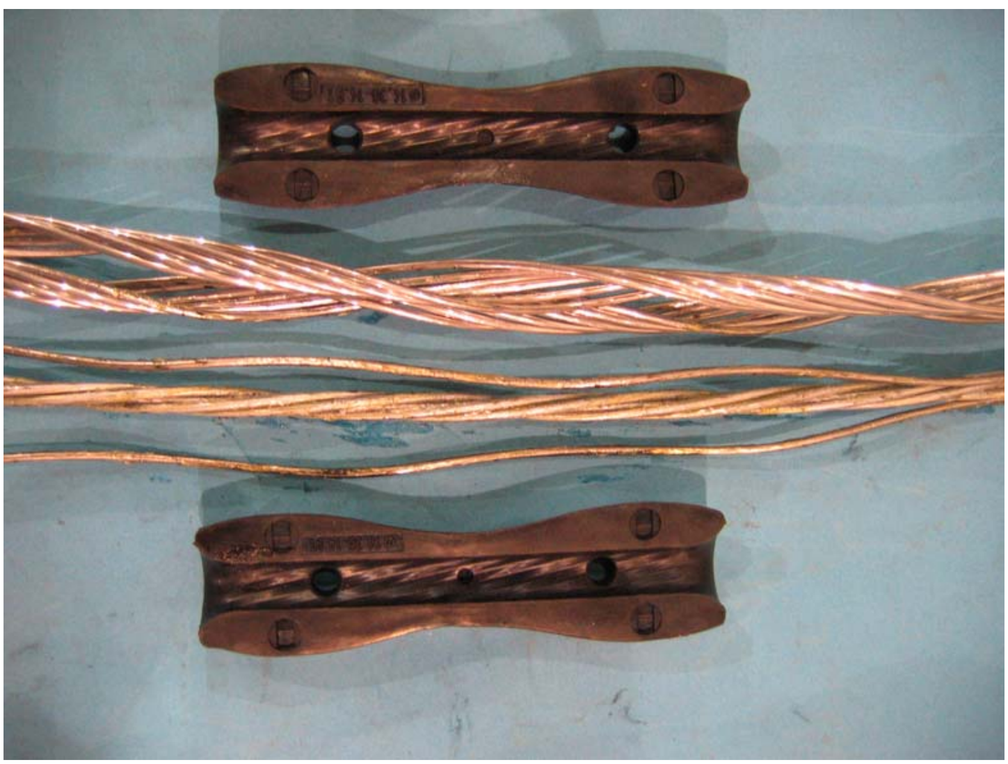


Figure 3b Dissected Components from Galloping Suspension Test

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**SHEAVE TEST**
Test Date:	March 10, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	SEFAG EXPORT AG Dead-end P/N: 182 929-568
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Sheave Test is to determine the ability of the cable to withstand passing over a sheave a number of times without significant damage to the cable or significant increase in optical attenuation.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138, Paragraph 4.1.1.6.

TEST SET-UP

The set-up for the Sheave Test is shown in Figures 1a and 1b.

Test Apparatus

The length of cable between the dead-end load points was approximately 11.97 m. The target tension of the cable was 1555 kgf or 25% of the cable RTS (6,220 kgf). The inside diameter of the sheave was 460 mm. The total angle of the cable over the sheave was 30.4°. The set-up allowed 2.5 m of cable to travel through the sheave at a speed of 0.157 m/sec. A load cell was installed at one end to measure the tension in the cable.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Twenty-four (24) of the forty-eight (48) fibres were spliced together to form one continuous loop. This provided a total fibre length under test of 287 m (24 x 11.97 m). The sample was terminated beyond both dead-end clamps such that the optical fibres could not move relative to the metallic parts of the cable. The cable and fibre terminations and the optical power measurement method are described in Appendix B.

Instrumentation and Data Acquisition

The load cell and the analog outputs of the optical power meters were monitored continuously and recorded every five (5) seconds during the test by a digital data logging system.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

A two and a half (2.5) meter length of the cable sample was pulled 70 times forward and backward over the sheave (i.e. 35 times each way). Before the first pull, the midpoint and both ends of the two and a half (2.5) meter length were located and marked. A digital caliper was used to measure the horizontal and vertical cable diameters at the three (3) locations after applying load and after the 1st, 10th, 20th, 30th and 35th cycle.

The dissection and visual examination of the cable components within the two and one half (2.5) meter test section were performed after the test. The outer cable strands were removed in the test section and the diameters of all components were measured.

TEST RESULTS

Optical attenuation, cable tension and accumulated test cycles are plotted against time and are shown in Figure 2. The maximum attenuation increase measured during the test was 0.022 dB/km. The number of forward/backward cycles over the sheave can be seen as cyclic variations in the cable tension.

The measured cable diameters after tensioning and after 0, 1, 10, 20, 30 and 35 cycles are shown in the following Table 1.

Table 1 Measured Cable Diameters

	North		Centre		South	
	Max (mm)	Min (mm)	Max (mm)	Min (mm)	Max (mm)	Min (mm)
Before Tension	14.96	14.52	14.73	14.58	14.80	14.62
Before 1st Cycle	14.64	14.56	14.64	14.52	14.65	14.53
After 1st Cycle	14.62	14.43	14.62	14.50	14.59	14.50
After 10th Cycle	14.68	14.43	14.54	14.44	14.57	14.41
After 20th Cycle	14.56	14.44	14.55	14.42	14.59	14.41
After 30th Cycle	14.55	14.44	14.56	14.44	14.65	14.41
After 35th Cycle	14.55	14.46	14.57	14.44	14.61	14.41

The maximum cable distortion from the measured diameters, with reference to the Before 1st Cycle was 0.13 mm. The corresponding diameters were 14.56 mm and 14.53 mm and were measured in the North-Min location after the 1st and 10th cycles.

The cable sample was dissected upon completion of this test. The measured diameters of the stainless steel tubes are shown in Table 2. The nominal diameter of the tube is 2.85 mm.

Table 2 Measured Diameters of Stainless-Steel Tubes

SS Tube	Location	North	1/3	2/3	Centre	1/3	2/3	South
#1 No Stripe	Max. Dia. (mm)	2.90	2.87	2.89	2.87	2.87	2.86	2.86
	Min. Dia. (mm)	2.80	2.84	2.83	2.83	2.84	2.84	2.83
#2 With Stripe	Max. Dia. (mm)	2.87	2.86	2.89	2.87	2.87	2.87	2.88
	Min. Dia. (mm)	2.82	2.84	2.81	2.81	2.81	2.83	2.81

The maximum distortion of Tube #1 from the nominal diameter was 0.05 mm. The corresponding diameters were 2.80 mm and 2.90 mm, and were measured in the North-Max and North-Min locations.

The maximum distortion of Tube #2 from the nominal diameter was 0.04 mm. The corresponding diameters were 2.89 mm and 2.81 mm, and were measured in the North 2/3-Max and Min locations, and in the South-Min location.

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.6, any significant damage to any component of the cable or central fibre optic unit at any points above deformation limits greater than 0.5 mm or attenuation greater than 1.0 dB/km shall constitute failure.

CONCLUSION

The cable, as tested, met the requirements for the Sheave Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.6.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

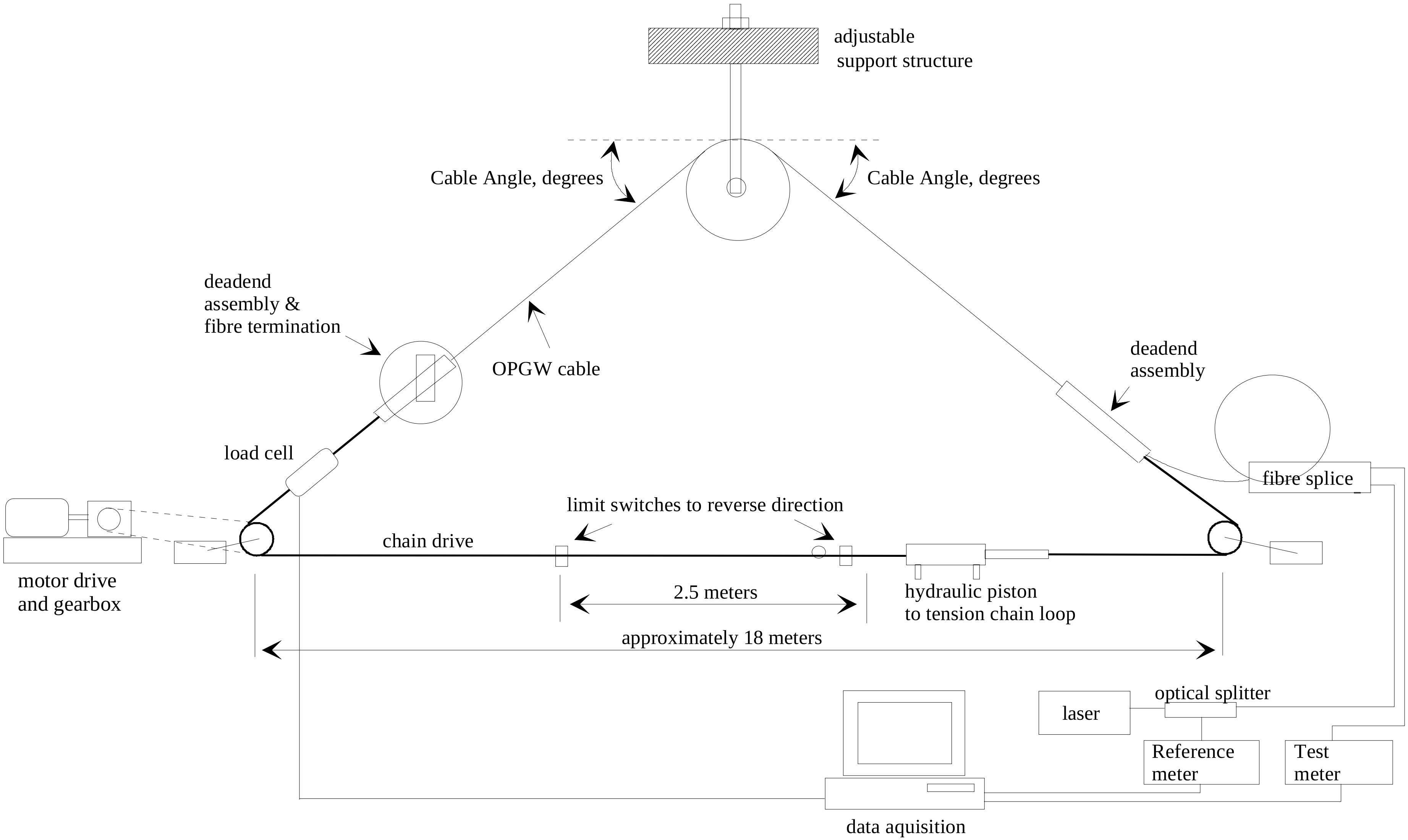


Figure 1a Set-up for Sheave Test (Schematic)

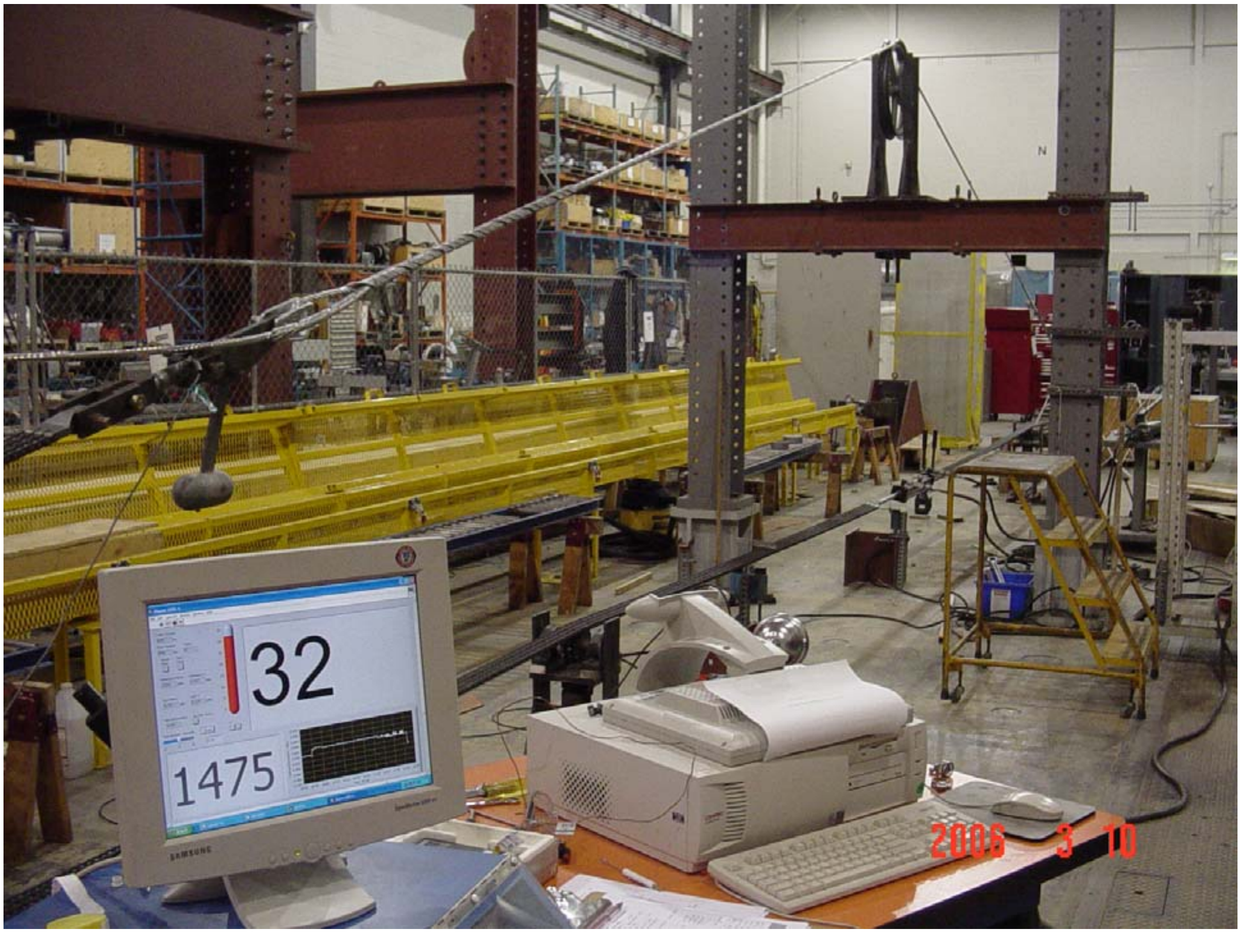


Figure 1b Typical Set-up for Sheave Test

Sheave Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

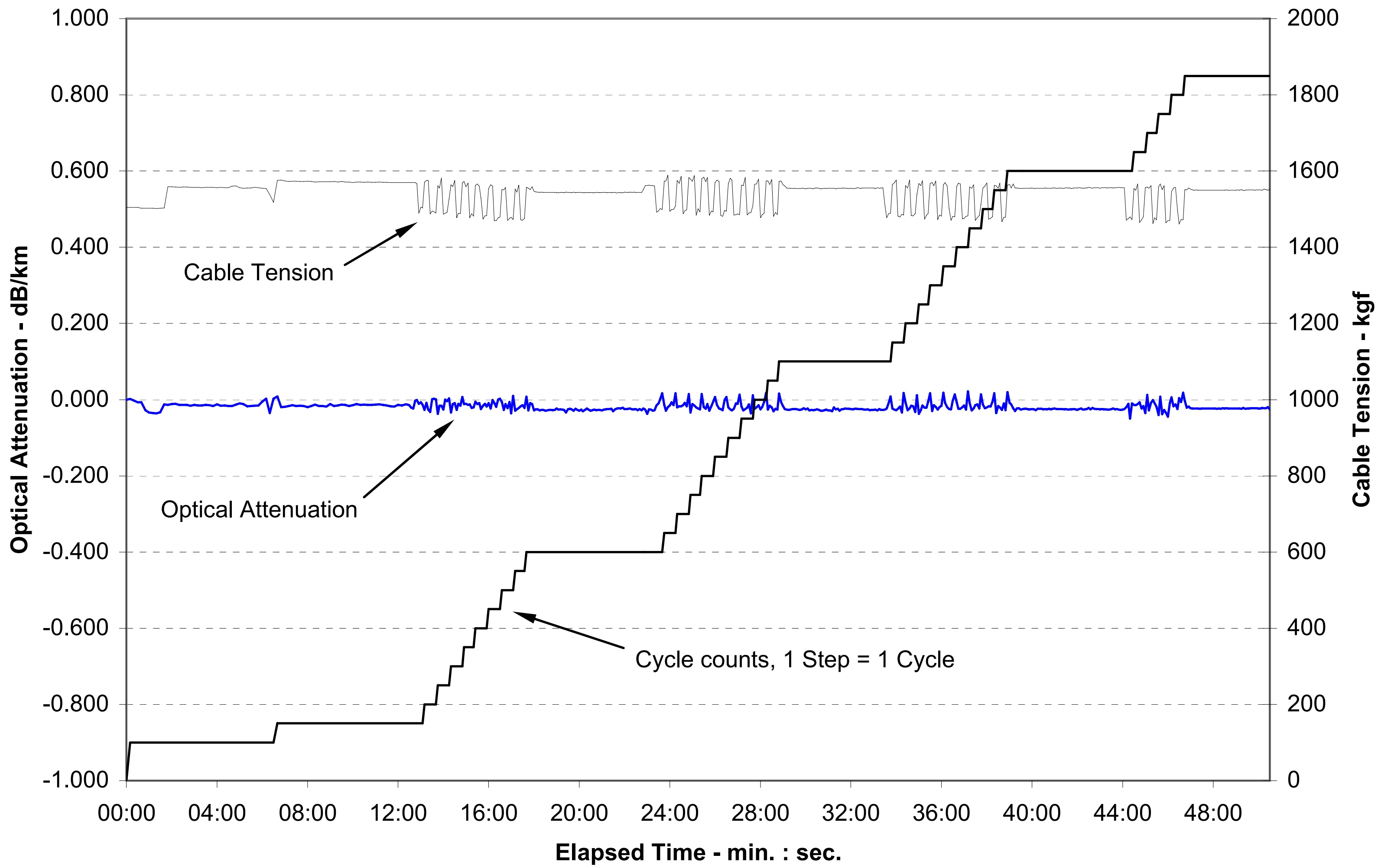


Figure 2 Cable Tension, Cycle Counts and Optical Attenuation vs Time

KINECTRICS INTERNATIONAL INC. TEST REPORT
<u>FOR EL SEWEDY CABLES LTD. OPGW CABLE</u>
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**CRUSH TEST**
Test Date:	March 10, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not Applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of this test is to verify the optical performance of the OPGW cable subjected to compression loading.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.7.

TEST SET-UP

The set-up for the Crush Test is shown in Figures 1a and 1b. An untested cable section from the test sample prepared for the Sheave Test and Impact Test was used for the Crush Test.

Test Apparatus

The cable was supported between two steel plates; a flat steel base and a moveable steel plate that transferred a compressive load uniformly over a 100 mm length of the sample. The edges of the moveable plate were rounded with 6 mm radius. The cable and plates were positioned between the jaws of a universal test machine.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Twenty-four (24) of the forty-eight (48) fibres were spliced together to form one continuous loop. This provided a total fibre length under compression of 2400 mm (24 x 100mm). The fibre terminations and the method to measure optical attenuation are described in Appendix B.

Instrumentation and Data Acquisition

The crush load and analog outputs of the optical power meters were monitored and recorded every second by a digital data logging system.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The cable was mounted between the plates so that lateral movement is prevented, and the load applied gradually without any abrupt change. The initial load was equal to 0 kgf. The load was then gradually increased at a rate of 454 kgf/min until the attenuation of the optical fibres exceeded 0.1 dB.

TEST RESULTS

The crush load and optical attenuation plotted against time are shown in Figure 2.

The crush load that caused a change in optical attenuation of 0.1 dB was approximately 2,387 kgf.

The crush area of the cable sample was dissected upon completion of this test and is shown in Figures 3a and 3b. The measured diameters of the SS tubes on the crush area and on the non-crush area are shown in Table 1. The nominal diameter of the SS tube is 2.85 mm.

Table 1 Measured Diameters of Stainless Steel Tubes

SS Tube	Measurement	Under Crush Area	Under Non Crush Area
#1 No Stripe	Minimum Diameter	2.64 mm	2.83 mm
	Maximum Diameter	3.11 mm	2.87 mm
#2 With Stripe	Minimum Diameter	1.56 mm	2.83 mm
	Maximum Diameter	3.80 mm	2.86 mm

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.7, the maximum allowable temporary or permanent attenuation is 0.1 dB. Since no load is specified for this optical condition, the objective of the test was to determine the load required which caused a 0.1 dB increase in attenuation.

CONCLUSION

The cable, as tested, met the requirements for the Crush Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.7.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

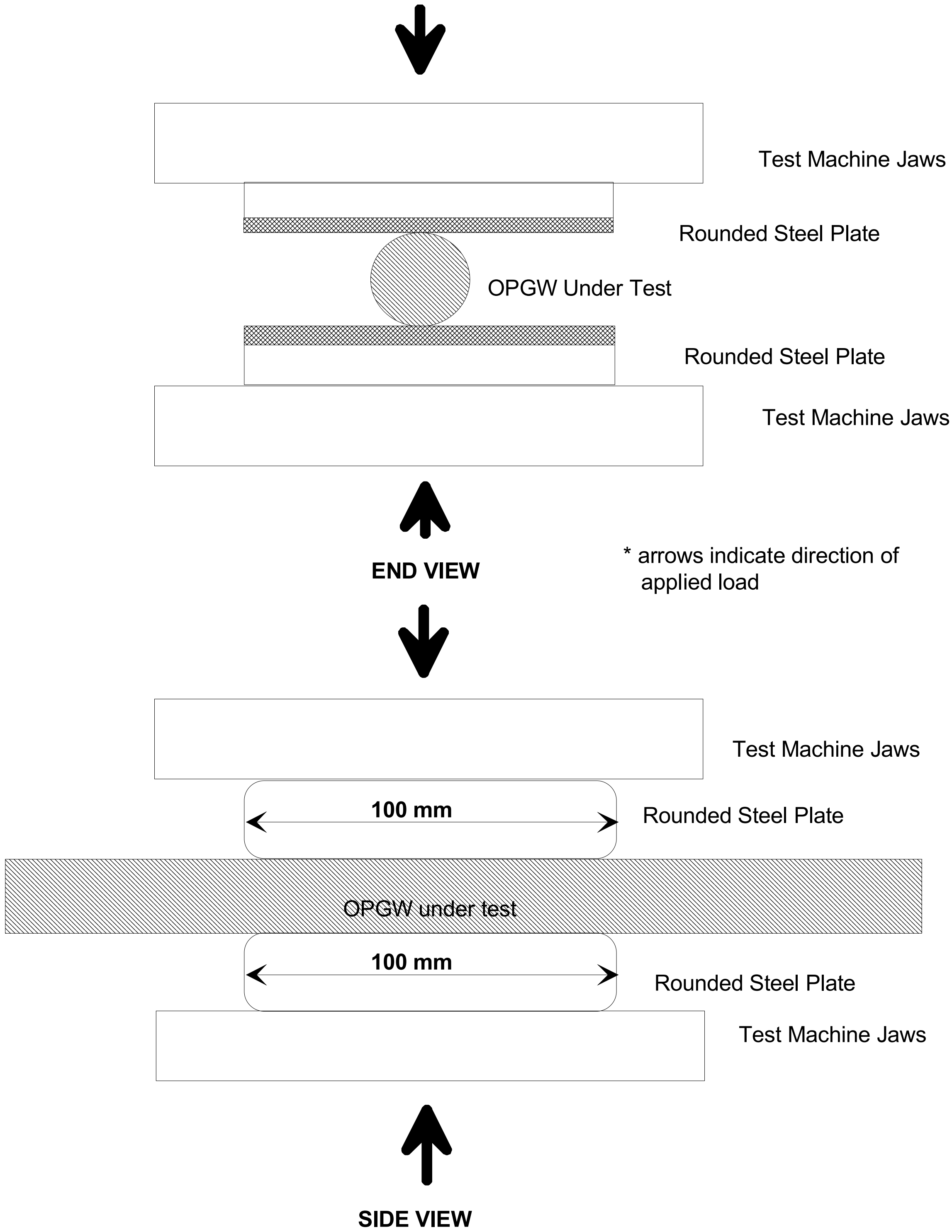


Figure 1a   Set-up for Crush Test

Figure 1b Typical Set-up for Crush Test

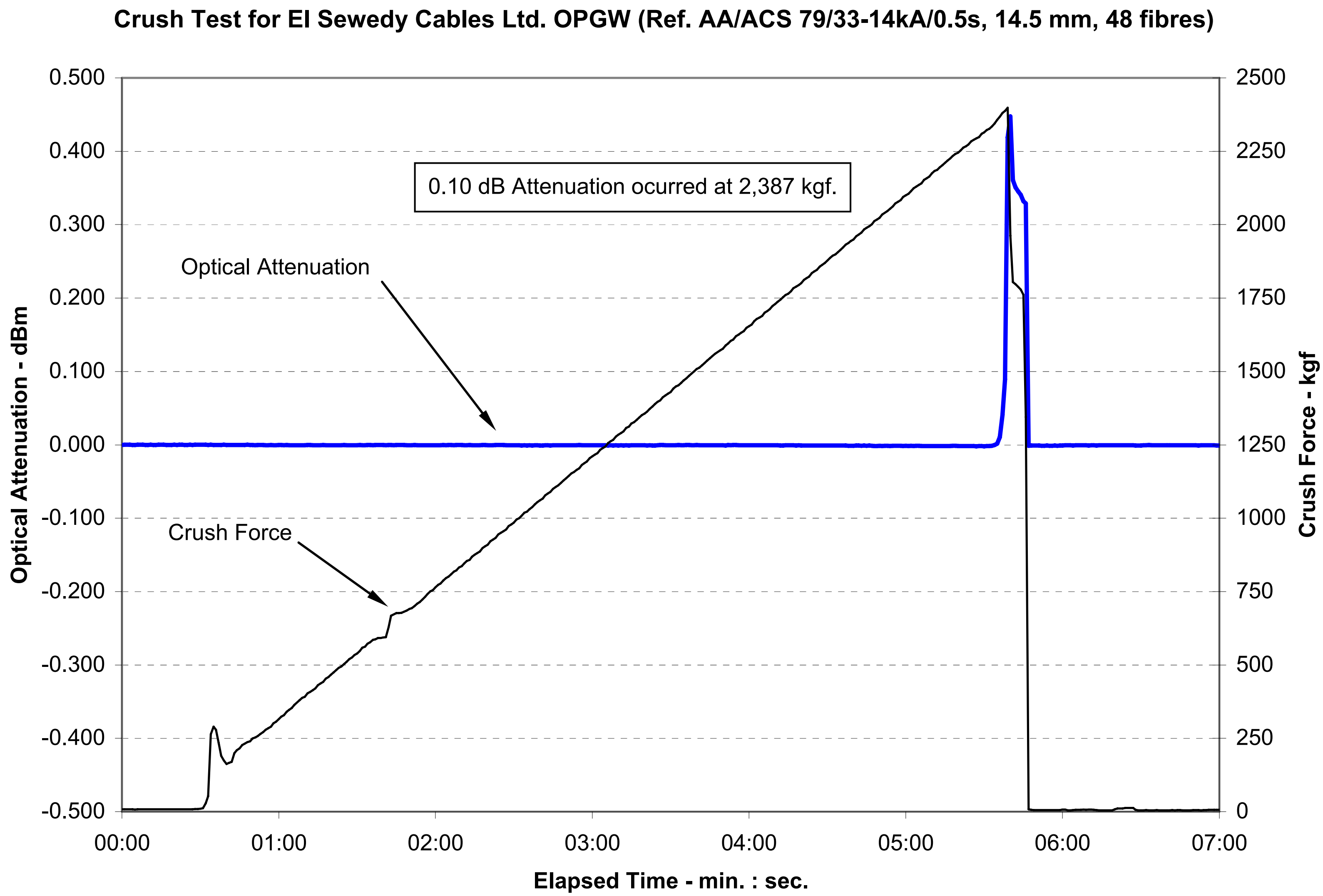


Figure 2 Optical Attenuation during Crush Test

Figure 3a   Dissected Sample from Crush test (AA wires removed)

Figure 3b   Dissected SS Tubes from Crush test

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**IMPACT TEST**
Test Date:	March 10, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Impact Test is to verify the optical performance of the OPGW cable subjected to repeated impact loading.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.7 and EIA/TIA 455-25B.

TEST SET-UP

The set-up for the Impact Test is shown in Figure 1. An untested cable section from the test sample prepared for the Sheave Test and Crush Test was used for the Impact Test.

Test Apparatus

The OPGW cable was supported on a flat steel base plate. The impact hammer was fixed to the bottom of a steel mass. The radius of the hammer was 12.5 mm. The apparatus was designed to allow a steel mass of 3.0 kgf to drop from a height of 150 mm onto the cable sample.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2.

Optical Network

Twenty-four (24) of the forty-eight (48) fibres were spliced for optical measurements.

Instrumentation and Data Acquisition

The impact counter and analog outputs of the optical power meters were monitored and recorded every second by a digital data logging system.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The 3.0 kgf mass was raised by an electric motor and released from a height of 150 mm. The hammer was prevented from subsequent impacts on the cable after the main impact. The hammer impacted the cable at a rate of approximately 30 impacts per minute. A total of twenty (20) impacts were applied to the cable.

TEST RESULTS

The optical attenuation and number of impacts plotted against time are shown in Figure 2.

There was 0.047 dB temporary increase in attenuation during the test. There was 0.017 dB permanent increase after the test was completed.

The impact area of the cable sample was dissected upon completion of this test and is shown in Figures 3a and 3b. The measured diameters of the SS tube on the impact area and on the non-impact area are shown in Table 1. The nominal diameter of the SS tube is 2.85 mm.

Table 1: Measured Diameters of Stainless Steel Tubes

SS Tube	Measurement	Under Impact Area	Under Non-Impact Area
#1 No Stripe	Minimum Diameter	1.49 mm	2.83 mm
	Maximum Diameter	3.78 mm	2.86 mm
#2 With Stripe	Minimum Diameter	2.70 mm	2.83 mm
	Maximum Diameter	2.90 mm	2.86 mm

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.7, a temporary or permanent increase in optical attenuation greater than 0.1 dB constitutes failure.

CONCLUSION

The cable, as tested, met the requirements for the Impact Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.7.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

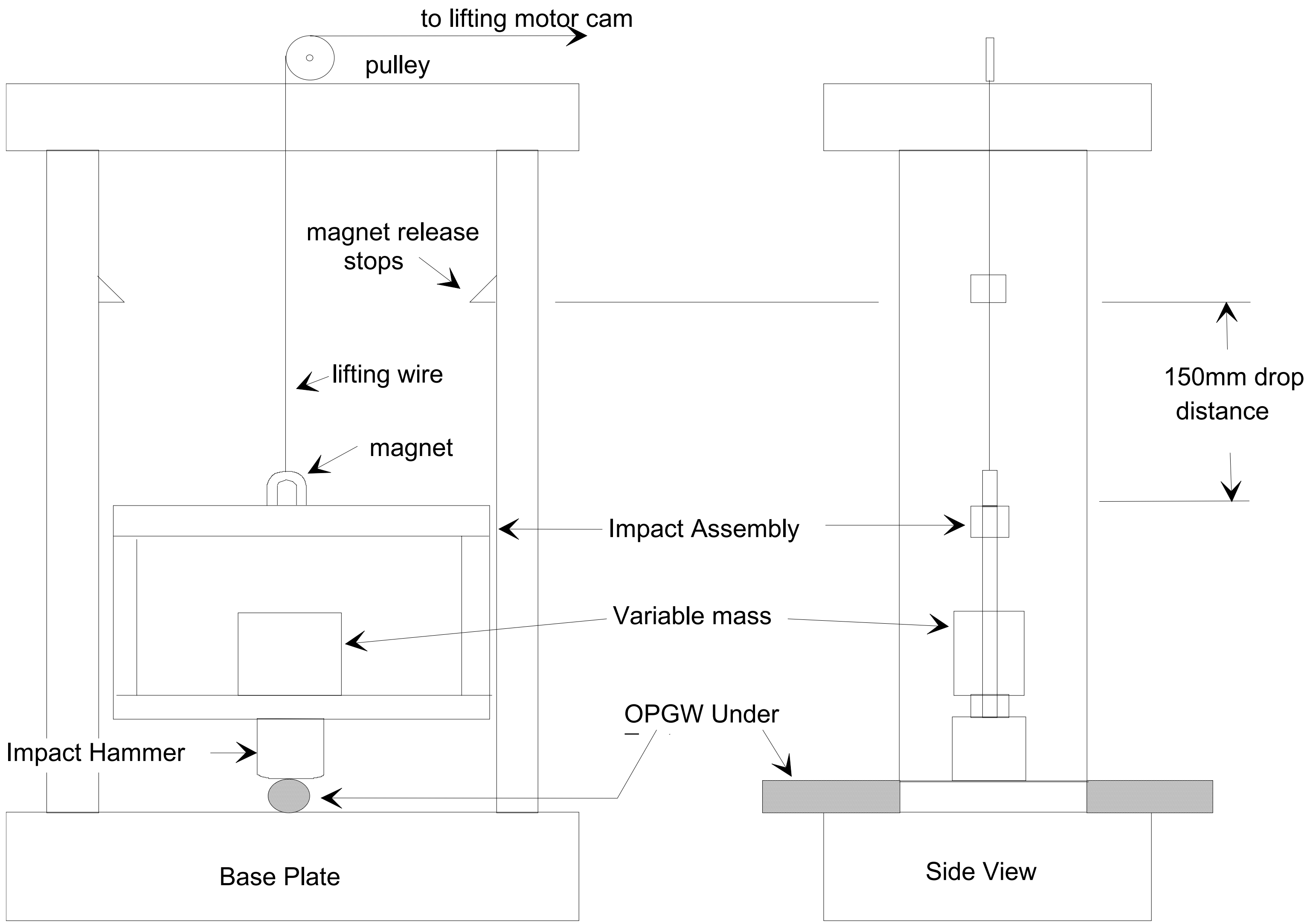


Figure 1a Set-Up for Impact Test

Figure 1b Set-Up for Impact Test

Impact Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

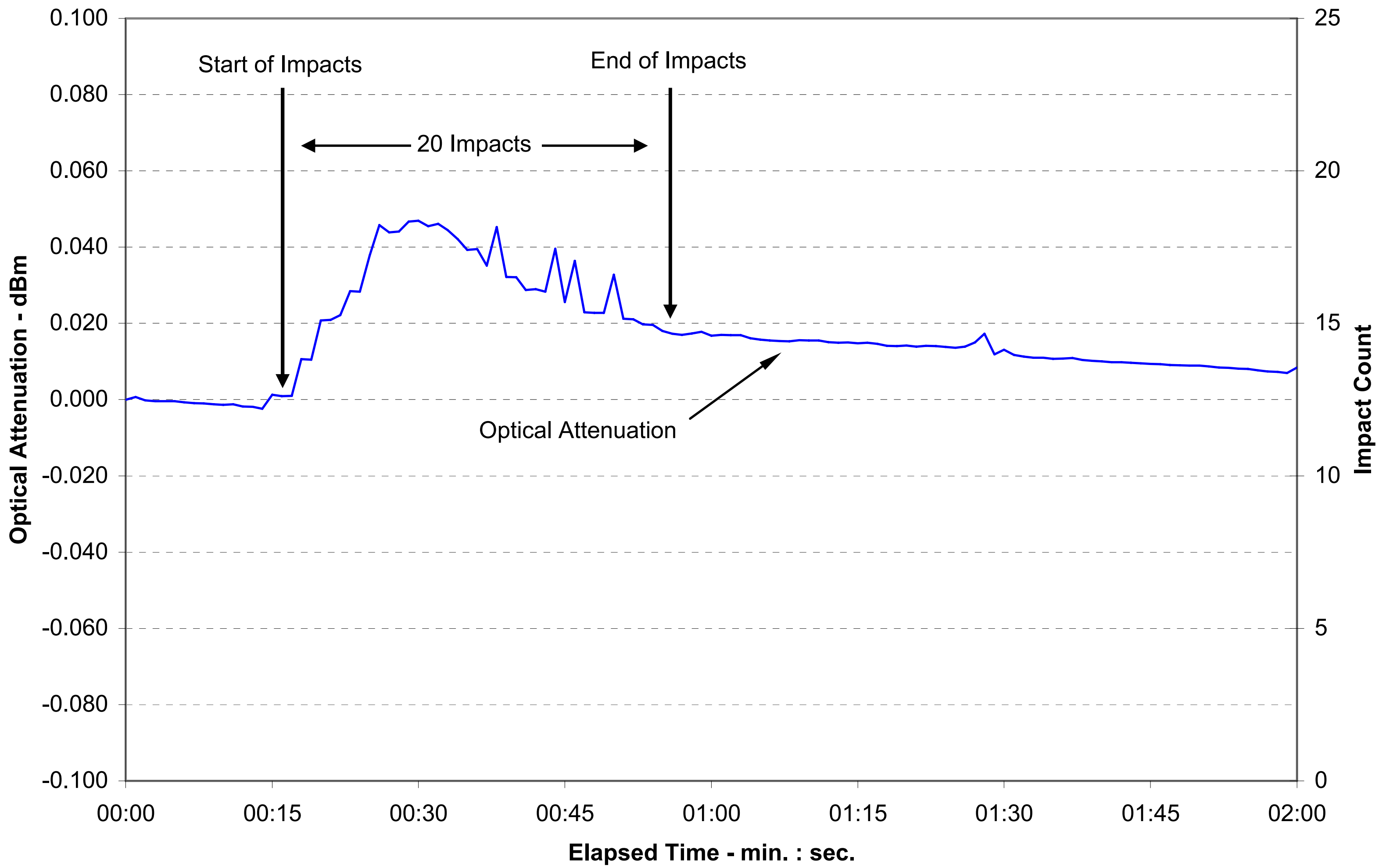


Figure 2 Optical Attenuation and Impacts vs Time

Figure 3a Dissected Sample from Impact Test (AA wires removed)

Figure 3b Dissected SS Tubes from Impact Test

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**STRESS-STRAIN AND FIBRE STRAIN TEST**
Test Date:	March 9, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	SEFAG EXPORT AG Dead-end P/N: 182 929-568
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of this test is to verify the optical and mechanical characteristics of the OPGW cable under test without optical variation up to breaking load.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.9 and 4.1.1.11.

TEST SET-UP

The set-up for the Strain Margin Test and Tensile Performance Test is shown in Figures 1a and 1b.

Test Apparatus

An OPGW sample was installed in a hydraulically activated horizontal test machine. The length of the cable between the load points of the dead-end assemblies was 13.65 m. A displacement transducer was fixed to the cable to measure cable elongation over an 8.0 m gauge length.

The OPGW sample was terminated beyond both dead-end assemblies such that the optical fibres could not move relative to the OPGW. The cable and fibre terminations and the method to measure optical attenuation are described in Appendix B.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Fibre elongation was measured using a millimetre resolution OTDR that measures the time of flight from the laser source to the receiver. By inputting the refractive index, the instrument converts the change in time of flight to change in length. For the fibre elongation measurement, four (4) fibres were spliced together to form 101.7 m (4 fibres x (16.0 m + 9.42 m)) of continuous fibre. The gauge length for fibre elongation was taken to be the length of fibre from dead-end to dead-end, plus half the length of each set of three loops beyond each dead-end. For the attenuation measurement, twenty-four (24) fibres were spliced together to form one continuous loop of 328 m (24 fibres x 13.65 m).

Instrumentation and Data Acquisition

The cable elongation, the GPIB outputs from the optical power meters, and the cable tension, as measured by the load cell, were monitored continuously using a digital data logging system. The sampling rate during loading was every one (1) second, and during holds, every ten (10) seconds. Fibre elongation measurements using the OTDR were taken manually at regular load intervals.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The cable sample was subjected to the loading schedule outlined in the Aluminum Association's "*A Method of Stress-Strain Testing of Aluminum Conductor and ACSR*".

The cable was tensioned according to the loading schedule on the following table. The loads were applied at a rate of 2,177 kgf/minute. Optical attenuation, cable tension and cable elongation were recorded throughout the test.

RTS	6,220 kgf			
Step	**% RTS**	**kgf**	**lbf**	**Hold (minutes)**
pre	**2%**	**124**	**274**	
1	**30%**	**1866**	**4,114**	**30**
2	**2%**	**124**	**274**	**2**
3	**50%**	**3110**	**6,856**	**60**
4	**2%**	**124**	**274**	**2**
5	**70%**	**4354**	**9,599**	**60**
6	**2%**	**124**	**274**	**2**

The load was then reduced and the cable strain transducer was removed. The load was then reapplied at a rate of 1,244 kgf/minute until the cable failed. Optical attenuation, fibre strain, and cable tension were recorded.

TEST RESULTS

Figure 2 shows load (cable tension) plotted against all cable strain data taken.

Figure 3 also shows load (cable tension) plotted against cable strain (%) and fibre strain (%). In this case, only those points that contribute to the stress-strain curve are plotted. For purposes of calculating fibre strain, the gauge length is taken to be 101.7 m.

Figure 4 shows optical attenuation and load (cable tension) plotted against time. The maximum attenuation, during the stress-strain test, was about 0.11 dB/km. The cable tension reached 7,558 kgf or 121.5% of the cable RTS before failure.

Table 1 shows the fibre strain versus cable tension. The fibre did not elongate during the test. There was no damage to the fibre during the test.

Table 1 (Fiber Strain vs. Cable Tension)

Cable Tension (kgf)	Fibre Length (m)	Change In Fibre Length (m)	Fibre Strain % (m/m)
124	204.8561	0.0000	0.00%
1866	204.8572	0.0011	0.00%
1866	204.8565	0.0004	0.00%
124	204.8550	-0.0011	0.00%
3110	204.8569	0.0008	0.00%
3110	204.8561	0.0000	0.00%
124	204.8540	-0.0021	0.00%
4354	204.8566	0.0005	0.00%
4354	204.8561	0.0000	0.00%
124	204.8540	-0.0021	0.00%

ACCEPTANCE CRITERIA

Stress-Strain Test - As specified in IEEE Std. 1138-1994, the maximum allowable temporary or permanent attenuation is 0.2 dB/km. Any significant damage to any component of the cable shall constitute failure.

Fibre Strain Test - As specified in IEEE Std. 1138-1994, any significant damage to any component of the cable shall constitute failure.

CONCLUSION

The cable, as tested, met the requirements for the Stress-Strain Test as specified in IEEE Std. 1138-1994.

The cable, as tested, met the requirements for the Fibre Strain Test as specified in IEEE Std. 1138-1994.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

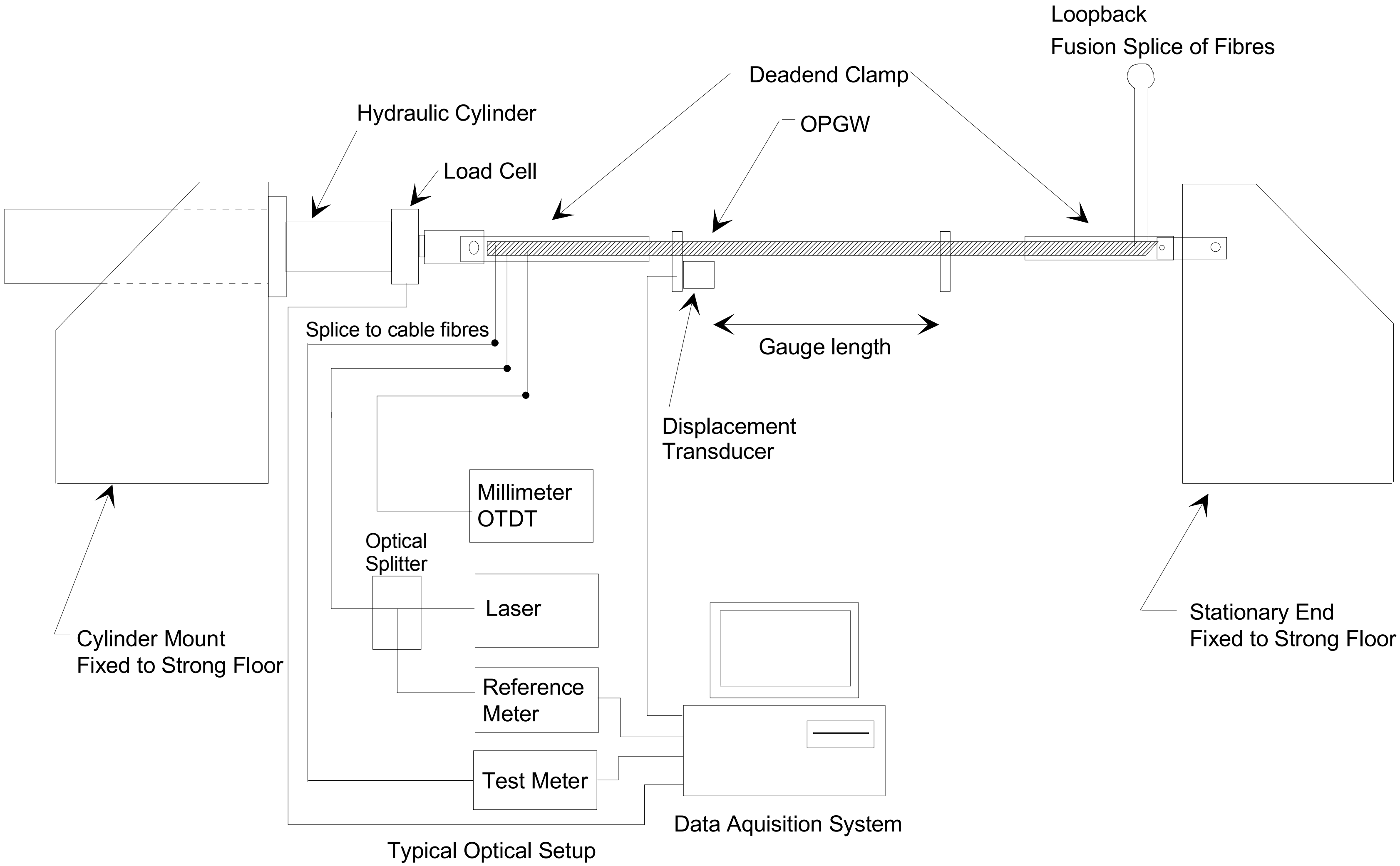


Figure 1a   Set-up for Stress-Strain/Fibre Strain Test (Schematic)

Figure 1b   Typical Set-Up for Stress Strain Test

Stress-Strain/Fibre Strain Test for El Sewedy Cables Ltd. (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

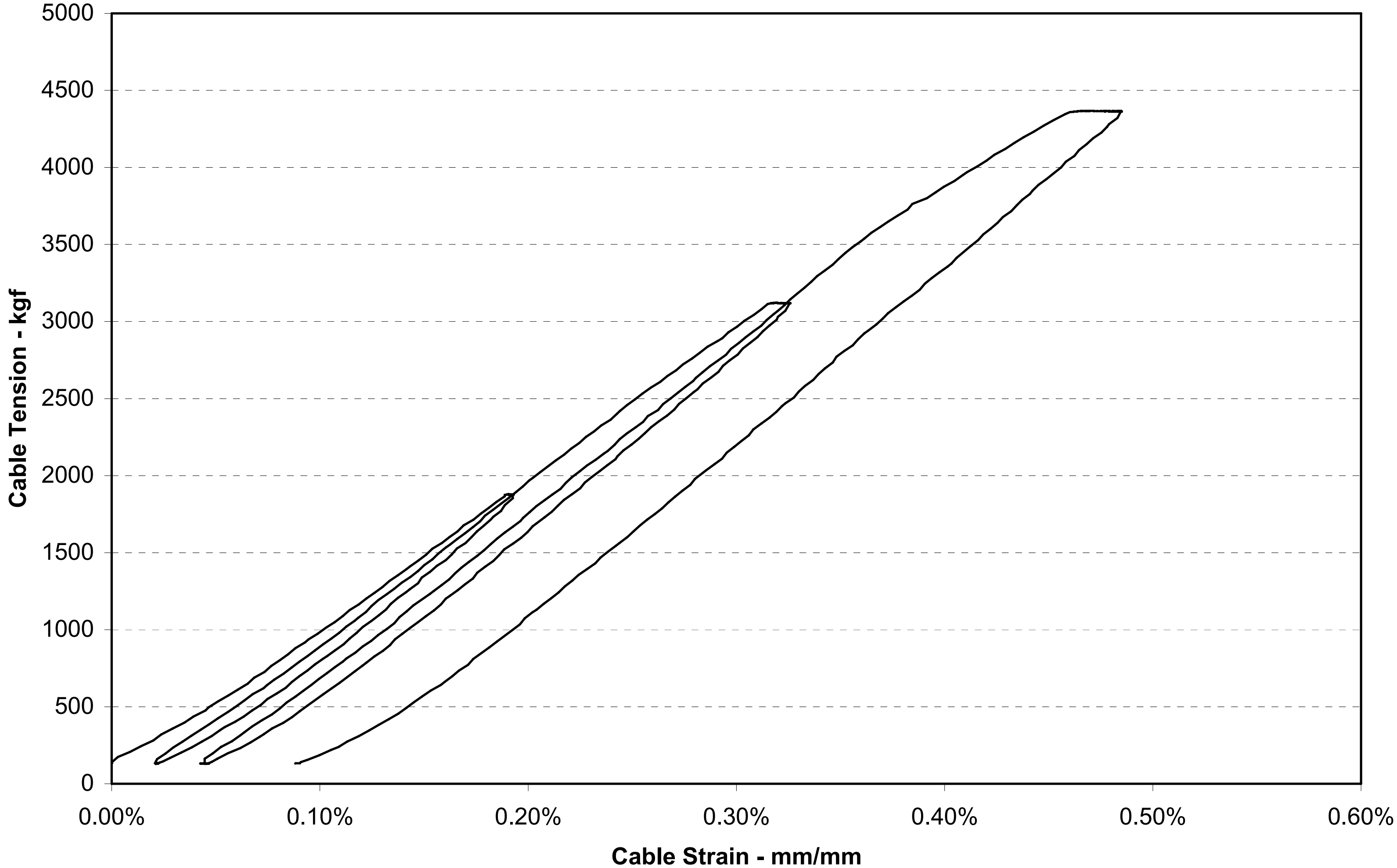


Figure 2 Load (cable tension) vs. All Cable Strain Data

Stress Strain/Fibre Strain Test for El Sewedy Cables Ltd. (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

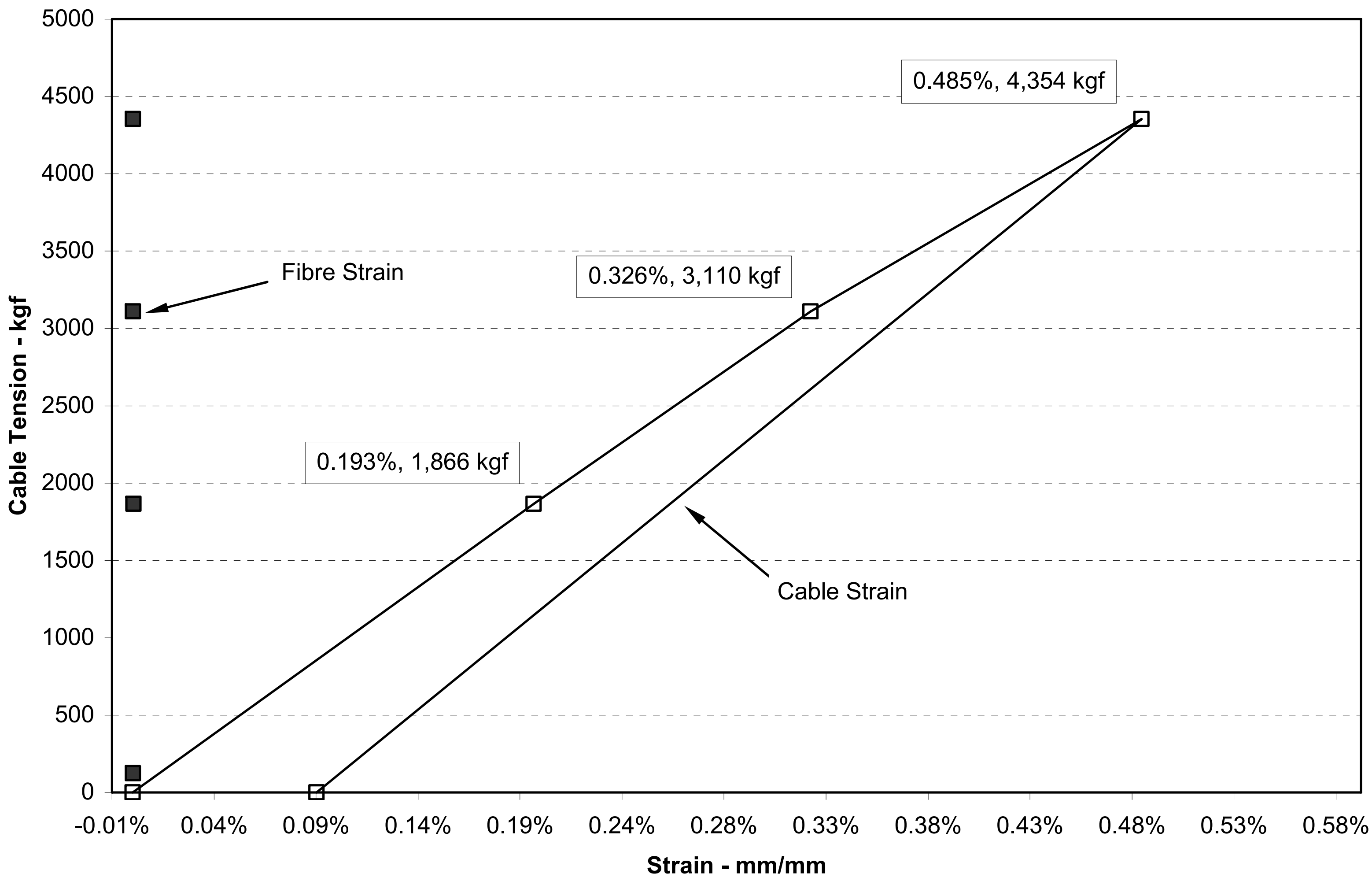


Figure 3 Load (cable tension) vs. Fibre Strain and Cable Strain for Only Those Points That Contribute to the Stress-Strain Curve

Stress-Strain/Fibre Strain Test for El Sewedy Cables Ltd. (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

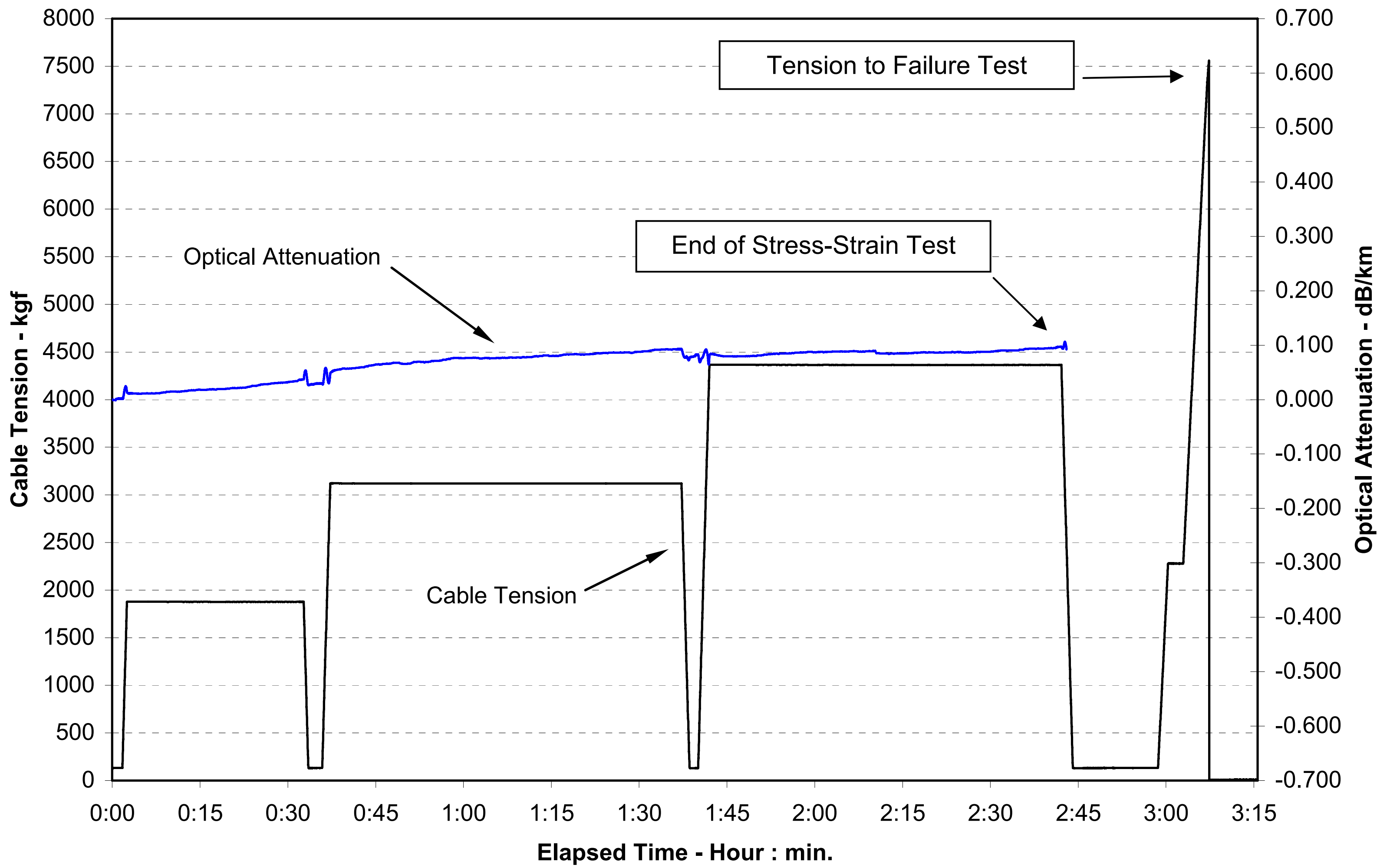


Figure 4 Load (cable tension) and Optical Attenuation vs. Time

KINECTRICS INTERNATIONAL INC. TEST REPORT
<u>FOR EL SEWEDY CABLES LTD. OPGW CABLE</u>
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**STRAIN MARGIN TEST AND TENSILE PERFORMANCE TEST**
Test Date:	March 9, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	SEFAG EXPORT AG Dead-end P/N: 182 929-568
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Strain Margin Test is to measure the loading value at which the optical fibres begin to elongate (or strain) and to verify the optical performance of the OPGW cable during the test. The objective of the Tensile Performance Test is to verify the tensile strength of the cable. This test is performed immediately following the Strain Margin Test on the same sample.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.10.

TEST SET-UP

The set-up for the Strain Margin Test and Tensile Performance Test is shown in Figures 1a and 1b.

Test Apparatus

An OPGW sample was installed in a hydraulically activated horizontal test machine. The length of the cable between the load points of the dead-end assembly was 13.17 m. A displacement transducer was fixed to the cable to measure cable elongation over an 8.0 m gauge length.

The OPGW sample was terminated beyond both dead-end assemblies such that the optical fibres could not move relative to the OPGW. The cable and fibre terminations and the method to measure optical attenuation are described in Appendix B.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Fibre elongation was measured using a millimetre resolution OTDR that measures the time of flight from the laser source to the receiver. By inputting the refractive index, the instrument converts the change in time of flight to change in length. For the fibre elongation measurement, four (4) fibres were spliced together to form 103.6 m (4 fibres x (16.48 m + 9.42 m)) of continuous fibre. The gauge length for fibre elongation was taken to be the length of fibre from dead-end to dead-end, plus half the length of each set of three loops beyond each dead-end. For the attenuation measurement, twenty-four (24) fibres were spliced together to form one continuous loop of 316 m (24 fibres x 13.17 m).

Instrumentation and Data Acquisition

The cable elongation, the GPIB outputs from the optical power meters and the cable tension as measured by the load cell were monitored continuously and recorded every one (1) second using a digital data logging system. Fibre elongation measurements using the OTDR were taken manually at regular load intervals of 125 kgf.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The loading schedule described in the procedure below was used for this test.

The cable was pre-tensioned to approximately 124 kgf or 2% of the cable RTS (6,220 kgf). At this point initial reference readings of the optical signals, cable elongation transducer and the OTDR were taken. The cable was then tensioned at 207 kgf/minute to 6,100 kgf or 98% of the cable RTS. The load was then reduced and the cable strain transducer was removed. This completed the Strain Margin Test.

The load was then increased, at a rate of 500 kgf/minute, until the cable failed. Optical attenuation and cable tension were recorded. This part of the test constituted the Tensile Performance Test and was performed after the Strain margin Test.

TEST RESULTS

Figure 2 shows load (cable tension) plotted against cable strain (%) and fibre strain (%). The strain margin is defined as the amount of stress a cable can sustain without strain on the fibre. Loading of the cable showed that the fibre began to strain between 6,200 and 6,500 kgf or between 99.7% and 104.5% of RTS. For purposes of calculating fibre strain, the gauge length is taken to be 103.6 m. The strain margin can be defined by the Y-intercept of a straight fitted through the fibre strain points above the strain margin (see red line on Figure 2). The strain margin by this definition is 6,440 kgf.

Figure 3 shows optical attenuation and load (cable tension) plotted against time. The maximum increase in optical attenuation was about 0.02 dB/km during the loading to 80%.

The cable tension reached 7,559 kgf or 121.5% of the cable RTS before failing.

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Paragraph 4.1.1.10 for the Strain Margin Test, a permanent or temporary increase in optical attenuation greater than 1.0 dB/km up to the strain margin shall constitute failure.

The actual tensile strength of the cable shall equal or exceed the rated tensile strength of the cable.

CONCLUSION

The cable, as tested, met the requirements for the Strain Margin Test as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.10.

The cable, as tested, met the requirements for the Tensile Performance Test.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

10/11-4

K-422180-RC-0001-R00

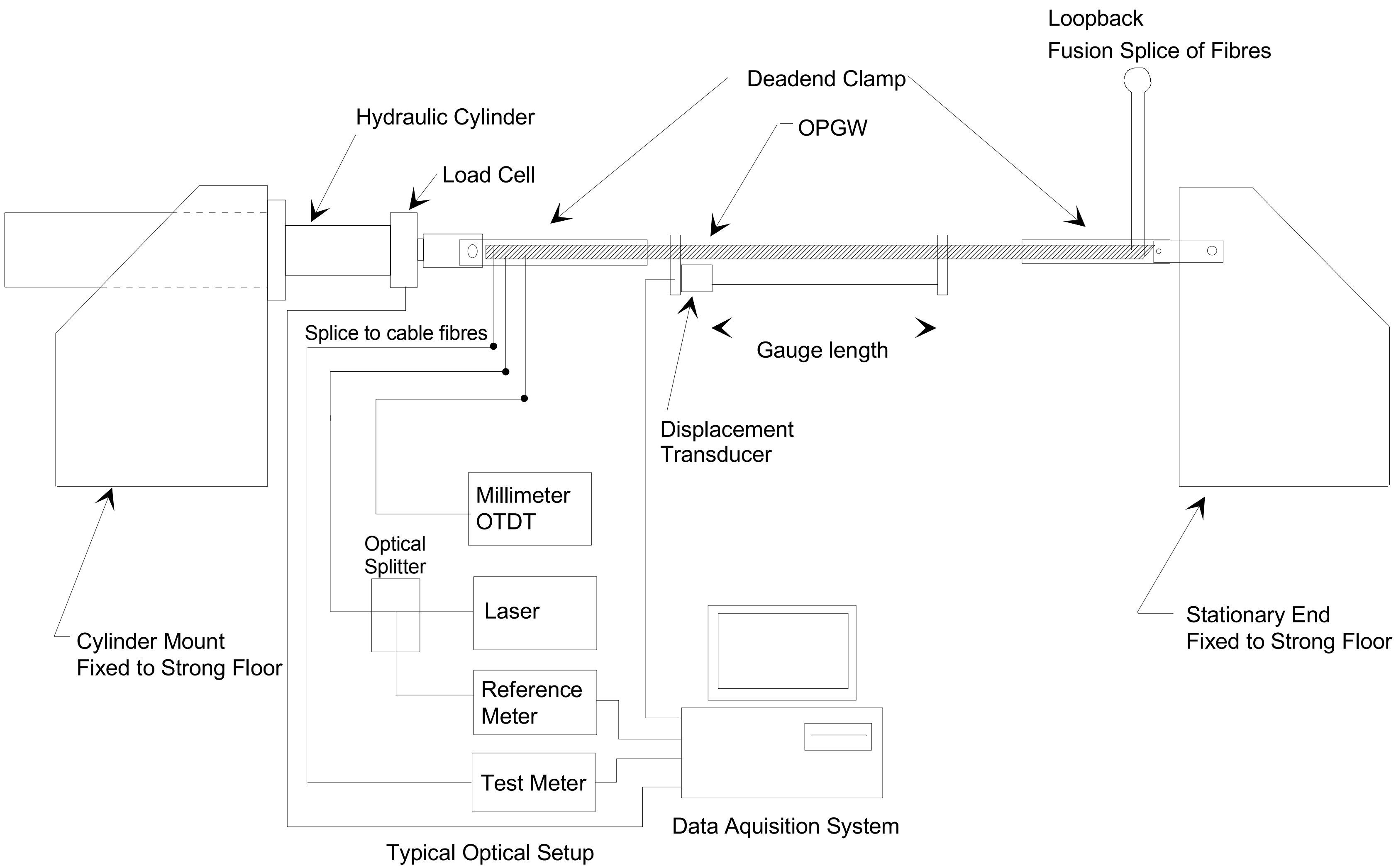


Figure 1a Set-Up for Strain Margin Test (Schematic)

Figure 1b   Typical Set-Up for Strain Margin Test

Strain Margin Test for El Sewedy Cables Ltd. (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

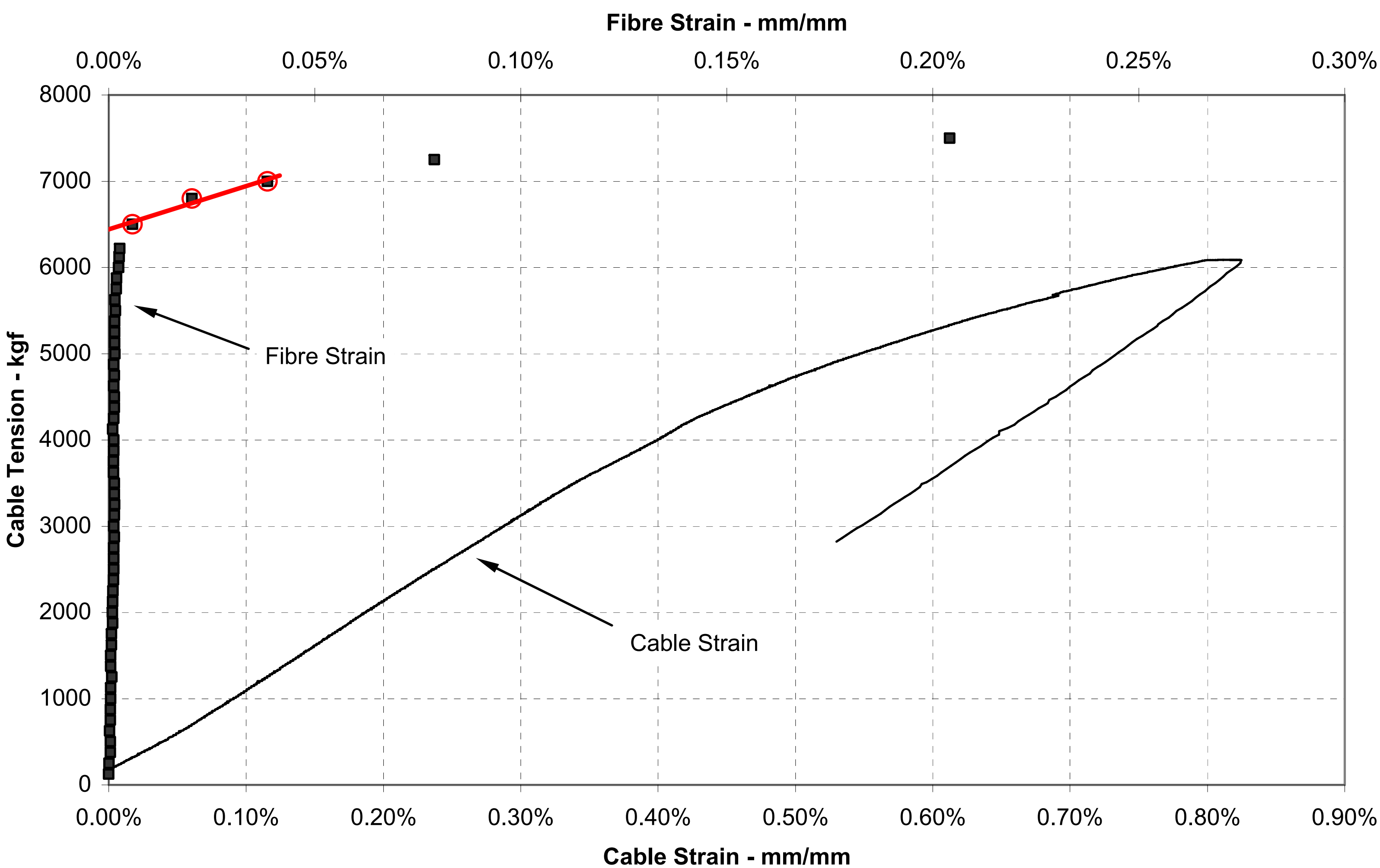


Figure 2: % Cable Strain and % Fibre Strain vs Cable Tension

10/11-6

K-422180-RC-0001-R00

10/11-7

K-422180-RC-0001-R00

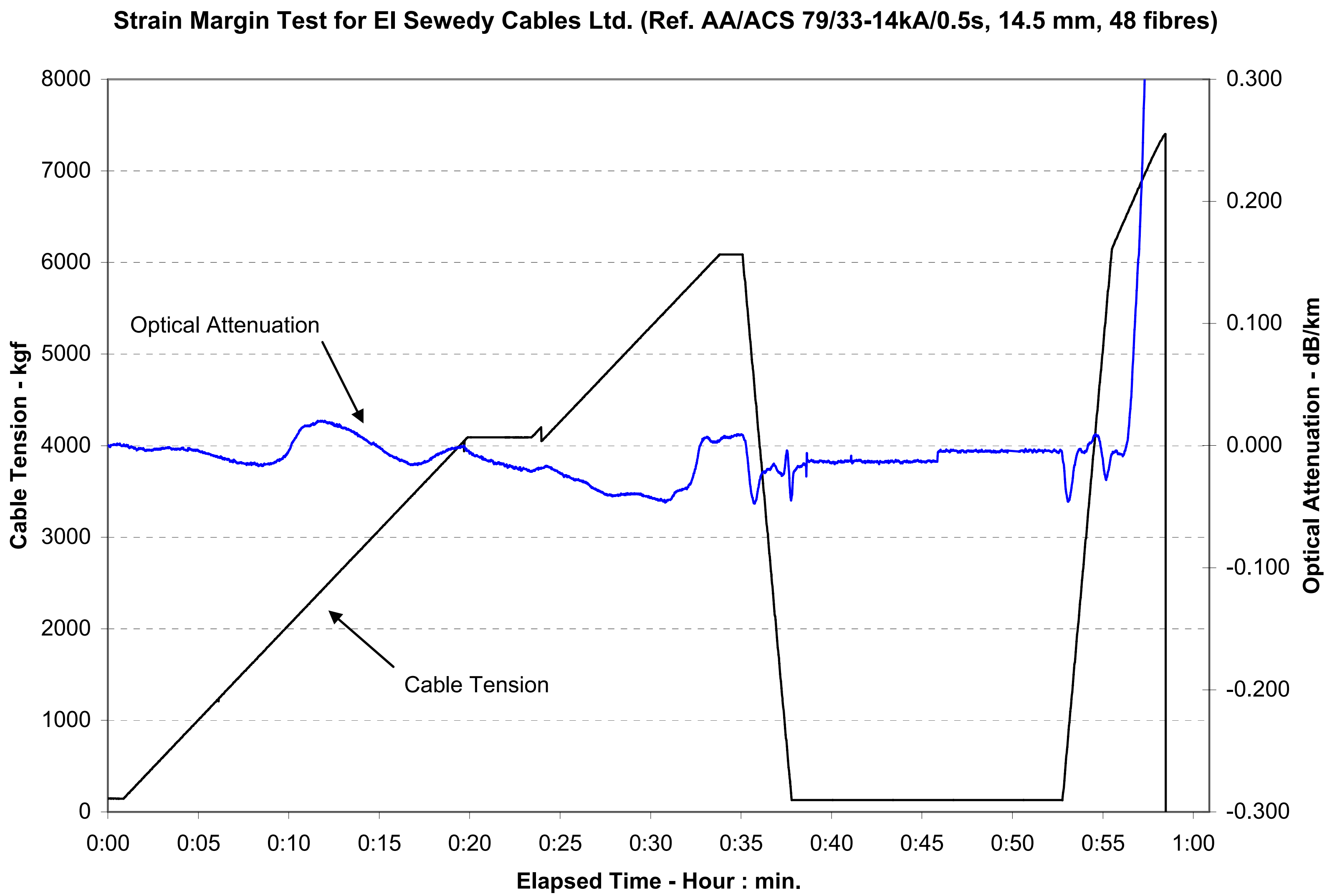


Figure 3 Optical Attenuation and Cable Tension vs Time

KINECTRICS INTERNATIONAL INC. TEST REPORT
<u>FOR EL SEWEDY CABLES LTD. OPGW CABLE</u>
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**TEMPERATURE CYCLING TEST**
Test Date:	March 8-10, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of this test was to verify the good performance of the fibre when the cable is subjected to extreme thermal cycles.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Par 4.1.1.13 and EIA-455-3A.

TEST SET-UP

The set-up for the Temperature Cycling Test is shown in Figure 1.

Test Apparatus

A coiled sample of OPGW approximately 100 m in length was placed in a 1 m x 1 m x 1 m environmental chamber.

Two (2) thermocouples were placed in the environmental chamber to measure the temperature. One thermocouple was attached to the 100 m test sample. The second thermocouple was placed on separate 25 cm cable sample and located next to the test sample.

Optical Network

All forty-eight (48) fibres were spliced to form one continuous loop. The total test fibre length under test was approximately 4.8 km. The method for measuring optical attenuation is described in Appendix B.

Instrumentation and Data Acquisition

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The cable was subjected to two (2) thermal cycles. A thermal cycle was based on the chamber temperature starting at 20ºC, lowering to -40ºC and holding for a minimum of 8 hours. The chamber temperature was then increased to 85ºC and held for a minimum of 8 hours. To complete the cycle, the chamber temperature was returned to 20ºC. All temperature transitions were conducted at a rate of 20ºC/hour. The chamber temperature is based on the average of the two thermocouples.

The cable reel temperature and optical data were recorded every 5 minutes throughout the test.

TEST RESULTS

Optical attenuation, and chamber temperature vs. time are shown in Figure 2. The variation in optical attenuation due to temperature was no greater than 0.005 dB/km.

ACCEPTANCE CRITERIA

As specified in IEEE Std. 1138-1994, Par 4.1.1.13 and EIA-455-3A, the maximum allowable change in attenuation is 0.2 dB/km.

CONCLUSION

The cable, as tested, met the requirements for the Temperature Cycling Test as specified in IEEE Std. 1138-1994, Par 4.1.1.13 and EIA-455-3A.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

Figure 1 Set-up for Temperature Cycling Test

Temperature Cycling Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

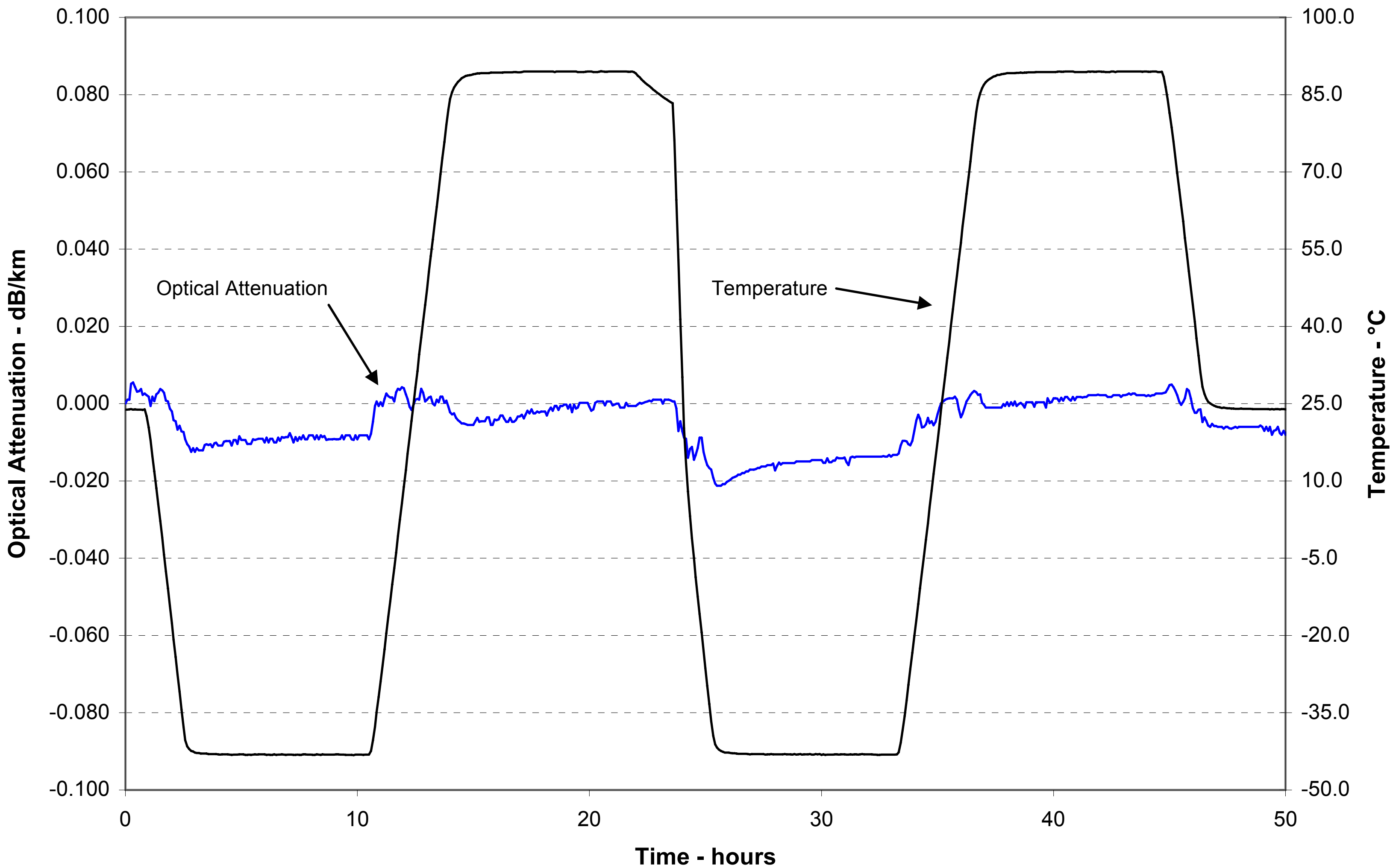


Figure 2 Temperature and Optical Attenuation vs. Time

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**SHORT TERM AND LONG TERM MINIMUM BENDING RADIUS TEST**
Test Date:	March 8-9, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Short Term and Long Term Minimum Bending Radius Test is to determine the effect of bending on the OPGW cable when fixed in a bend configuration for different periods of time.

TEST STANDARD

The Short Term Minimum Bending Radius test was performed in accordance with IEC 60794-1-2, Method E11B, Bend Test-Procedure 2. The Long Term Minimum Bending Radius test was performed in accordance with IEC 60794-1-2, Method E11A, Bend Test-Procedure 1.

TEST SET-UP

An untested portion of the test sample from the Sheave Test and Crush Test was used for the Bend Test.

Short Term Minimum Bending Radius - The apparatus used for this test is shown in Figure 1. The cable was forced to bend backward and forward in a "U" shape. The mandrels used for this test were positioned such that the cable could bend in a full "U" shape. The cable was bent manually by hand backward and forward around the mandrels.

Long Term Minimum Bending Radius – The apparatus used for this test is shown in Figure 2.

The tests were carried out in an indoor laboratory at 20ºC ± 5ºC.

Optical Network

Twenty-four (24) of the forty-eight (48) fibres were spliced together to form one continuous loop. The cable and fibre terminations and the optical power measurement method are described in Appendix B.

Instrumentation and Data Acquisition

The GPIB outputs of the optical power meters were monitored and recorded every one-third second by a digital data logging system.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

Short Term Minimum Bending Radius – The sample was bent manually around a mandrel through 180º (U-Bend) and kept hand taut during the bending. A cycle consists of one U-bend followed by a reverse U-bend. The total angle that the cable was forced to bend was +/-180˚. The diameters of the test mandrels were 800 mm, 610 mm, 407 mm, 345 mm, and 290 mm.

Long Term Minimum Bending Radius – The cable was wrapped two (2) complete turns around a 460 mm diameter mandrel and held tightly against the mandrel for 24 hours.

TEST RESULTS

Short Term Minimum Bending Radius - The optical attenuation recorded during this test is shown in Figure 4. The maximum optical attenuation measured during the test was 0.005 dBm.

Long Term Minimum Bending Radius - The optical attenuation recorded during this test is shown in Figure 5. The maximum optical attenuation measured during the test was 0.031 dBm.

ACCEPTANCE CRITERIA

Short Term Minimum Bending Radius - The maximum allowable attenuation is 0.1 dB for the Bend Test.

Long Term Minimum Bending Radius - The maximum allowable attenuation is 0.1 dB for the Bend Test.

CONCLUSION

Short Term Minimum Bending Test - The cable, as tested, met the requirements for the Short Term Minimum Bending Test

Long Term Minimum Bending Test - The cable, as tested, met the requirements for the Long Term Minimum Bending Test.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

Figure 1 Test Apparatus for Minimum Bending Radius Short-Term Bend Test

Figure 2 Test Apparatus for Minimum Bending Radius Long-Term Bend Test

Short Term Min. Bending Radius Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

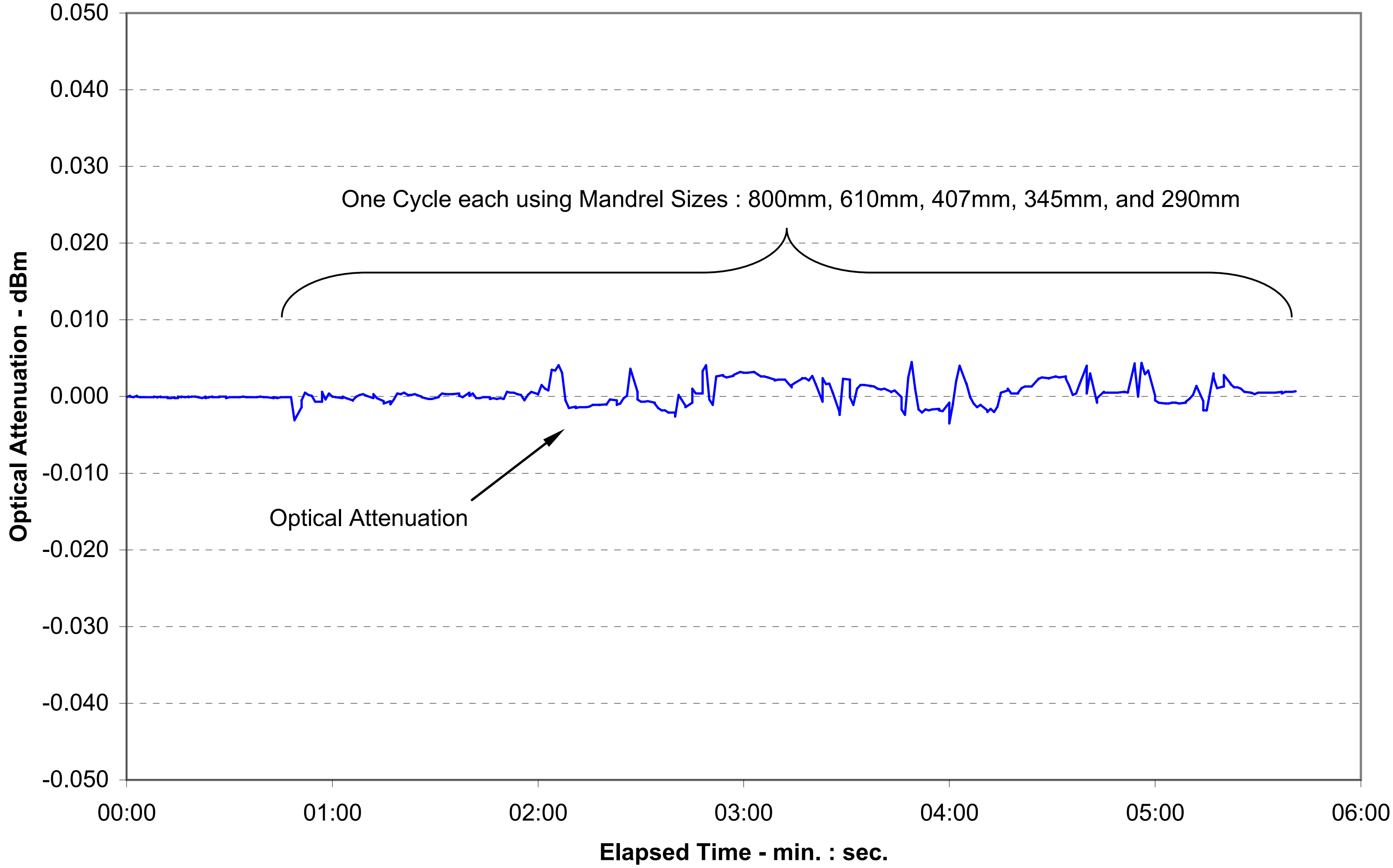


Figure 3 Optical Attenuation vs. Time

Long Term Min. Bending Radius Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

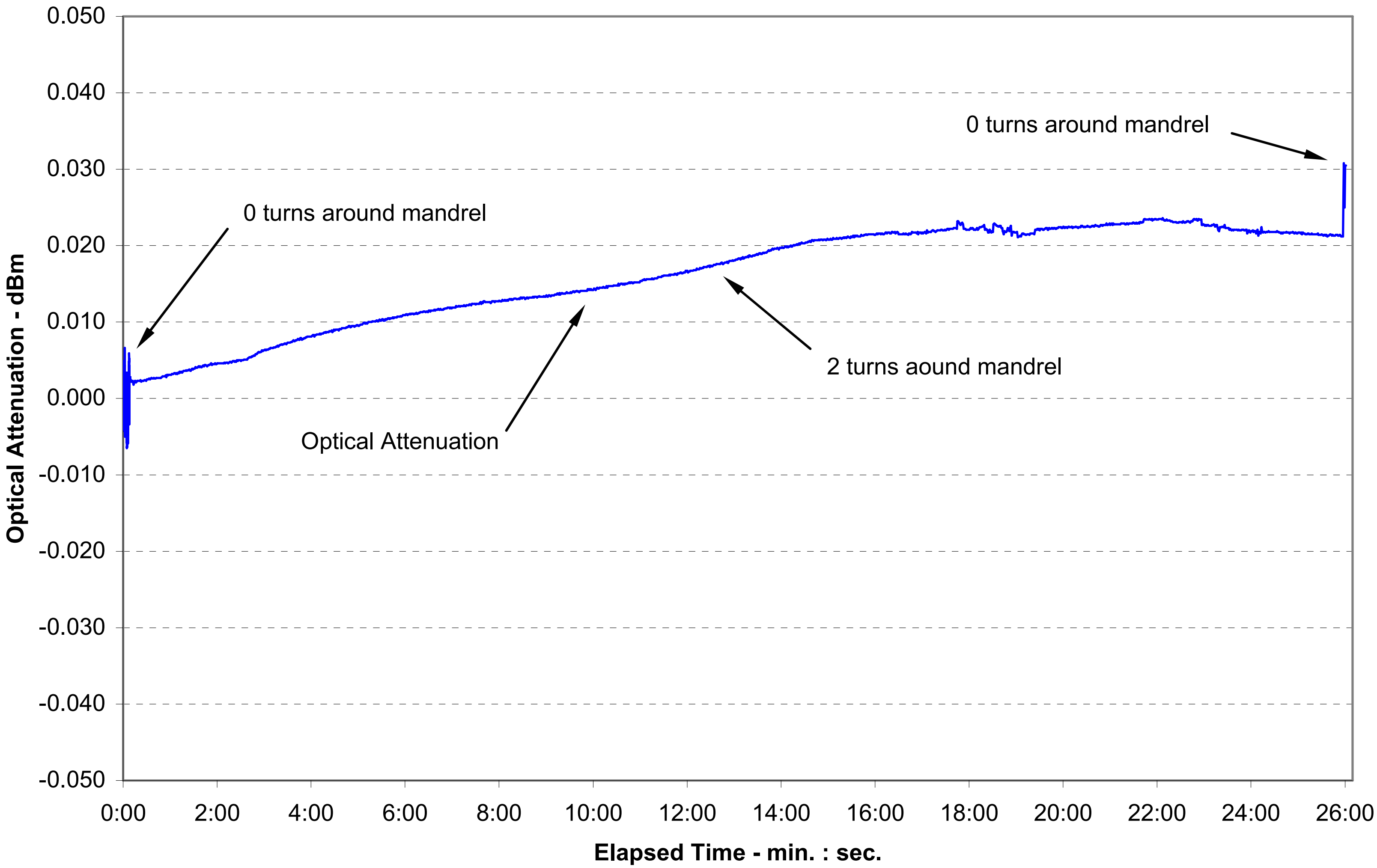


Figure 4 Optical Attenuation vs. Time

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**SALT SPRAY CORROSION TEST**
Test Date:	February 1 – March 15, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of this test was to determine the effects of a controlled salt-laden atmosphere on the OPGW sample.

TEST STANDARD

The test was performed in accordance with EIA/TIA-455-16A and ASTM B117-03.

TEST SET-UP

The salt spray chamber designed to meet ASTM B117-1994 was used to perform the test. The chamber has a salt-solution reservoir that is capable of maintaining an adequate solution. There is equipment to atomize the salt-solution including suitable nozzles and compressed air to provide a uniform spray within the chamber. The temperature of the chamber can also controlled. The facility used to perform the test was an Industrial Filter and Pump 411.3ACD salt spray chamber and is shown in Figure 1.

Optical Network

Optical measurements were not required for this test.

TEST PROCEDURE

The fog chamber was programmed to provide a finely divided, wet dense fog while the air supply to the atomizer was maintained at a relative humidity of 95% to 98%. The chamber air temperature was maintained at 35 °C ± 1. The salt solution was 5% concentration and was prepared by dissolving by weight, 5 +/-1 parts of de-mineralized salt in 95 parts of de-ionized water. The quantity of collected salt spray was maintained at between about 1 to 2 ml/hour, as measure by a collecting area of 80 square cm. The pH of the collected solution was maintained between 6.5 to 7.2 at 25ºC, by adding the appropriate amount of sodium hydroxide.

Five (5) complete cable samples cut to about 80 cm in length were used for the test. Three (3) complete samples were placed in the chamber with an angle 20° from vertical. The fourth sample was dissected and the individual wires were also placed in the chamber with an angle 20° from vertical. They were exposed to a salt spray for 1000 hours. Prior to insertion into the chamber, the samples were suitably cleaned to remove any contaminants. Tie-wraps were used to hold both ends of the sample in place. Silicon rubber was used to seal the ends of the sample. The samples in the chamber are shown in Figure 2.

The fifth sample was used for the “untested” sample. Six (6) of the twelve (12) aluminum alloy strands and all five (5) aluminum clad steel strands were tensioned to failure to establish a base line for the initial reference strength.

After completion of the salt spray test, six (6) of the twelve (12) aluminum alloy strands and all five (5) aluminum clad steel strands from one (1) of the three (3) complete tested cable samples were tensioned to failure. Six (6) of the twelve (12) aluminum alloy strands and all five (5) aluminum clad steel strands of the individual wires were tensioned to failure.

The measuring instruments used in this test are listed in Appendix C.

TEST RESULTS

Photographs of the tested and untested samples are shown in Figures 3a, 3b, 3c, and 3d. The breaking strength of the individual strands are listed in Table 1. The average tensile strength of all the tested strands had breaking strengths greater than 90% of the average reference strands.

Table 1 Breaking Strength of Individual Strands

Strand No.	"Untested" Breaking Strength (kgf)	Breaking Strength After Salt Spray, kgf (% of "Average Untested")	
		Complete Sample	Individual Wires
AA-1	217	216 (99.1)	219 (100.5)
AA-2	219	223 (102.3)	221 (101.4)
AA-3	221	219 (100.5)	219 (100.5)
AA-4	218	218 (100)	220 (100.9)
AA-5	217	215 (98.6)	217 (99.5)
AA-6	217	221 (101.4)	218 (100)
Average	**218**	**219 (100.5)**	**219 (100)**
ACS-1	920	921 (100.1)	923 (100.3)
ACS-2	923	906 (98.5)	913 (99.2)
ACS-3	910	919 (99.9)	926 (100.7)
ACS-4	926	922 (100.2)	923 (100.3)
ACS-5	921	923 (100.3)	915 (99.4)
Average	**920**	**918 (99.8)**	**920 (100)**

ACCEPTANCE CRITERIA

The average tensile strength of the strands subjected to the salt spray test must be greater than 90% of the average tensile strength of untested strands.

CONCLUSION

The cable, as tested, met the requirements for the Salt Spray Corrosion Test as specified by EIA/TIA-455-16A.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

Figure 1   Industrial Filter and Pump, Model 411.3ACD Salt Spray Chamber

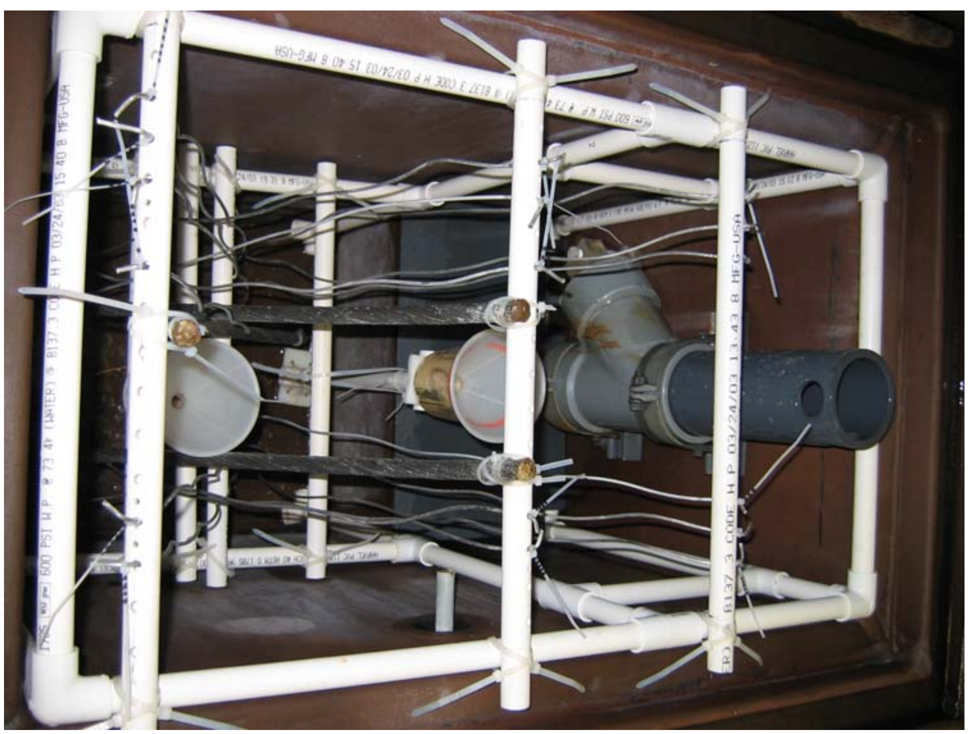


Figure 2   Setup of Samples in the Salt Spray Chamber

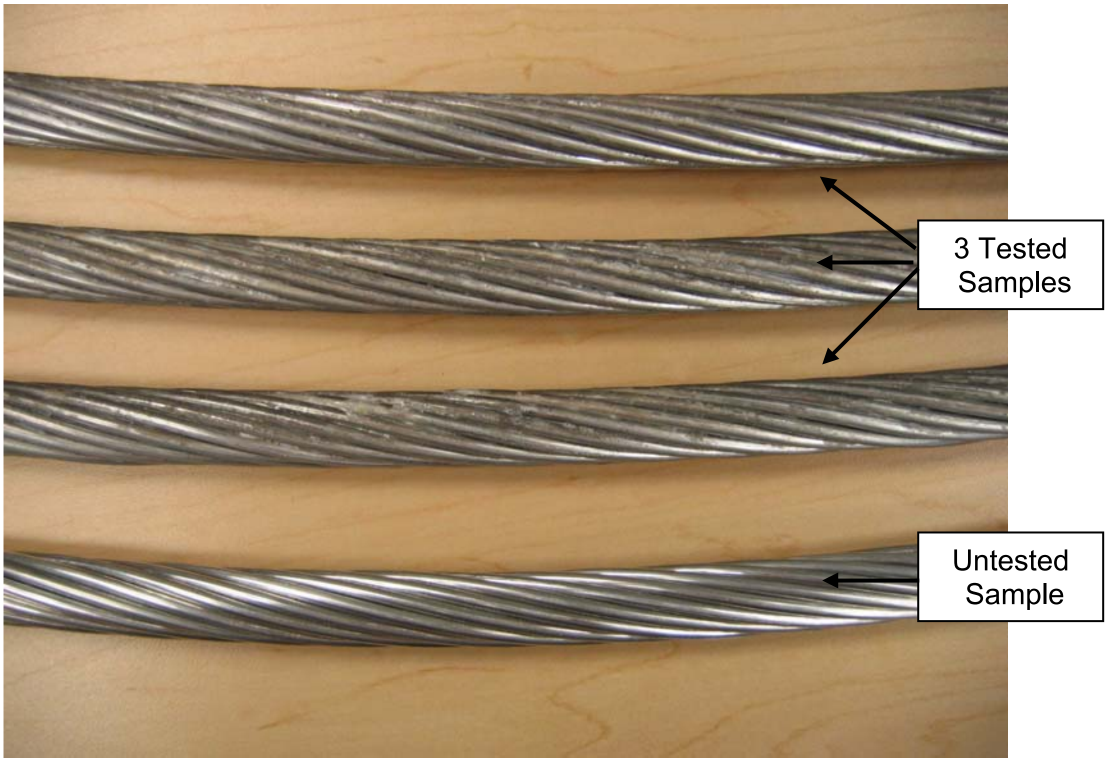


Figure 3a 3 Tested Samples and 1 Untested Sample

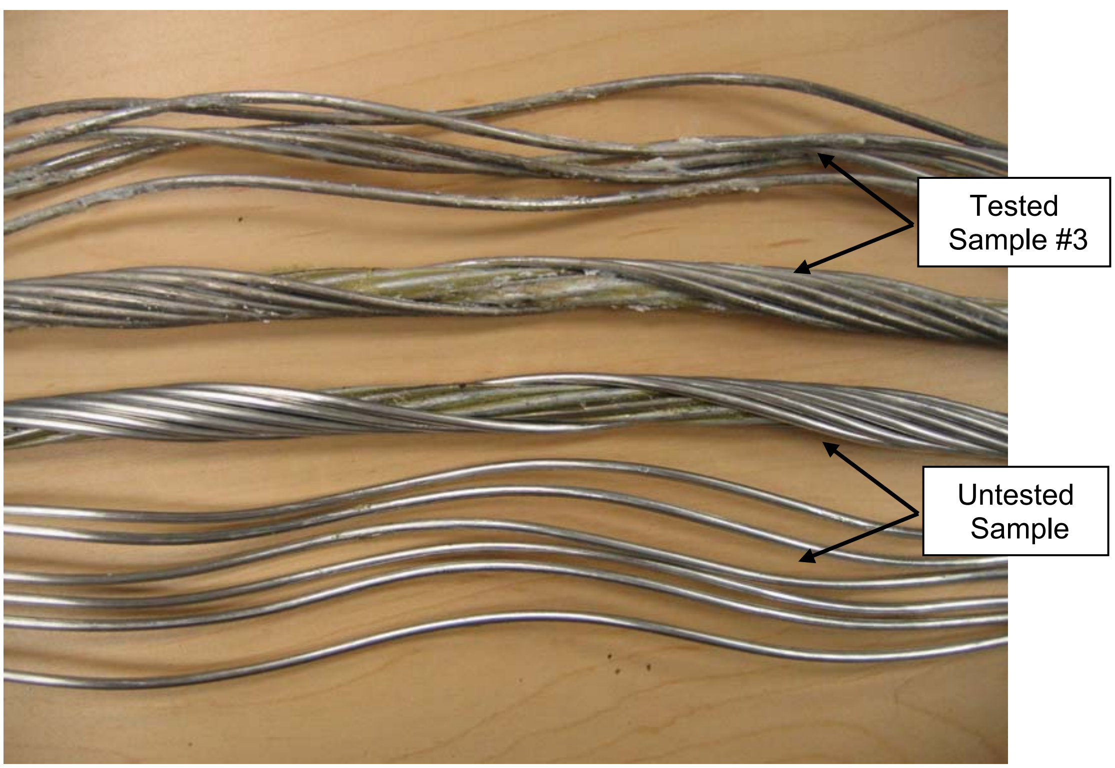


Figure 3b Tested and Untested Samples Partially Dissected

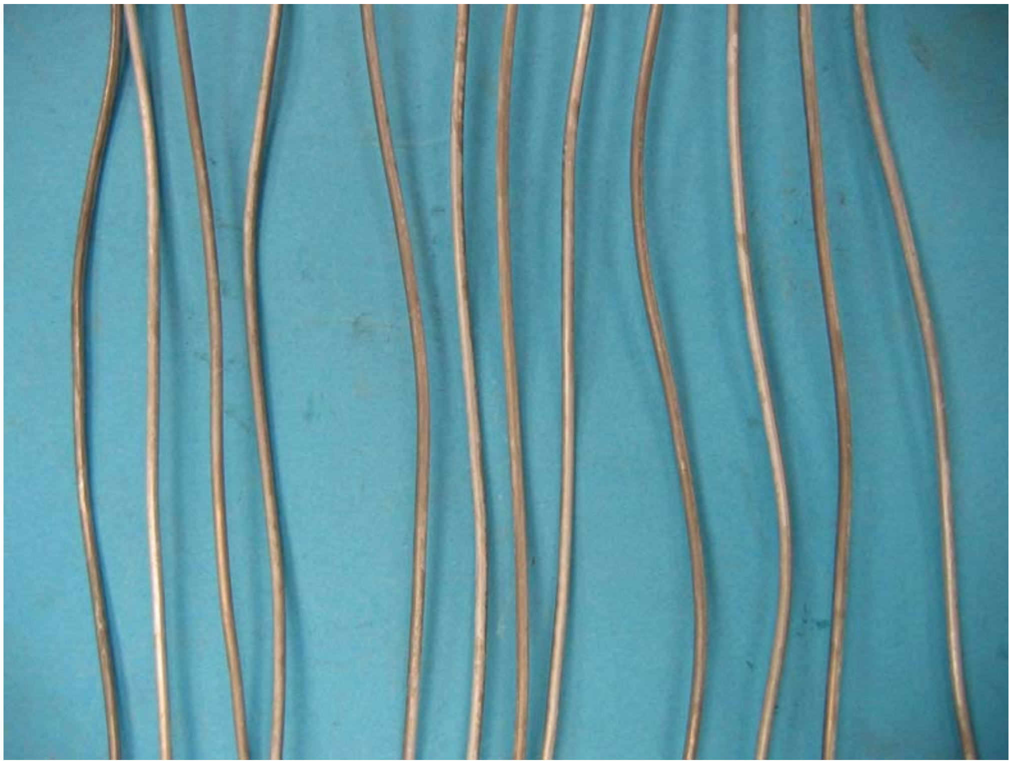


Figure 3c 12 Tested Individual AA Wire Samples after 1000 hours

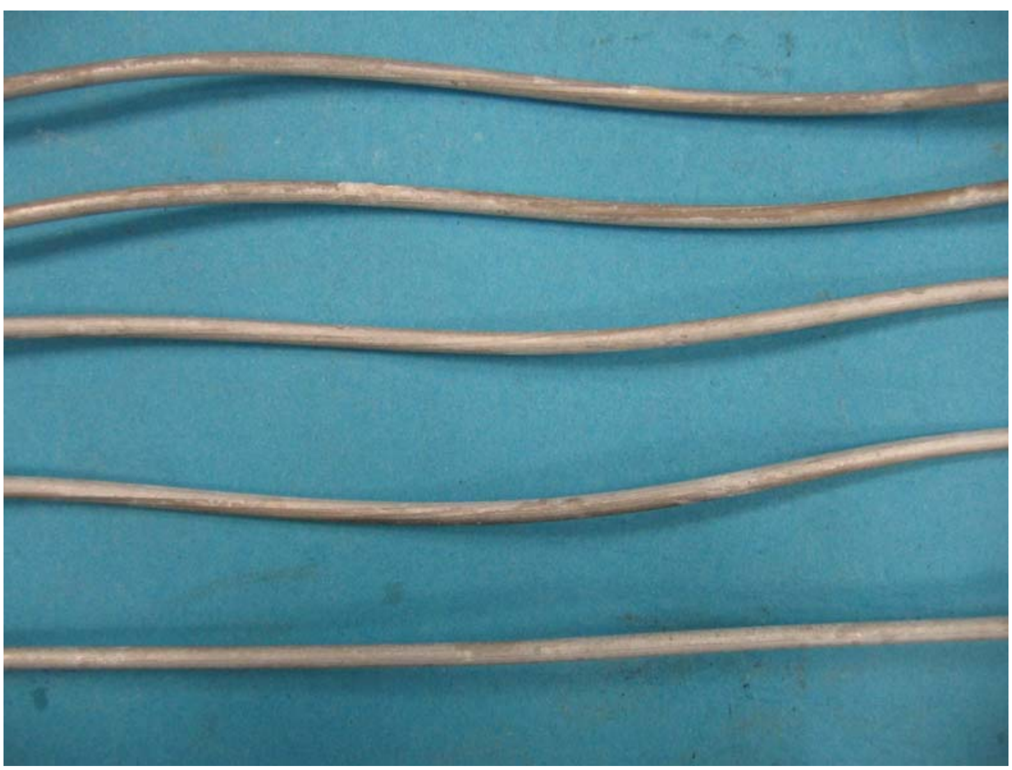


Figure 3d 5 Tested Individual ACS Wire Samples after 1000 hours

KINECTRICS INTERNATIONAL INC. TEST REPORT
<u>FOR EL SEWEDY CABLES LTD. OPGW CABLE</u>
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**LIGHTNING ARC TEST**
Test Date:	March 17, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	SEFAG EXPORT AG Dead-end P/N: 182 929-568
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale Ms. Jody Levine Mr. George Gouliaras
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of this test was to verify the ability of the OPGW to withstand a lightning strike.

TEST STANDARD

The test was performed in accordance with IEC 60794-1-2, Section 38, Method H2.

TEST SET-UP

Figure 1 shows a schematic diagram of the configuration for this test.

Test Apparatus

An OPGW sample was installed between two fixed abutments. The length of the cable between the load points of the dead-end assembly was 11.0 m. A load cell was installed at one end to measure the tension in the cable.

Optical Network

Twenty-four (24) of the forty-eight (48) fibres of the test cable sample were spliced together to form one continuous loop. The test sample was terminated beyond both dead-ends such that the optical fibres could not move relative to the OPGW. The cable and fibre terminations and the method for measuring optical attenuation are described in Appendix B.

Instrumentation and Data Acquisition

The GPIB outputs of the optical power meters were monitored and recorded every one-third second by a digital data logging system. The load cell readings were manually recorded.

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

Five (5) sections of the cable sample were tested separately as follows.

Each section was tensioned to 933 kgf or 15% of the cable RTS. The test conditions were based on Table 2, Class 1 parameters. A nominal arc current of 200 A with negative polarity was applied to the cable through a one (6) cm long thin filament. The filament was blown and the current increased and created an arc to the cable. The duration of the arc was nominally 0.50 seconds. This produced a nominal charge transference of 100 coulombs. The tolerance on the charge transference was ±10% (i.e. 90 C – 110 C). The tests were carried out at room ambient temperature.

After the Lightning Arc test, the remaining breaking strength was calculated for each of the five (5) sections of the cable sample.

RESULTS

A summary of the test results is listed in Table 1. There was no increase in optical attenuation during the tests. The optical attenuation versus time for the five (5) arcs are shown in Figures 2a, 3a, 4a, 5a, and 6a. The current waveforms for arcs are shown in Figures 2b, 3b, 4b, 5b and 6b. Photographs of the arcs are shown in Figures 2c, 3b, 4b, 5b and 6b.

Table 1 Summary of Test Results

Test (Figure)	Total Charge (coulombs)	Change in Attenuation Before/After (dBm)	Cable Tension During Test (kgf)	Number of Broken Wires	Calculated Residual Strength (kgf)	% of RTS
2a,b,c (Hit 1)	95	0.00	934	2	5,784	93
3a,b,c (Hit 2)	98	0.00	930	4	5,348	86
4a,b,c (Hit 3)	107	0.00	934	3	5,566	89
5a,b,c (Hit 4)	111	0.00	934	3	5,566	89
6a,b,c (Hit 6)	95	0.00	930	1	6,002	96

No ACS wires in the first (inner) layer were damaged or broken during the tests.

The residual remaining strength for each of the five (5) sections of the cable sample was calculated by subtracting the breaking strength for each broken AA wires from the cable RTS (6,220 kgf). The value used for the breaking strength for each individual AA wire was taken from the Table 1 of the Salt Spray Corrosion Test. This breaking strength was obtained by performing a tension to failure on 5 untested wire samples. This value was measured to be 218 kgf.

ACCEPTANCE CRITERIA

As specified in IEC 60794-1-2, Section 38, Method H2.

The average residual strength of the OPGW cable shall not be less than 75% of the cable rated tensile strength. The optical attenuation during the test shall not exceed 1.0 dBm.

CONCLUSION

The cable, as tested, met the requirements for the tensile strength for the Lightning Arc Test as specified by IEC 60794-1-2.

The cable, as tested, met the requirements for the optical attenuation of 1.0 dBm during the test.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

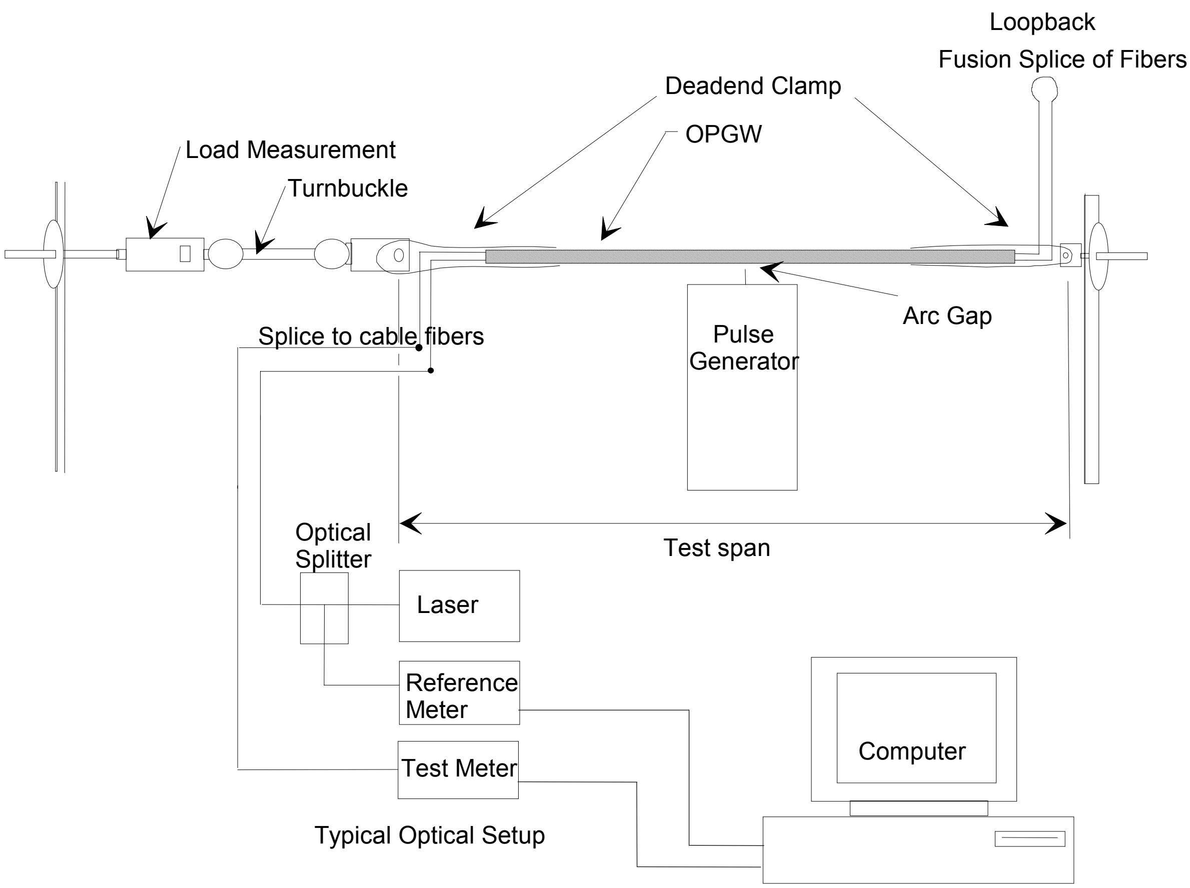


Figure 1 Set-up of Lightning Arc Test (Schematic)

Lightning Arc Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

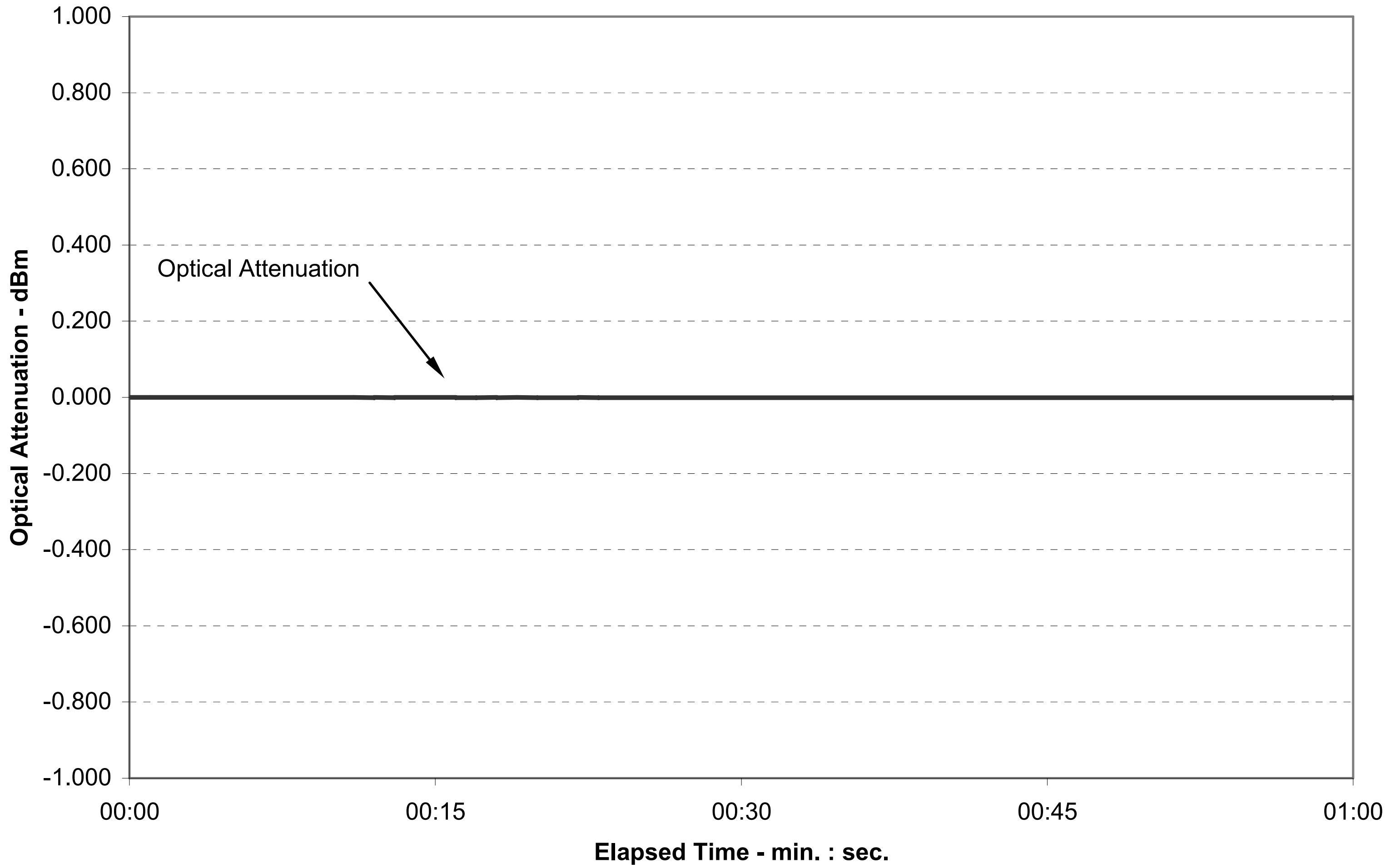


Figure 2a Optical Attenuation for Lightning Arc – Hit 1

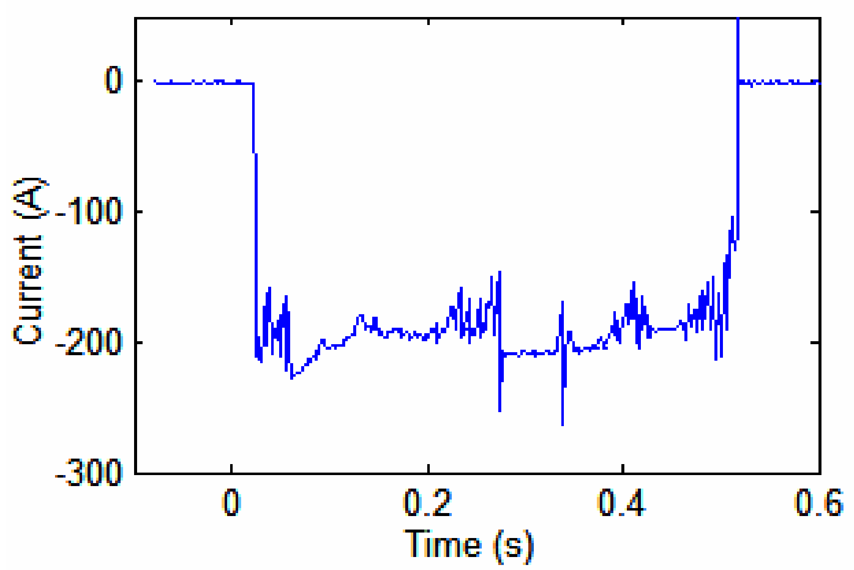


Figure 2b Current Waveform for Lightning Arc – Hit 1, 95 C

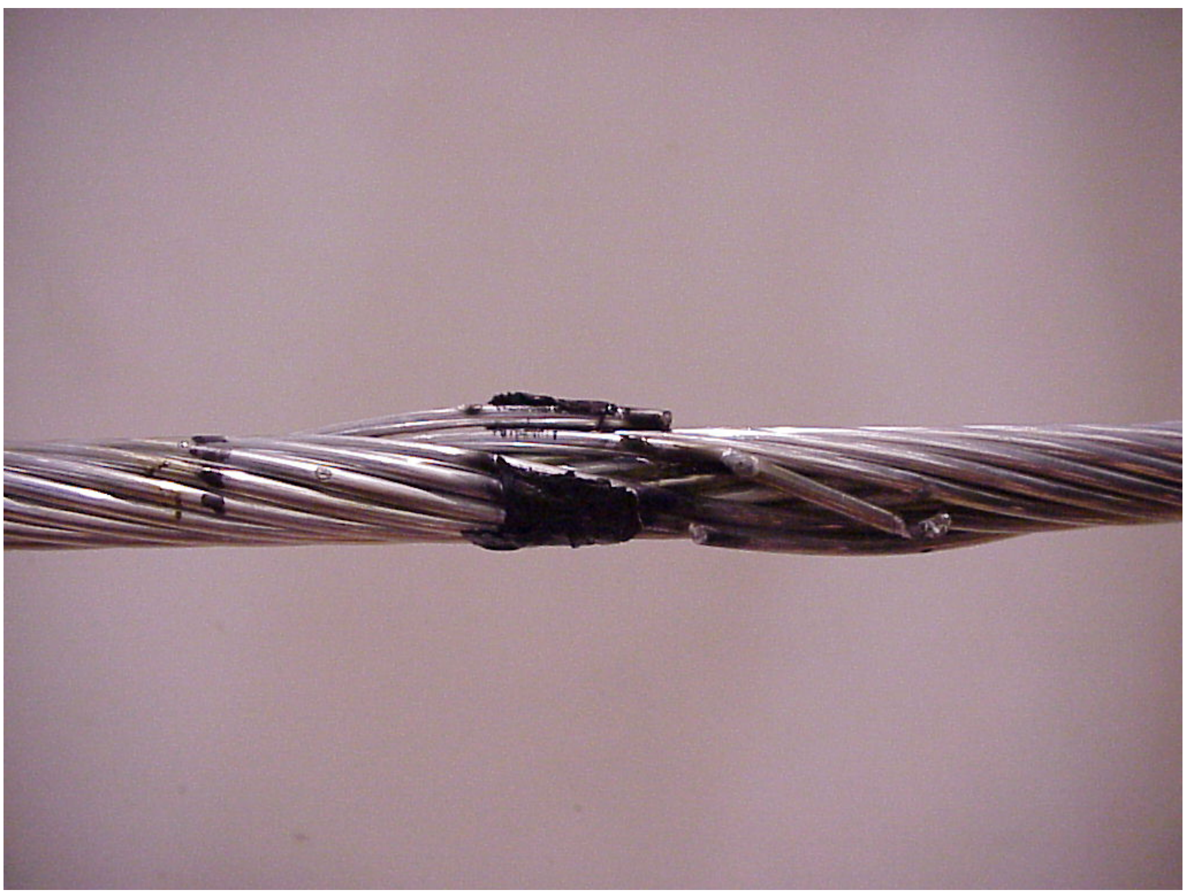


Figure 2c Photograph of OPGW after Lightning Arc – Hit 1

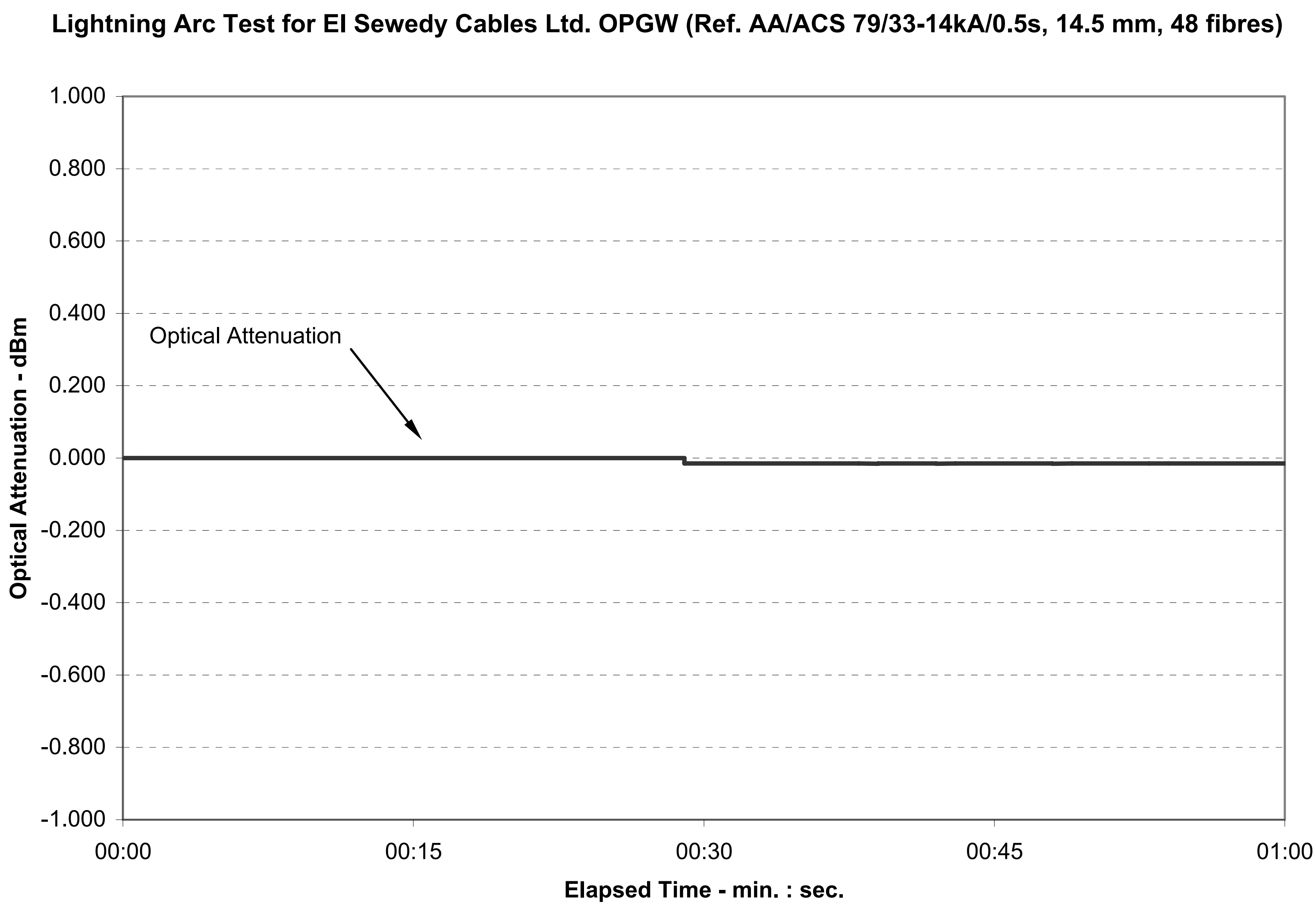


Figure 3a Optical Attenuation for Lightning Arc – Hit 2

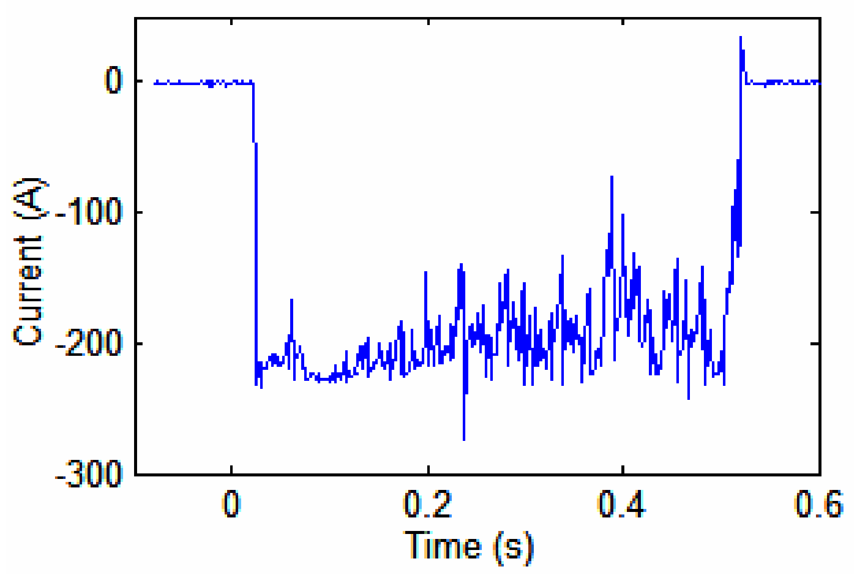


Figure 3b   Current Waveform for Lightning Arc – Hit 2, 98 C

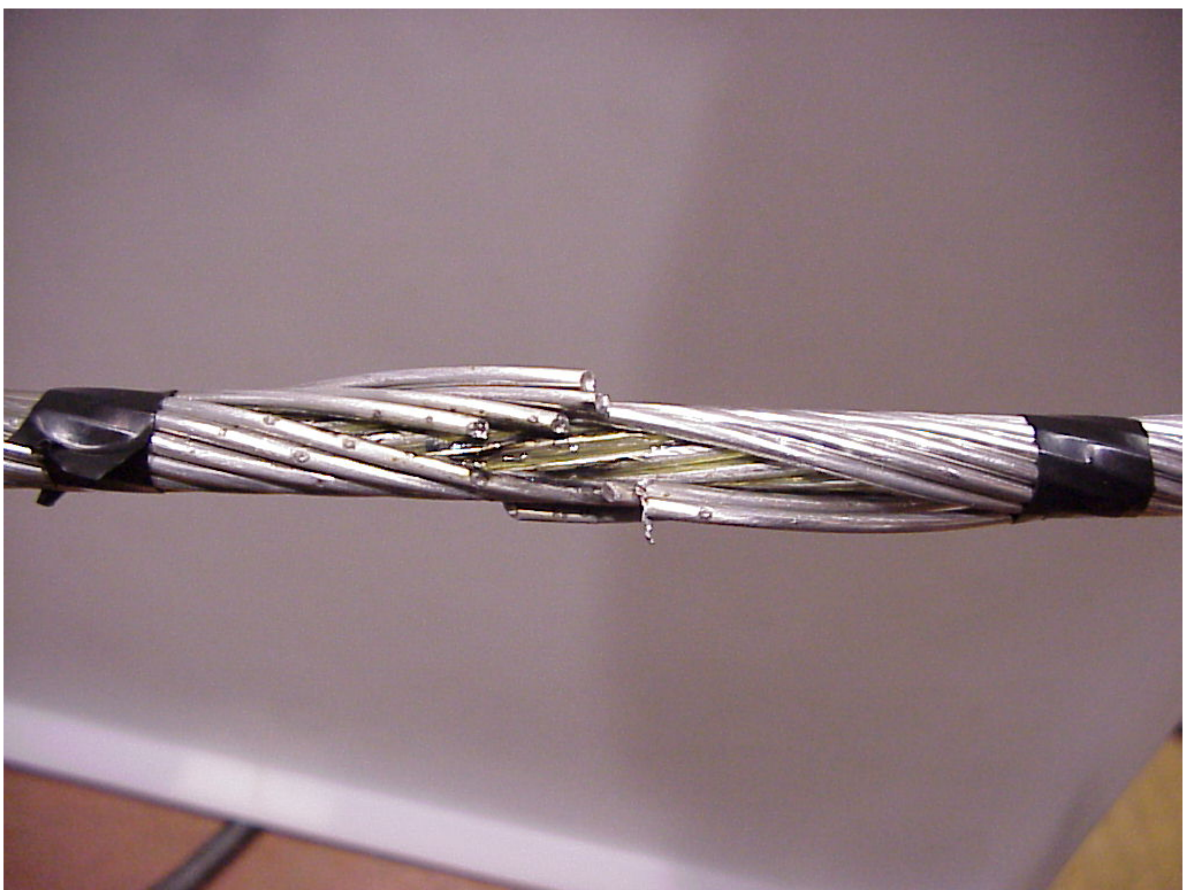


Figure 3c   Photograph of OPGW after Lightning Arc – Hit 2

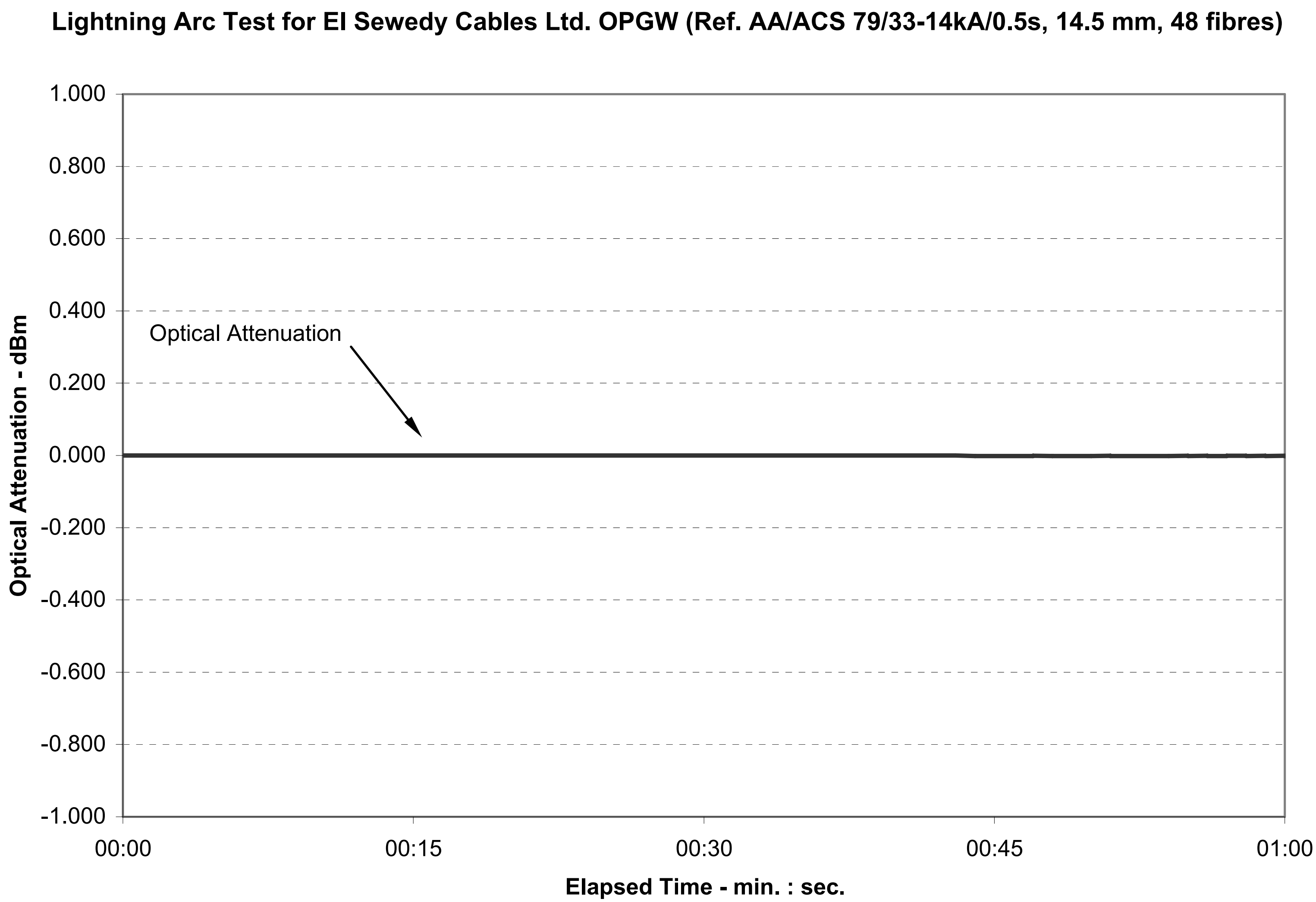


Figure 4a Optical Attenuation for Lightning Arc – Hit 3

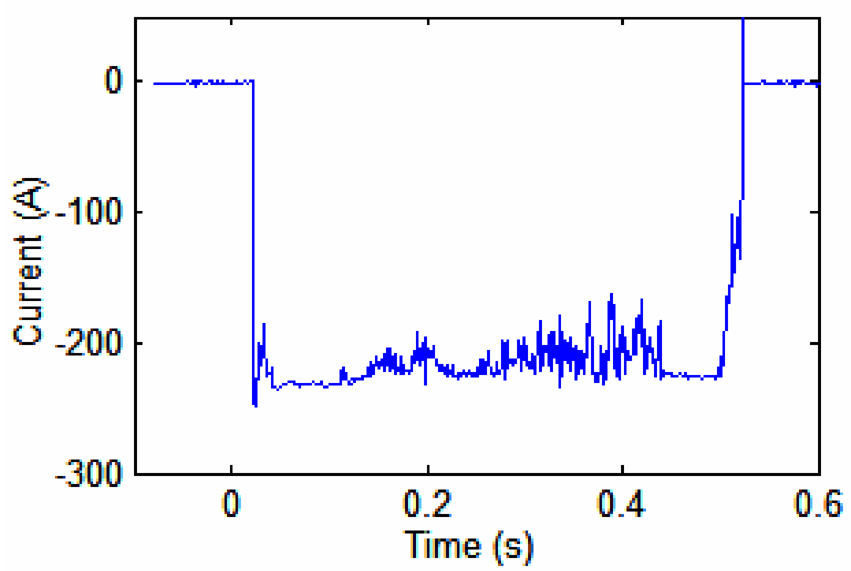


Figure 4b   Current Waveform for Lightning Arc - Hit 3, 107 C

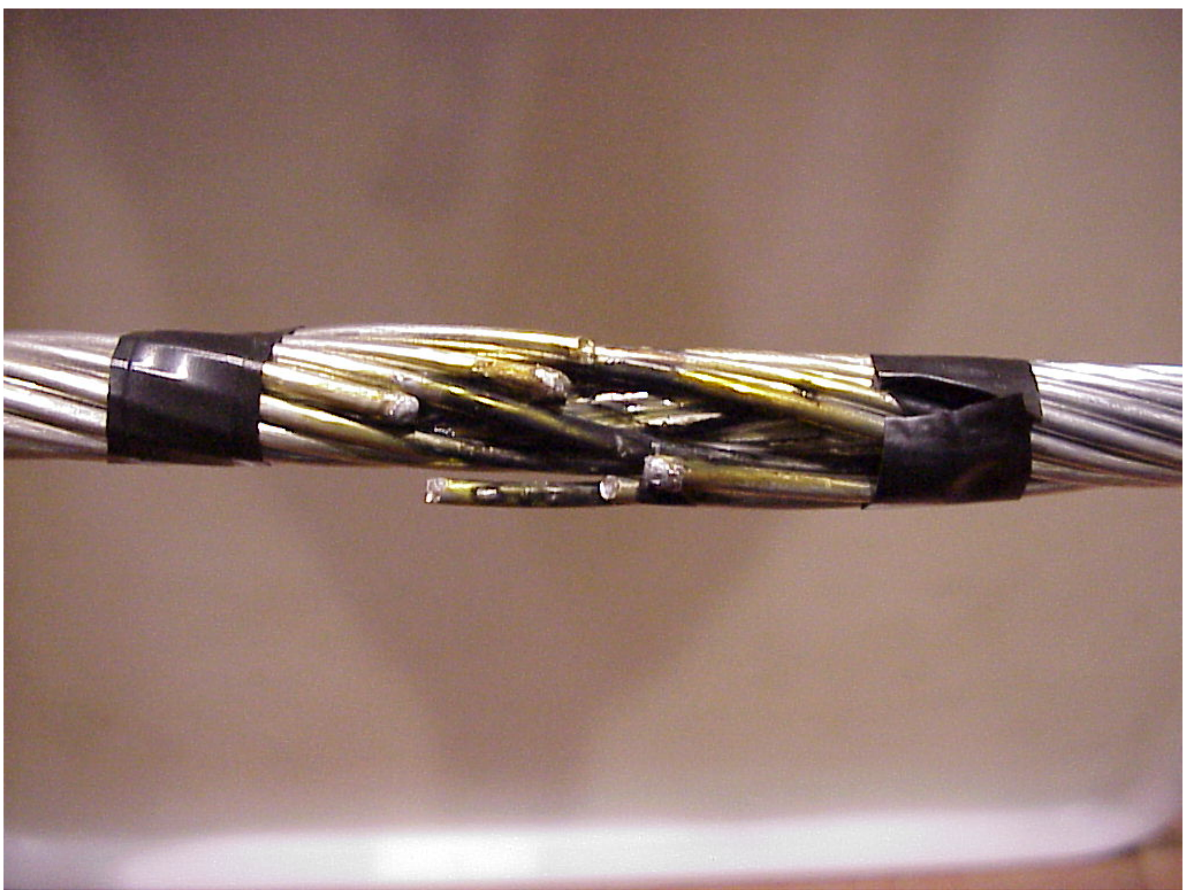


Figure 4c   Photograph of OPGW after Lightning Arc – Hit 3

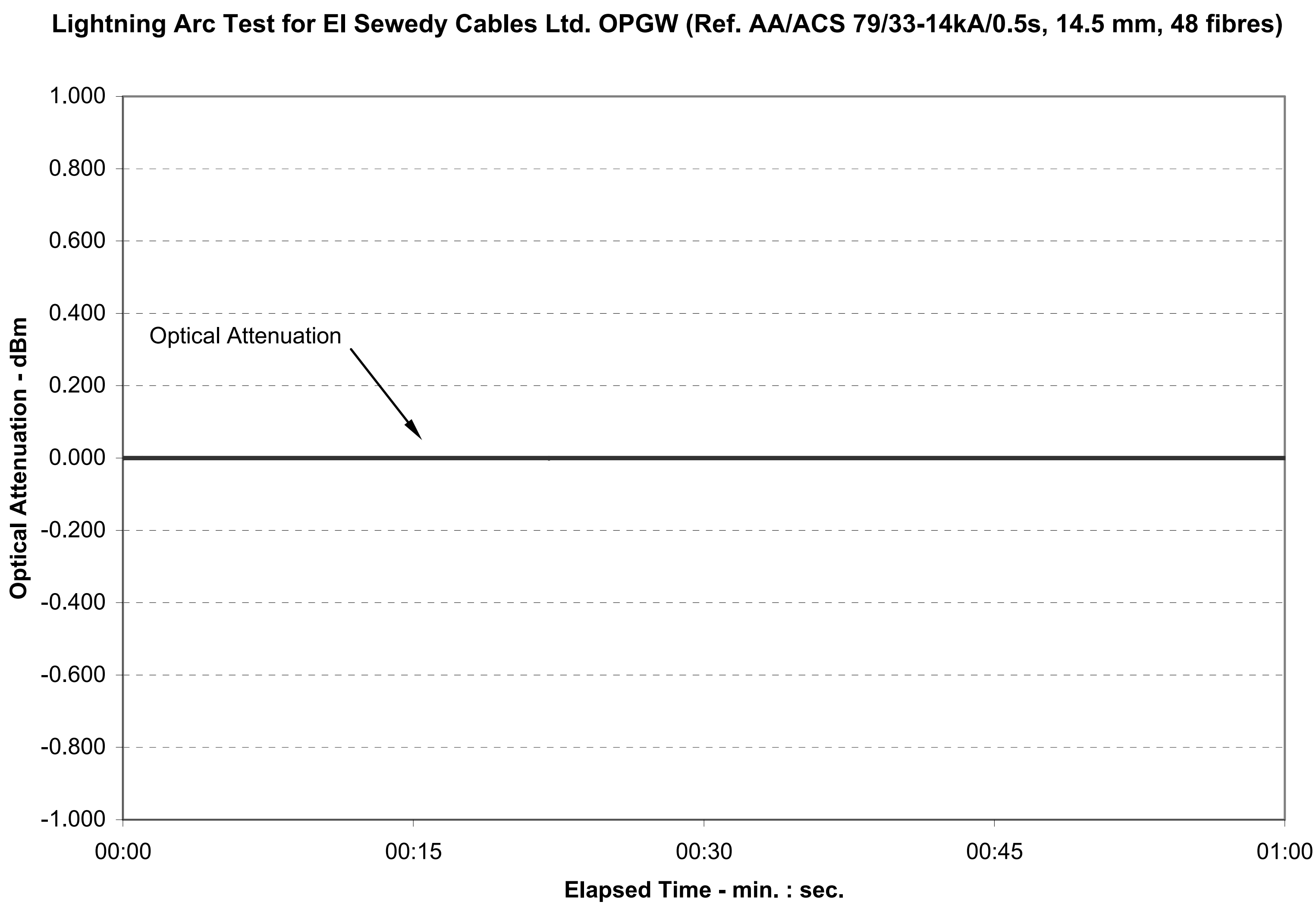


Figure 5a Optical Attenuation for Lightning Arc – Hit 4

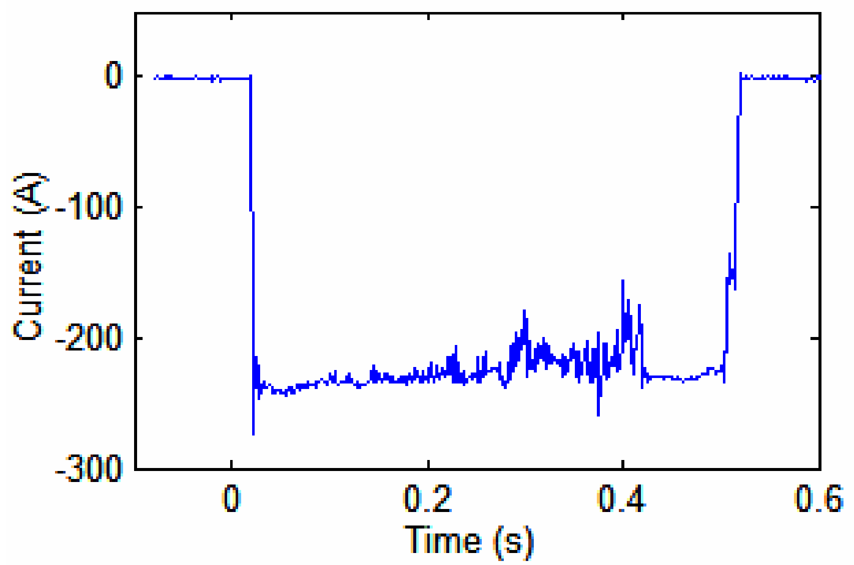


Figure 5b Current Waveform for Lightning Arc – Hit 4, 111 C

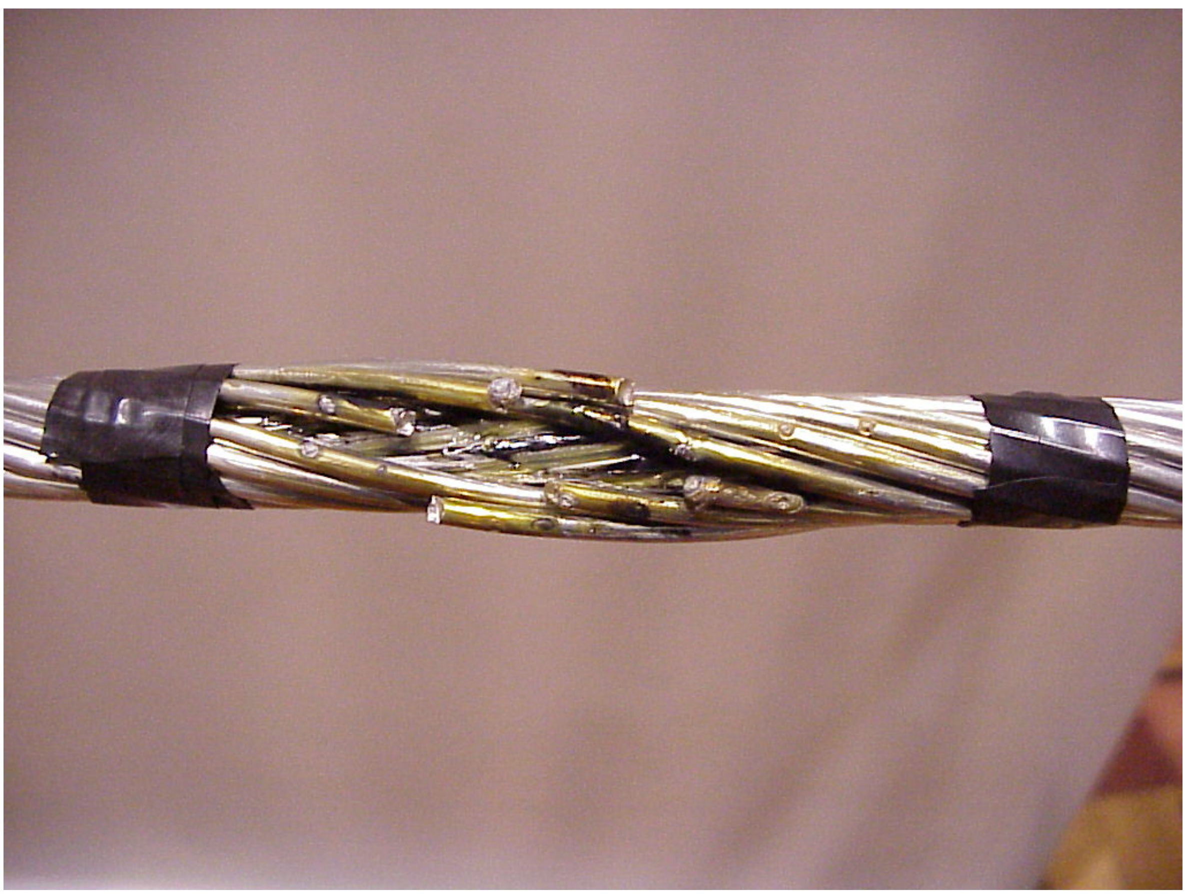


Figure 5c Photograph of OPGW after Lightning Arc – Hit 4

Lightning Arc Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

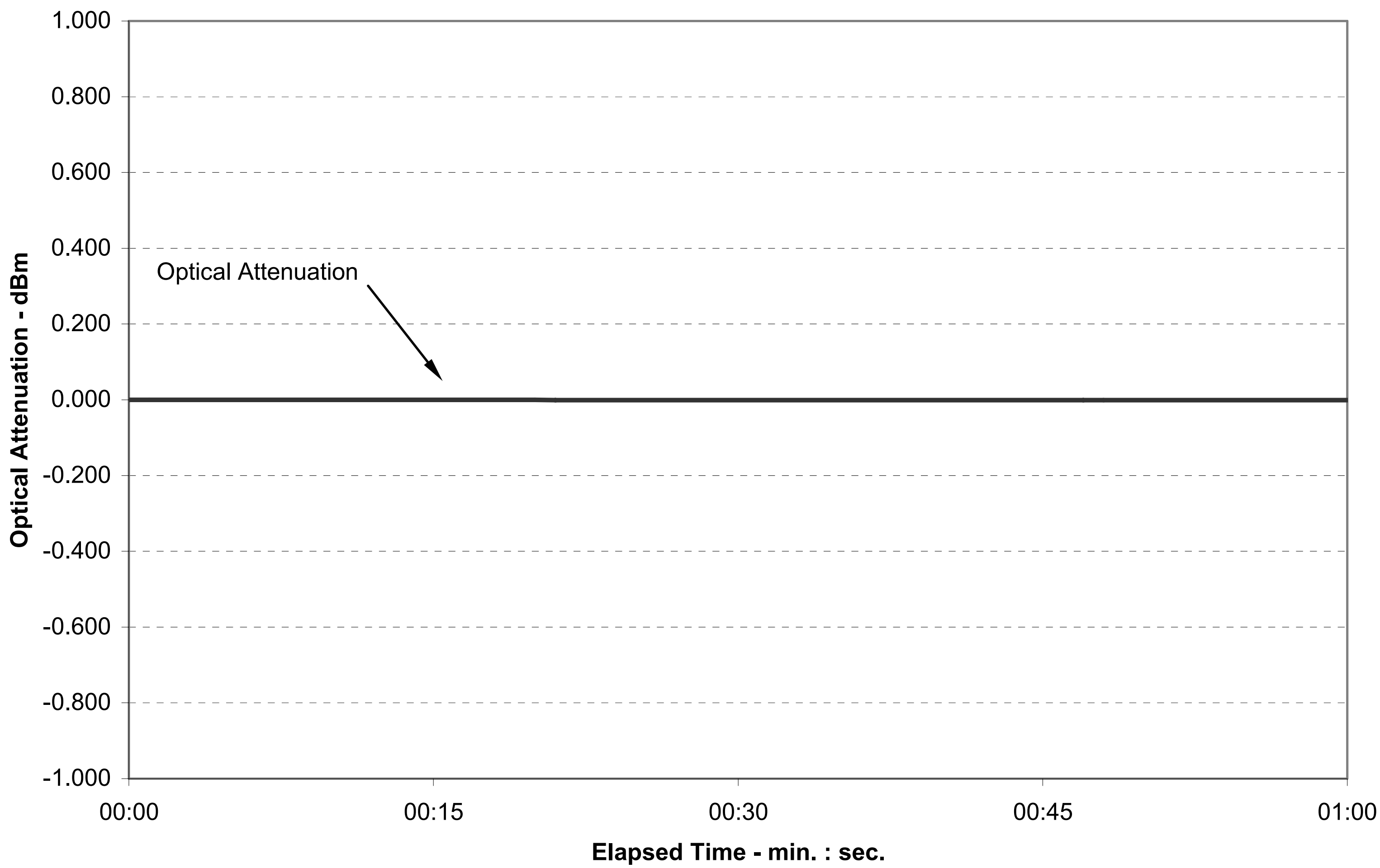


Figure 6a Optical Attenuation for Lightning Arc – Hit 5

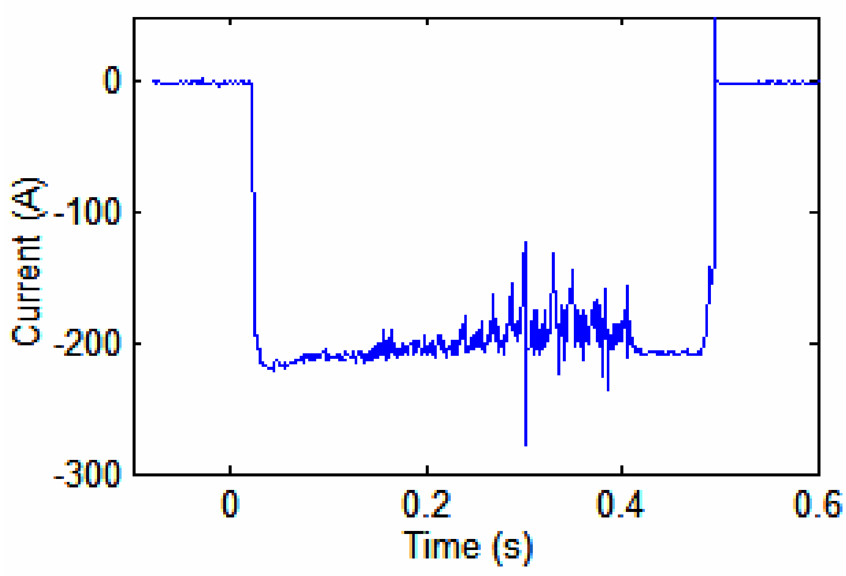


Figure 6b   Current Waveform for Lightning Arc – Hit 5, 95 C

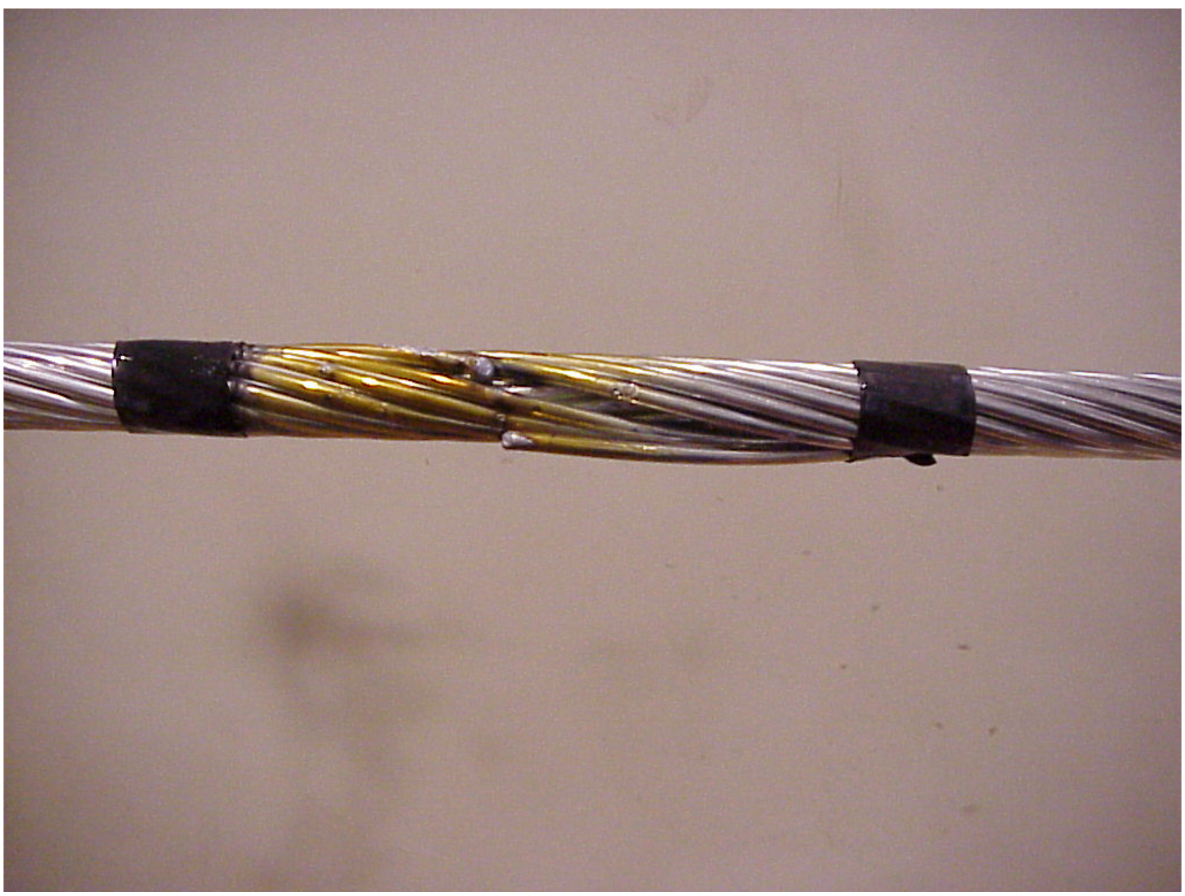


Figure 6c   Photograph of OPGW after Lightning Arc – Hit 5

KINECTRICS INTERNATIONAL INC. TEST REPORT
<u>FOR EL SEWEDY CABLES LTD. OPGW CABLE</u>
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**DC RESISTANCE TEST**
Test Date:	March 9, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not Applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the DC Resistance Test is to measure the actual DC resistance of the OPGW cable.

TEST STANDARD

There is no industry standard to perform DC Resistance Measurements on OPGW cables. Kinectrics developed a set-up and procedure that provides satisfactory results.

TEST SET-UP AND PROCEDURE

The DC Resistance Test was performed on the Stress-Strain sample prior to performing the Stress-Strain Test.

The cable was tensioned to approximately 124 kgf (273 lbf), or 2% of its rated tensile strength. The temperature of the cable was measured by a thermocouple was placed between two outer strands of the cable.

A constant current source of 100 amps from a digital micro-ohmmeter was clamped to two points on the cable spaced 9 m (29.53 ft) apart. The potential drop across this portion of the cable was measured by the micro-ohmmeter. To verify the uniformity of the measurement, the potential drops across five different sections of the cable were made. The micro-ohmmeter displayed the resistance of the sample based on the voltage drop measured across its voltage input and the current scale selected. To reduce error due to heating, the current was circulated through the cable for only a few seconds to obtain a reading then turned off to reposition the electrodes for the next reading.

The resolution of the measurement is 1 μΩ/ 10 metres (ie. 0.00001 ohms/km).

TEST RESULTS

The five (5) resistance readings are shown in the table below.

<u>Resistance Readings Measured Across Test Electrodes Spaced at 9m</u>

Reading #	Resistance (μΩ)
1	3.24
2	3.24
3	3.24
4	3.25
5	3.24
Avg.	**3.24**

The conductor temperature at the time of testing was 20ºC

The calculated DC resistance of the conductor per km is 0.360 Ω at 20ºC.

ACCEPTANCE CRITERIA

As specified by the manufacturer, the measured DC resistance of the cable shall be no greater than the manufacturer's stated value after correcting for temperature.

CONCLUSION

The cable, as tested, met the requirements for the DC Resistance Test as specified by the manufacturer.

Kinectrics International Inc.

____

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**CABLE CUT-OFF WAVELENGTH TEST**
Test Date:	March 8, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	Egyptian Electricity Transmission Company
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Not Applicable
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Cable Cut-off Wavelength Test is to determine the cable cut-off wavelength of the OPGW cable.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.12 and EIA/TIA 455-170 Method B.

TEST SET-UP

The set-up for the Cable Cut-Off Wavelength Test is shown in Figure 1.

Test Apparatus

A cable length totaling 22 m was supported horizontally such that it was flat and straight. A fiber loop 76 mm in diameter was made at each end.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

A tungsten-halogen bulb focused with a lens and shown through a photochopper was used as the light source. A grating on a small turntable was used as a monochromator. The grating was rotated to obtain the required test wavelengths. A multimode fiber was used as the launch optics to overfill the sample over the full range of test wavelengths. A multimode fiber coupled to the detector was used as the detection optics.

Instrumentation and Data Acquisition

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The grating was rotated in steps to produce wavelengths of 900 to 1345 nm in increments of 5 nm. The optical power for the test cable was recorded for each step, $P_s(\lambda)$. The test cable was replaced with a multimode reference fibre and the power transmitted was recorded, $P_m(\lambda)$, for the same spectral increments as the test cable. The spectral transmittance, $A_m(\lambda)$, of the test sample referenced to the multimode fibre in dB was calculated by:

$$A_m(\lambda) = 10 \log_{10} (P_s(\lambda) / P_m(\lambda)$$

The cutoff wavelength was calculated by first fitting a straight line using only values of A_m from the long wavelengths, and shifting the line +0.1 dB. The longest wavelength at which the fitted straight line intersects the line drawn through all values of A_m is the cable cutoff wavelength.

Four (4) fibers from each of the two (2) SS tubes were tested.

TEST RESULTS

The results of the test are shown in Figures 2-9 and are summarized in the following table.

Figure	Stainless Steel Tube	Binder	Fibre Tested	Cable Cut-Off Wavelength (λ_c)
2	No Stripe	Orange	Yellow	1125
3	No Stripe	Orange	White	1086
4	No Stripe	Blue	Violet	1110
5	No Stripe	Blue	Turquoise	1131
6	Striped	Orange	Red	1140
7	Striped	Orange	Green	1143
8	Striped	Blue	Blue	1107
9	Striped	Blue	Orange	1060
AVERAGE				1113

ACCEPTANCE CRITERIA

According to IEEE Std. 1138-1994, Paragraph 4.1.1.12, the cable cut-off wavelength shall be less than 1250 nm.

CONCLUSION

The cable, as tested, met the requirements for the Cable Cut-Off Wavelength as specified in IEEE Std. 1138-1994, Paragraph 4.1.1.12 and EIA/TIA 455-170 Method B.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

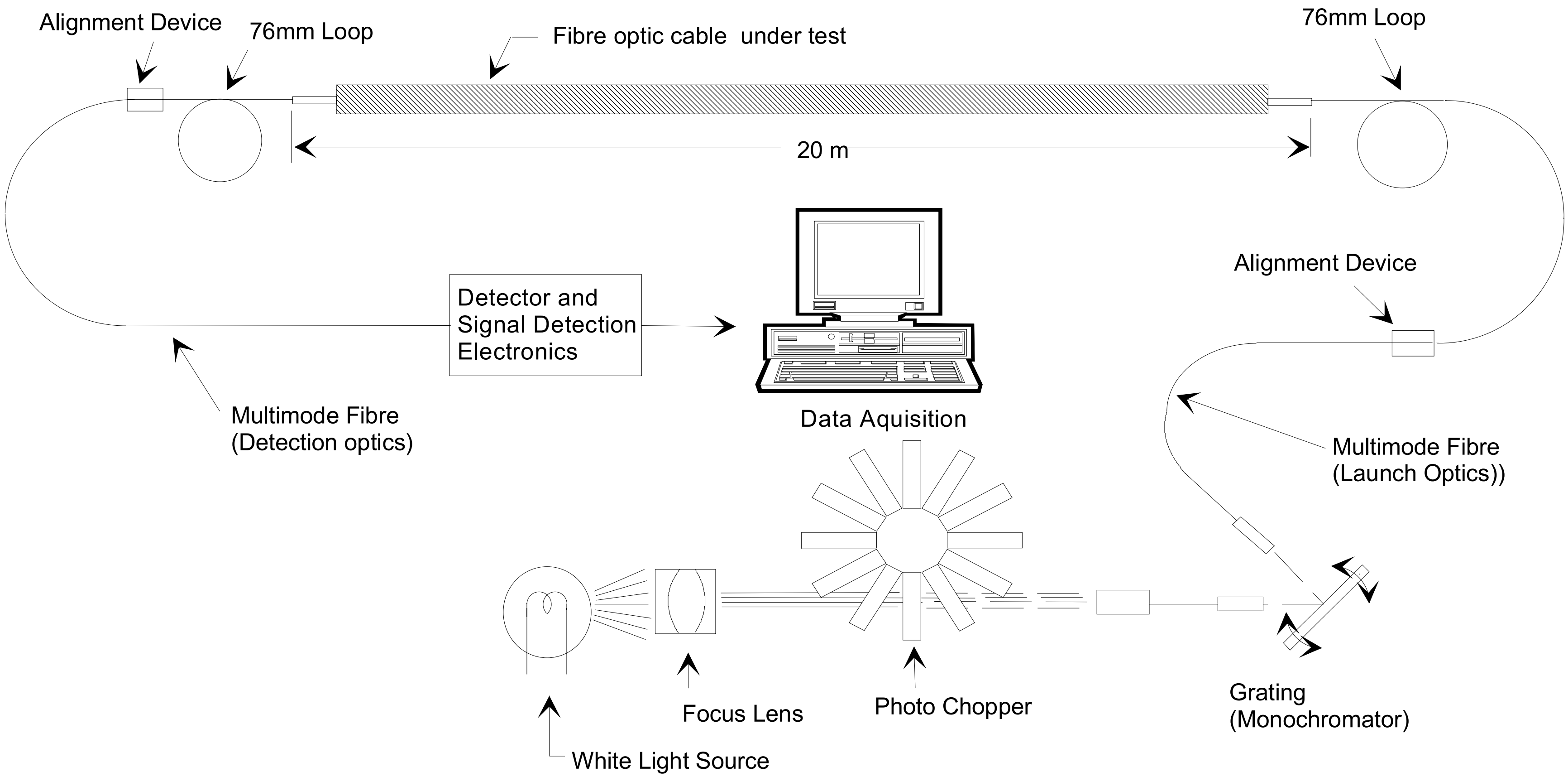


Figure 1 Set-Up for Cable Cutoff Wavelength Test

Cable Cutoff Wavelength Test for Cabled Fibre (Multimode-Reference Method)

No Stripe SS Tube, Orange Binder - Yellow Fibre

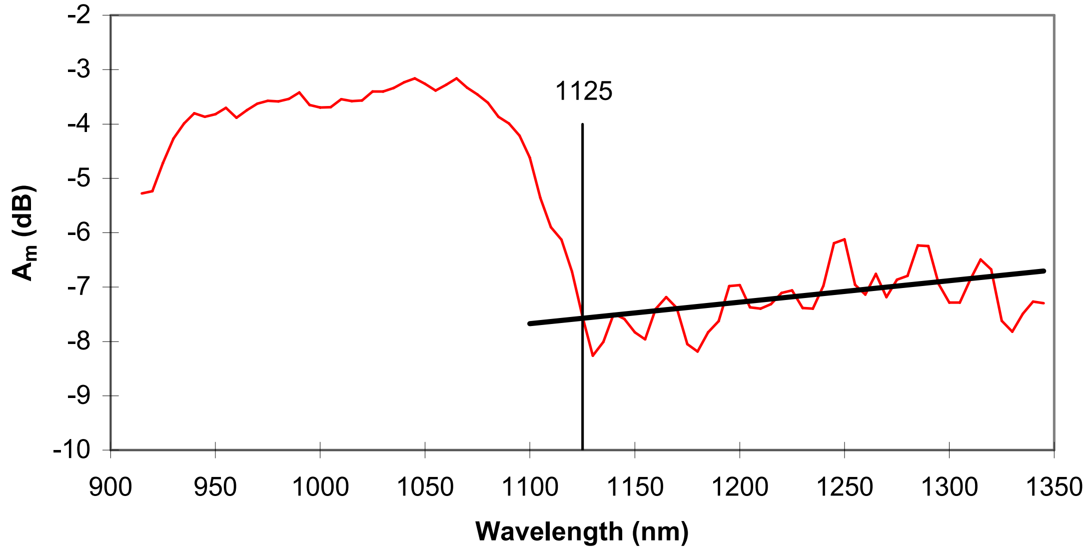


Figure 2 Spectral transmittance vs. Wavelength

Cable Cutoff Wavelength Test for Cabled Fibre (Multimode-Reference Method)

No Stripe SS Tube, Orange Binder - White Fibre

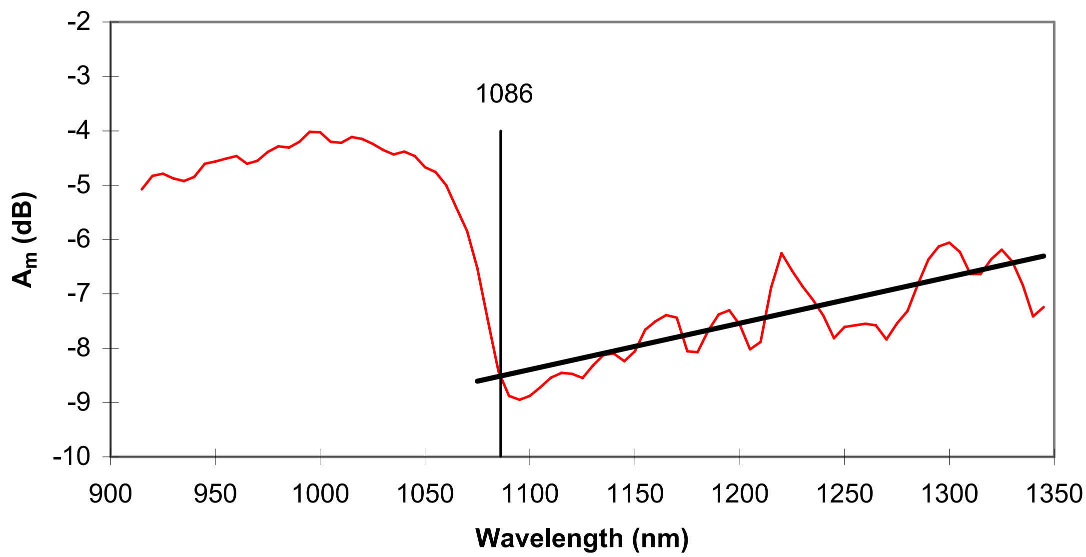


Figure 3 Spectral transmittance vs. Wavelength

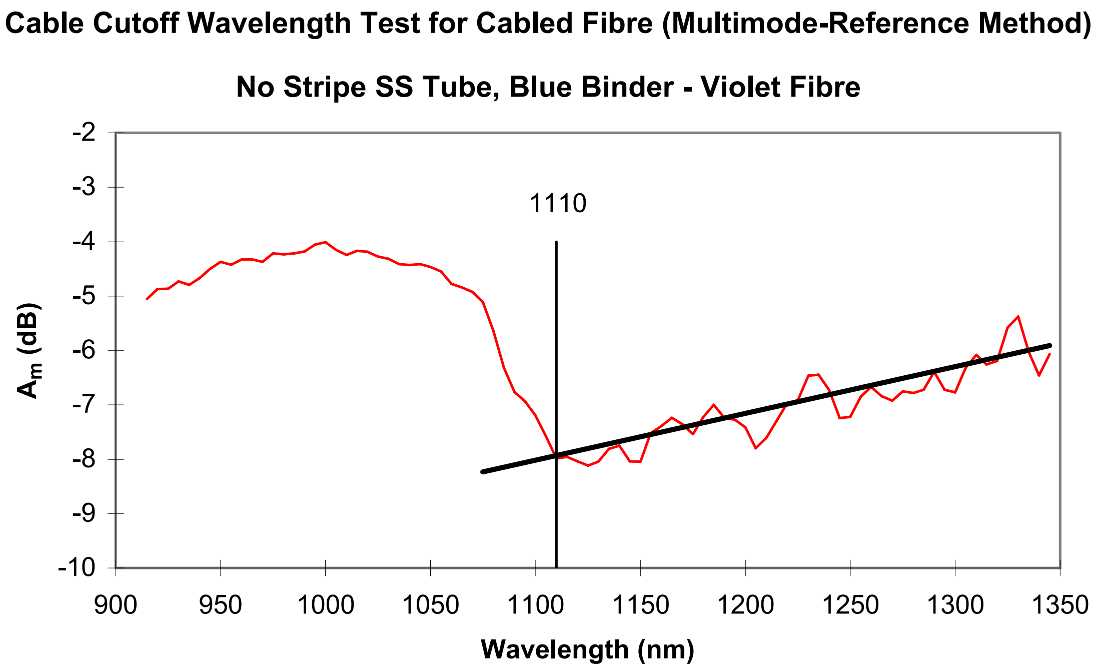


Figure 4 Spectral transmittance vs. Wavelength

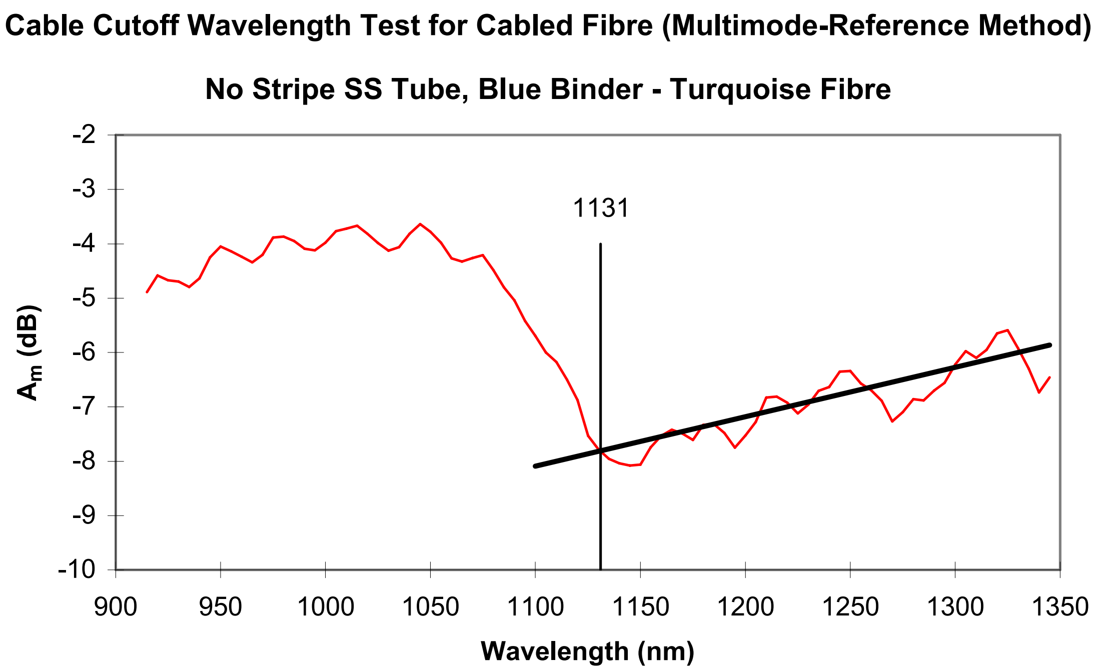


Figure 5 Spectral transmittance vs. Wavelength

Cable Cutoff Wavelength Test for Cabled Fibre (Multimode-Reference Method)

Striped SS Tube, Orange Binder - Red Fibre

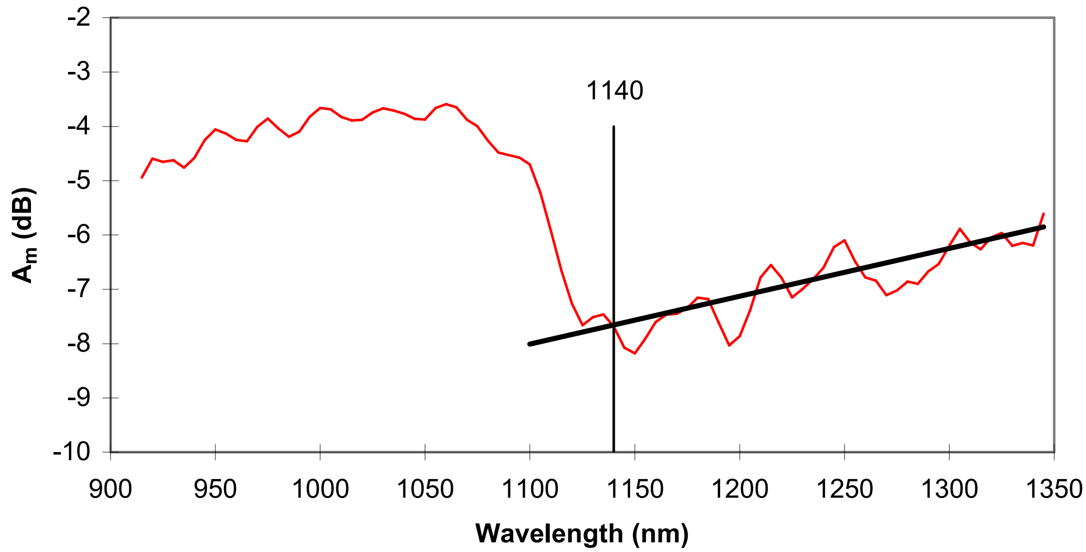


Figure 6 Spectral transmittance vs. Wavelength

Cable Cutoff Wavelength Test for Cabled Fibre (Multimode-Reference Method)

Striped SS Tube, Orange Binder - Green Fibre

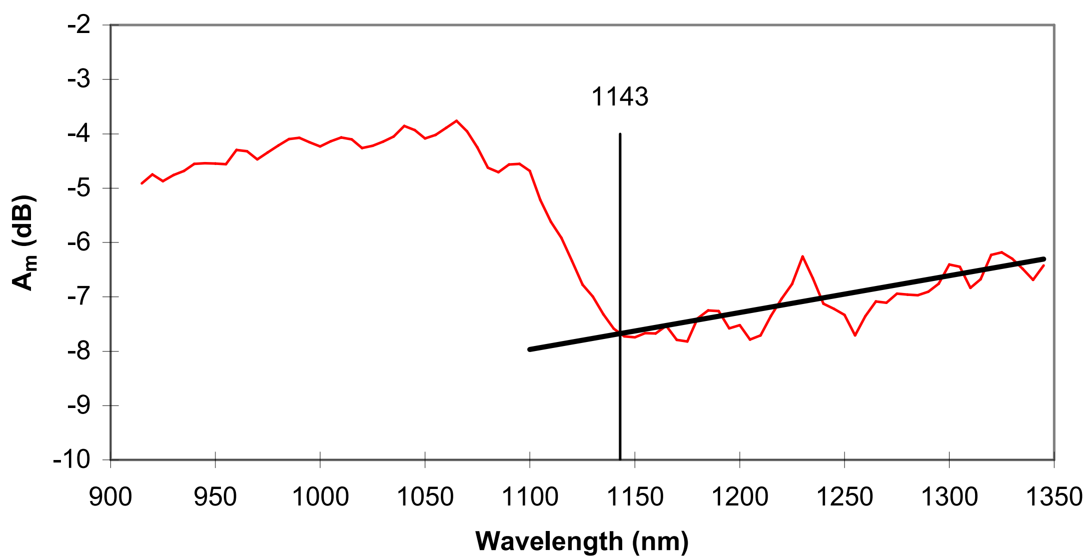


Figure 7 Spectral transmittance vs. Wavelength

Cable Cutoff Wavelength Test for Cabled Fibre (Multimode-Reference Method)

Striped SS Tube, Blue Binder - Blue Fibre

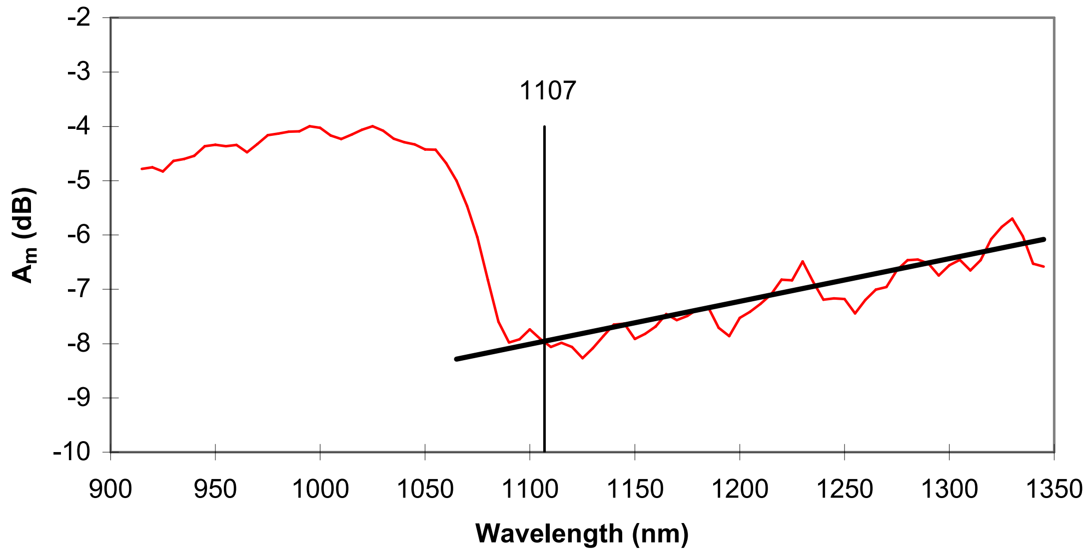


Figure 8 Spectral transmittance vs. Wavelength

Cable Cutoff Wavelength Test for Cabled Fibre (Multimode-Reference Method)

Striped SS Tube, Blue Binder - Orange Fibre

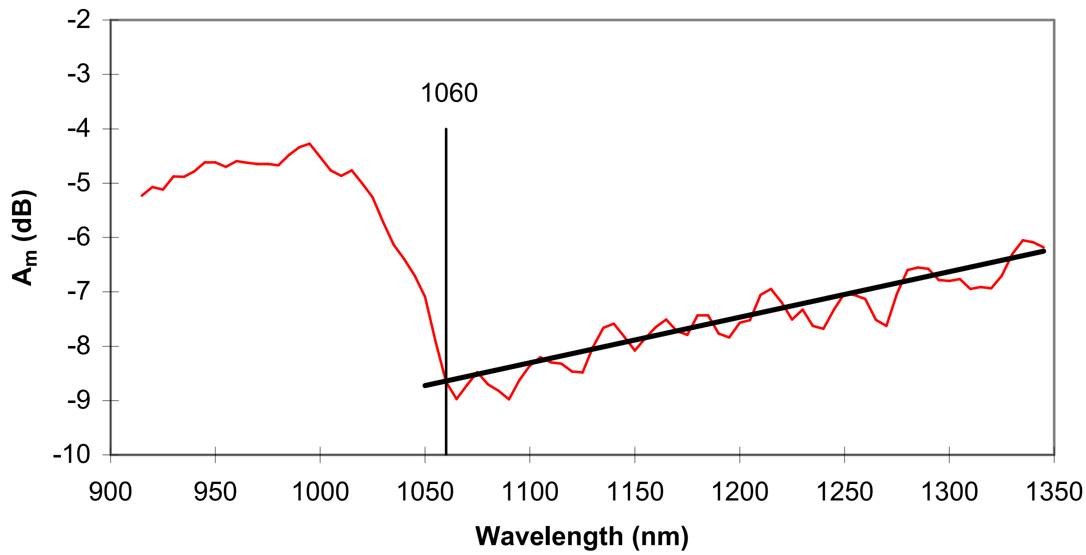


Figure 9 Spectral transmittance vs. Wavelength

KINECTRICS INTERNATIONAL INC. TEST REPORT
FOR EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Name:	**CREEP TEST**
Test Date:	January 31 – March 14, 2006
Test Laboratory:	Kinectrics International Inc. 800 Kipling Avenue Toronto, Ontario, M8Z 6C4 CANADA
Cable Manufacturer:	El Sewedy Cables Ltd.
End-User:	**Egyptian Electricity Transmission Company**
Cable Designation:	AA/ACS 79/33-14kA/0.5s
Accessories:	Epoxy Resin Dead-ends applied by Kinectrics
Kinectrics Staff:	Mr. Craig Pon Mr. Mike Kastelein Mr. Mike Colbert Mr. Gord Hale
Witnesses:	Mr. Hassan Refaat – El Sewedy Cables Mr. Mohamed Fouad – Egyptian Electricity Transmission Company

TEST OBJECTIVE

The objective of the Creep Test is to measure the room temperature long-term tensile creep properties of the cable. The data from this test are used to assist in the calculation of sags and tensions.

TEST STANDARD

The test was performed in accordance with IEEE Std. 1138-1994, Paragraph 4.1.1.8.

TEST SET-UP

The set-up for the Creep Test is shown in Figure 1. The test was performed on the span designated KB019 South-West.

Test Apparatus

The cable length between dead-end clamps was 12.50 meters. Two metal "paddles" were installed on the cable 8.005 meters apart, centred midway between the ends of the cable. Two calibrated linear variable differential transformers (LVDT) with 0.04 mm resolution were installed on a steel-aluminum reference bar. The reference bar was assembled to have the same thermal coefficient of linear expansion as the cable.

The test was carried out in a temperature-controlled laboratory at 20ºC ± 2ºC.

Optical Network

Optical measurements are not required for the Creep Test.

Instrumentation and Data Acquisition

The measuring instruments used in this test are listed in Appendix C.

TEST PROCEDURE

The cable was pre-tensioned to approximately 124 kgf or 2% of the cable RTS (6,220 kgf) and LVDTs installed. The cable was then loaded to 1,244 kgf or 25% RTS using a cantilever weight system, which ensured near constant tension for the duration of the test. The LVDTs were read automatically using a digital data logging system for the duration of the test. The data from the LVDT's was taken on a logarithmic scale.

TEST RESULTS

As stated in the Aluminum Association method, the long-term tensile creep of a cable under constant tension is taken to be the permanent strain occurring between 1 hour and the specified test time. The last reading during this test was taken at 1000 hours.

A log-log plot of strain versus elapsed time for the LVDT's is shown in Figure 2.

On completion of the test, a best-fit straight line was fitted to the LVDT data and was extrapolated to 10 years (87,600 hours). The equation of the line is:

$$\text{Strain} = A \times (\text{Hours})^{B}$$

where	A =	Y-intercept =	4.0306E-05	ε
	B =	slope =	0.16817	

The initial creep value (defined at 1 hour) using the fitted line is:
(Strain at 1 hr) = 4.031E-05 ε

The creep during the test using the fitted line is:
(Strain at 1000 hrs) - (Strain at 1 hr) = 1.288E-04 - 4.031E-05 = 8.848E-05 ε

The 10-year (87,600 hrs) creep using the fitted line is:
(Strain at 87600 hrs) - (Strain at 1 hr) = 2.731E-04 - 4.031E-05 = 2.328E-04 ε

ACCEPTANCE CRITERIA

There are no acceptance criteria for the creep test stated in IEEE Std. 1138-1994 or the Aluminum Association 1971.

CONCLUSION

The primary purpose of the Creep Test is to provide the long-term creep characteristics of the OPGW to be used in sag-tension calculations.

Kinectrics International Inc.

Craig Pon
Principal Engineer
Transmission and Distribution Technologies Business

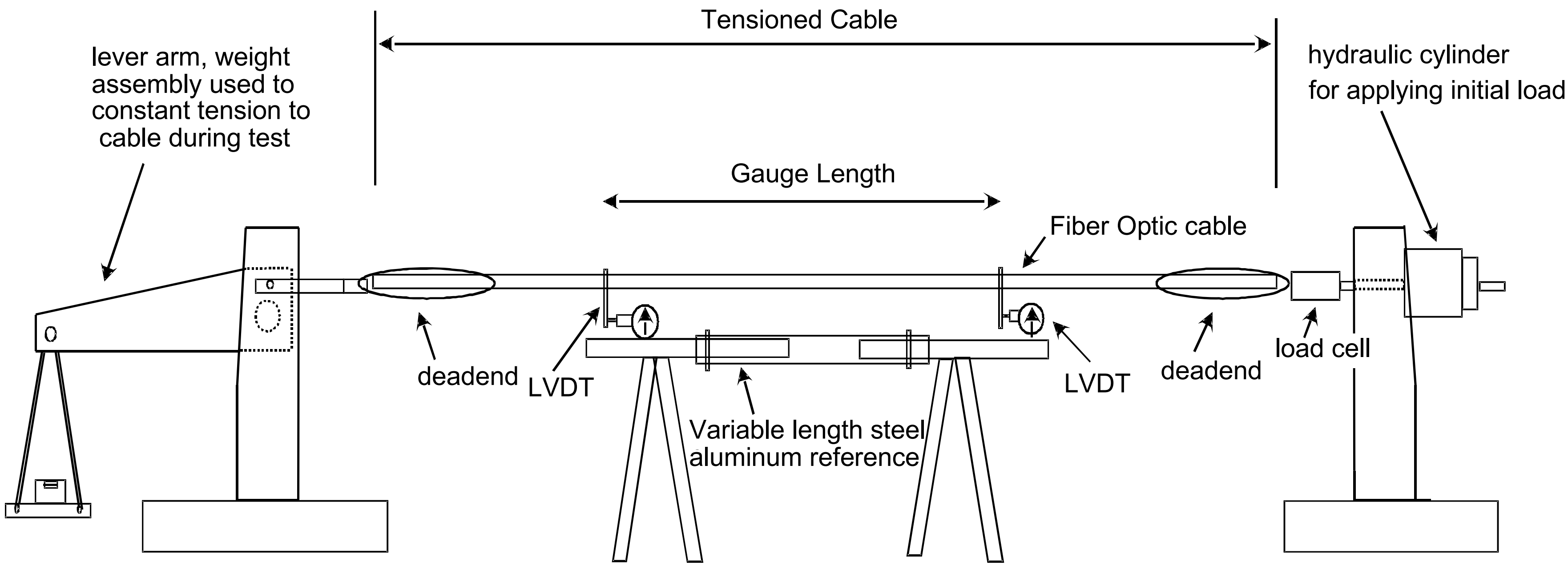


Figure 1 Set-up for Creep Test

Creep Test for El Sewedy Cables Ltd. OPGW (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

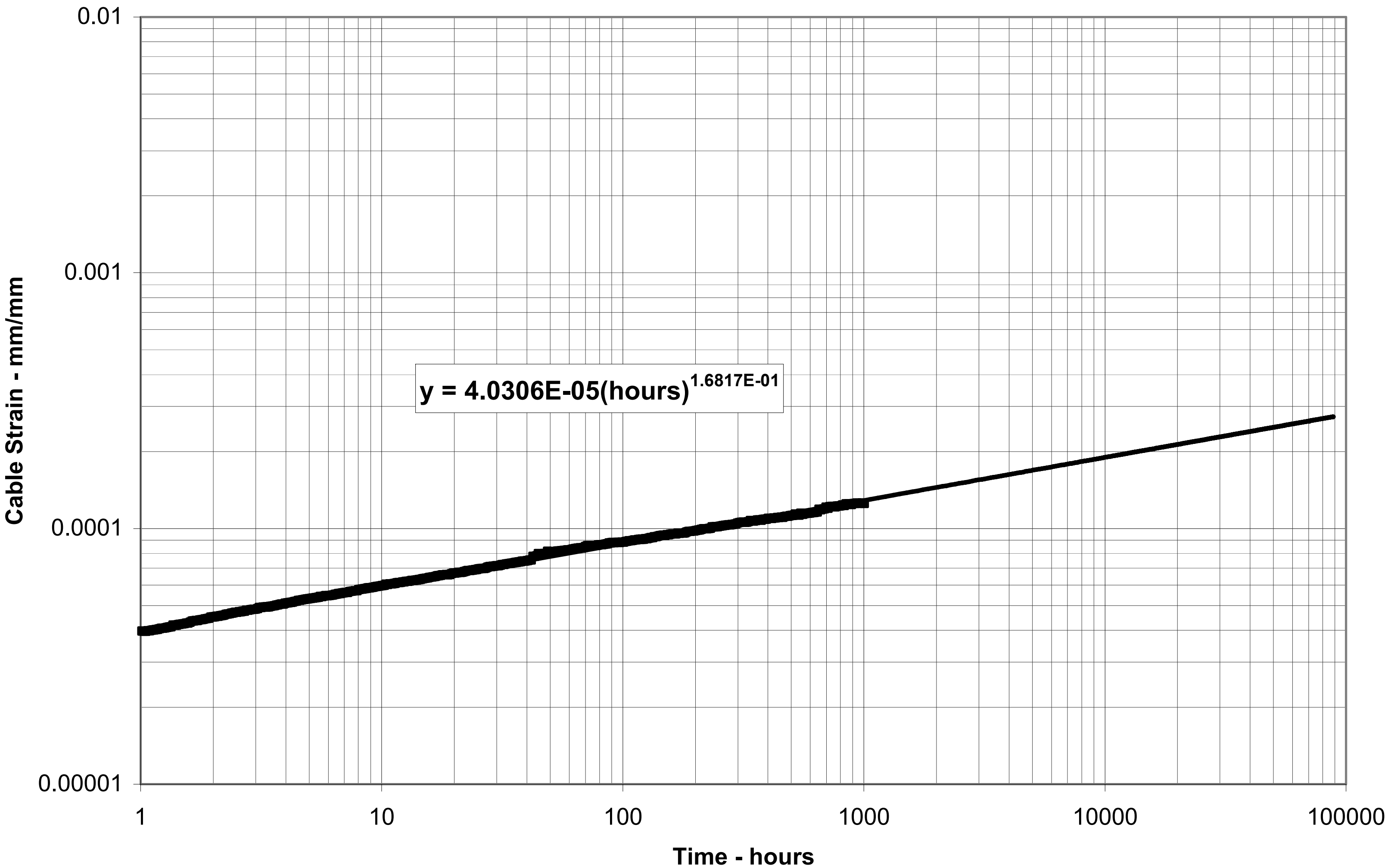


Figure 2 Cable Strain vs. Time

APPENDIX A

DESCRIPTION OF EL SEWEDY CABLES LTD. OPGW CABLE
(Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

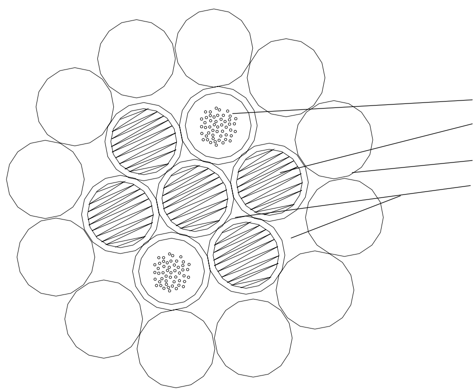
APPLICATION

These cables are suitable for installation as optical ground wire in powerline installations.
The cable acts as an normal ground wire protecting phase wires from lighting strikes and carries earth fault currents.
The cable provides also an optic path in powerline installations for telecommunication needs.

FEATURES

- Installation in the same way as normal ground wire with conventional machinery.
- Most reliable optic solution for fibre optic utilities.
- Best solution in old ground wire replacement and in new line constructions.
- Low cost

Cross Sectional Diagram



CONSTRUCTION

Optical fibre	: For fibre specification see optical characteristics.	
Secondary coating	: The secondary coating consists of one laser welded stainless steel tube. Every fibre is uniquely identified by a fibre colour and for fibre counts above 12 fibres with a coloured fibre bundle yarn. The tube is filled with a water-repellent filling compound.	
Central element	: 1 ACS wires (20SA)	: 2.9 mm
First layer	: 2 stainless steel tube 4 ACS wires (20SA) : Direction layer	: 2.85 mm : 2.9 mm : "Left "
Second layer	: 12 aluminium alloy (AA) wires : Direction layer	: 2.9 mm : "Right "
Grease	: The interstices of the cable core are filled with grease according to IEC 1089 ANNEX C figure C.2	

All values in this product data sheet are nominal unless otherwise stated.

TECHNICAL CHARACTERISTICS

Number of tubes	2	
Number of fibres / tube	24	
Cable ∅	14.5	mm
Cable weight	485	kg/km
Supporting cross-section	112.29	mm^2
AA cross-section	79.26	mm^2
ACS cross-section	33.03	mm^2
Calculated breaking load (UTS)	61	kN
Modulus of elasticity	87.88	kN/mm^2
Coefficient of thermal expansion $.10^{-6}$	17.58	1/K
Permissible tensile stress acc.		
Everyday stress	90	N/mm^2
Maximum tensile stress	236	N/mm^2
Endurance tensile stress	404	N/mm^2
Nominal short-time current IEC 724 at		
Initial/Final temperature 40 / 200 °C	14.45	kA, 0.5 s.
D.C. resistance at 20 °C	0.360	Ω/km
Transport, storage, operation	- 40 to + 80	°C
Installation	- 10 to + 50	°C

Optical characteristics (cabled max. values)

Fibre type	Single mode			
Acc. to specification	ITU-T G.652			
Mode field diameter	9.2 ± 0.5			µm
Cladding diameter	125 ± 1			µm
Coating diameter	245 ± 10			µm
Wavelength	1310	1285-1330	1550	nm
Max. Attenuation coefficient	0.38	0.40	0.25	dB/km
Average Attenuation coefficient	0.35	0.36	0.22	dB/km
Dispersion	-	3.5	18.0	ps/nm.km
PMD	0.5			$ps.km^{-½}$

Fibre colouring

Fibre No.	1	2	3	4	5	6
Fibre colour	Blue	Orange	Green	Brown	Grey	White

Fibre No.	7	8	9	10	11	12
Fibre colour	Red	Black	Yellow	Violet	Rose	Turquoise

Customised colouring upon request

Binder yarn colouring

Fibre bundle	1	2
Yarn colour	Blue	Orange

Testing and inspection

Testing will comprise the following:	
- Optical characteristics (each cable length)	Attenuation (Single mode at 1310 / 1550nm)
- Mechanical characteristics - Electrical characteristics - Visual inspection of cable	Diameter of cable DC resistance Colouring / markings of fibres / tubes
The mechanical characteristics and visual inspection shall be carried out with a frequency of 1 out of 10 drums, starting with the first drum. The first drum shall always be checked when the quantity is less than 10 drums. Certified test results are provided upon request. If testing and inspection to be carried out by third parties is required, such parties will be nominated and paid by the Purchaser.	

Packing

Standard length	≥ 3000	m
Length tolerance	+/-100, we reserve the right to deliver up to a maximum of 10 % of the ordered quantity in shorter lengths with a minimum of 2000 m / drum.	m
Sealing of cable ends	To prevent ingress of moisture the cable ends are sealed with heat shrinkable end caps.	
Protection / Packing	The reel shall be lagged with strong wooden battens so as to prevent the OPGW from damage in ordinary handling and shipping.	

APPENDIX B

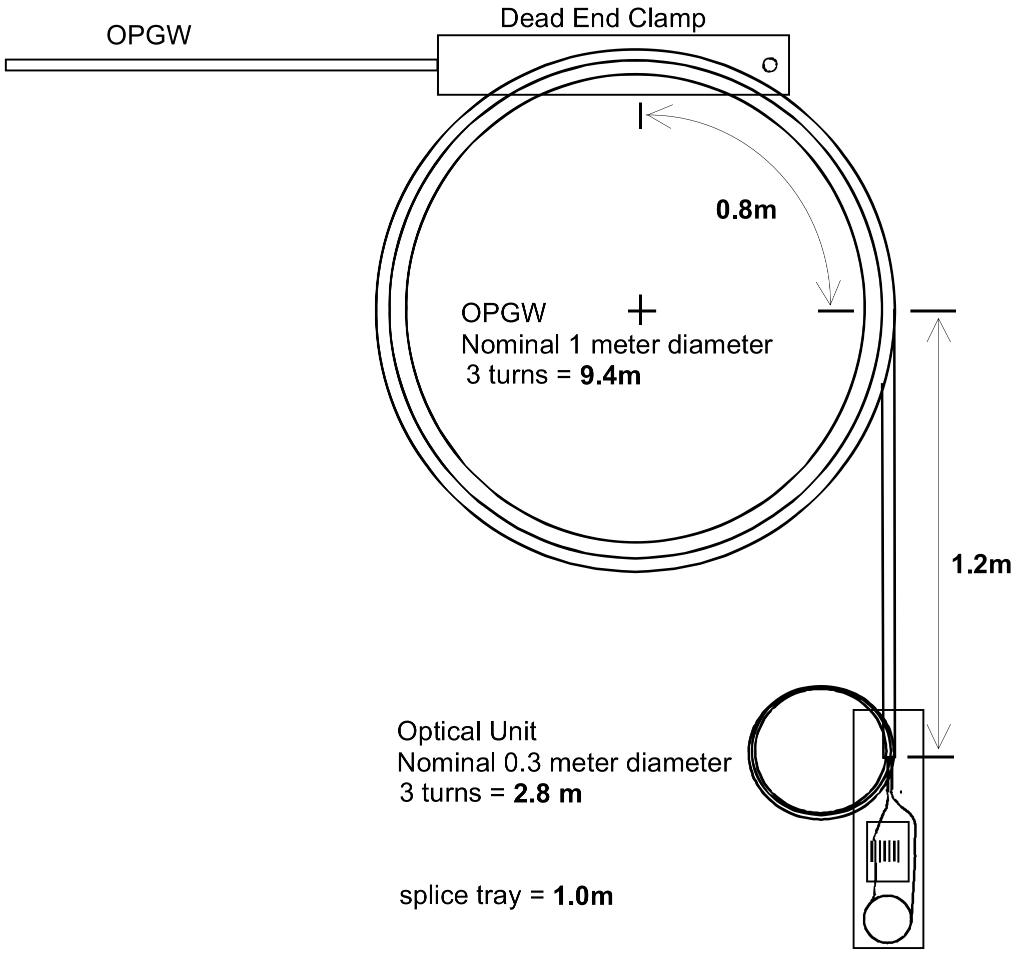
OPTICAL MEASUREMENTS
General Set-up and Procedures

OPTICAL ATTENUATION MEASUREMENTS

The set-up to monitor the optical attenuation for the mechanical and electrical tests is recommended by IEEE Std. 1138-1994, **"Standard Construction of Composite Fiber Optic Groundwire (OPGW) For Use on Electric Utility Power Lines".** To increase the sensitivity to changes in attenuation, a number of fibers in each test sample are spliced together, or concatenated, to form one continuous length. Typically, twelve (12) fibers may be spliced for each test sample. A laser source with a nominal wavelength of 1550 nm is injected to an optical splitter. The splitter divides the source signal into two signals each with nominally one-half the power as the original source signal. One of the split signals is sent directly to an optical power meter and serves as the reference signal. The other split signal is spliced into one of the free ends of the concatenated test fibers. A second power meter is connected to the returning end of the test fibers. This measurement is the test signal. During the tests the readings from both optical power meters are monitored continuously. The data are stored periodically in a computer for future analysis. Manual readings are taken periodically to confirm the logged data. Any changes in the difference between the reference and test signals indicate a change in the attenuation in the test fiber. A net increase in attenuation means a loss in the optical signal. A net decrease in attenuation indicates a gain in the signal.

TEST SAMPLE TERMINATION ARRANGEMENT

The test samples are terminated in a manner such that the optical fibers at both ends of the sample cannot move relative to the OPGW. The general arrangement of preparing loops between the test sample and the fiber splice tray is shown in Figure B-1.



Total length: 9.4 + 0.8 + 1.2 + 2.8 + 1.0 = 15.2m

Figure B-1: Test Sample Termination Arrangement

ISO-9001
Form: QF11-1
Rev 0, 97-10

APPENDIX C
INSTRUMENT SHEET
EL SEWEDY CABLES LTD. OPGW
(Reference: AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Test Description: OPGW Cable QualificationTests
Project Number: K-422180

Test Start Date: February 1, 2006
Test Finish Date: March 20, 2006

TEST DESCRIPTION	EQUIPMENT DESCRIPTION	MAKE	MODEL	ASSET # or SERIAL #	ACCURACY CLAIMED	CALIBRATION DATE	CALIBRATION DUE DATE	TEST USE
Sheave, Crush, Impact, Strain Margin, Fibre Strain, Stress-Strain, Breaking-Load.	A/D Board	National Instruments	PCI-6034E	CA1C1A	±0.1% of reading	February 9, 2006	February 9, 2007	Data Acquisition
	Optical Power Sensor Module	HP	81531A	2947G02841 #9	±0.15dB, ±1pW	October 20, 2005	October 20, 2007	Reference Meter
	Optical Power Sensor Module	HP	81531A	11140-0-3 #7	±0.15dB, ±1pW	October 20, 2005	October 20, 2007	Test Meter
	Load Cell (MTS) Load Cell Conditioner	Lebow MTS	3156 493.01DC	17356-0 10000686-0	±1% of reading	May 10, 2005	May 10, 2006	Strain Margin, Stress Strain, Breaking Load.
	Displacement Transducer Conditioner	Genisco Trans-tek	PT-10AS0100G 1002	19697-0 19698-0	±0.1mm	February 27, 2006	February 27, 2007	Cable Strain
	Test Machine	Satec	120WHVL	11110-0	±1% of F.S.	April 29, 2005	April 29, 2006	Crush Load
	Load Cell Load Conditioner	Eaton Daytronics	3124 3170	17952-0 11148-0	±1% of reading	Dec. 20, 2005	Dec. 20, 2006	Cable Tension (Sheave)
	Digital Calipers	Mitutoyo	500-138	10090-0	±0.025 mm	Nov. 11, 2003	Nov. 11, 2006	Cable and Tube Diameters
	Digital Scale	Mettler Toledo	SB32000	10000640-0	±5 grams	April 27, 2005	April 27, 2006	Impact Mass

Aeolian Vibration (North Span)	A/D Board	National Instruments	PCI-6034E	CA1BF8	±0.1% of reading	February 9, 2006	February 9, 2007	Data Acquisition
	Optical Power Sensor Module	HP	81531A	2947G01386 #1	±0.15dB, ±1pW	October 19, 2005	October 19, 2007	Reference Meter
	Optical Power Sensor Module	HP	81531A	2947G02843 #8	±0.15dB, ±1pW	October 20, 2005	October 20, 2007	Test Meter
	Load Cell	Interface	102AF-50KN-B	12505-0				
	Load Cell Conditioner	Daytronics	3170	10717-0	±1% of reading	April 28, 2005	April 28, 2006	Cable Tension
	Digital Protractor	Mitutoyo	Pro 3600	19693-0	0 to -0.1 degree	January 7, 2004	January 7, 2005	Cable Sag Angle
Galloping (South Span)	Data Logger	National Instruments	PCI6034E	CCC804	0.1% of reading	February 9, 2006	February 9, 2007	Data Acquisition
	Optical Power Sensor Module	HP	81531A	11139-0 #2	±0.15dB, ±1pW	November 7, 2005	November 7, 2007	Reference Meter
	Optical Power Sensor Module	HP	81531A	10000680-0 #5	±0.15dB, ±1pW	November 7, 2005	November 7, 2007	Test Meter
	Load Cell	Straincert	TSN-10	19679-0				
	Load Cell Conditioner	Daytronics	3170	19678-0	±1.0% of reading	Dec. 20, 2005	Dec. 20, 2006	Cable Tension
Lightning Arc	Optical Power Sensor Module	HP	81531A	10708-1 #3	±0.15dB, ±1pW	November 7, 2005	November 7, 2007	Reference Meter
	Optical Power Sensor Module	HP	81531A	10000679-0 #6	±0.15dB, ±1pW	November 7, 2005	November 7, 2007	Test Meter
	Data Analyzer	Tektronix	TDS 540D	10000733-0	-	January 19, 2006	January 19, 2007	Data Acquisition
	Load Cell	Artec	20210-10K	50268-0	±1.0% of reading	Dec. 20, 2005	Dec. 20, 2006	Cable Tension
Short and Long Term Minimum Bending Radius	Optical Power Sensor Module	HP	81633B	KIN-00148 #11	±0.15dB, ±1pW	March 18, 2004	March 18, 2006	Reference Meter
	Optical Power Sensor Module	HP	81637B	KIN-00147 #10	±0.15dB, ±1pW	March 18, 2004	March 18, 2006	Test Meter

Creep KB 019 South-East Span	Datalogger	Campbell Scient.	CR7	17377-0	±0.1% of F.S.	May 10, 2005	May 10, 2006	Data Acquisition
	Load Cell	Aries	TRC 5000	11138-0	±1% of Reading	Dec. 21, 2005	Dec. 21, 2006	Tension
	LVDT	Lucas-Schaevitz	GCD-121-1000	12506-0	±0.04 mm	May 4, 2005	May 4, 2006	Cable Displacement
	LVDT	Lucas-Schaevitz	GCD-121-1000	10727-0	±0.04 mm	May 4, 2005	May 4, 2006	Cable Displacement
	Voltage Divider	Campbell Scientific	CVD 20	20537-0	±0.2%	May 16, 2005	May 16 2006	Voltage Divider for LVDT
	LVDT Power Supply	Calex	CM2.15.200-115	KIN 50371	0.08% at FS	April 28 2005	April 28, 2006	LVDT Power Supply
Seepage of Flooding	Digital Thermometer	Fluke	51 / Type K	17616-0 / 14427-2	±1 degree C	May 20, 2004	May 20, 2005	Chamber Air Temperature
	Digital Scale	Mettler Toledo	PB153-S	1120133358	±0.001 g	Sept. 8, 2005	Sept. 8, 2006	Weight Scale
Temperature Cycling	Data Logger	Campbell Scientific	21X	20525-0	±0.1% of F.S.	Feb. 13, 2006	Feb. 13, 2007	Data Acquisition
	Optical Power Sensor Module	HP	81531A	10000679-0 #6	±0.15dB, ±1pW	November 7, 2005	November 7, 2007	Reference Meter
	Optical Power Sensor Module	HP	81531A	10708-1 #3	±0.15dB, ±1pW	November 7, 2005	November 7, 2007	Test Meter
	Thermocouple	Omega	Type T	KIN-00437	±1 degree C	November 3, 2005	November 3, 2006	Chamber Temperature
	Thermocouple	Omega	Type T	KIN-00438	±1 degree C	November 3, 2005	November 3, 2006	Chamber Temperature
Cutoff Wavelength	Cutoff Wavelength	Lightguide Systems	SMST-020	19025-0	±4.0 nm	May 2, 2005	May 2, 2006	Cable Cutoff
DC Resistance	Micro-ohm Meter	Megabras	MPK-102	20002019-0	0.00001 ohms/km	January 24, 2006	January 24, 2007	Cable Resistance
	Digital Thermometer	Fluke	51 / Type K	17616-0 / 14427-2	±1 degree C	Sept. 8, 2005	Sept. 8, 2006	Cable Temperature
	Measuring Tape	Mastercraft	57-7190-0	KIN-00314	±0.1 inch	March 17, 2005	March 17, 2006	Cable Length

Short Circuit	Dynamometer	Dillion	4000 KG	10721-0	±2.0% of reading	December 20, 2005	December 20, 2006	Cable Tension
	Resistive Instrumentation Shunt	0.5 ohm	HCL-SP	17616-0	0.1%	September 3, 2005	September 3, 2006	Non Inductive Shunt
	Waveform Recorder	Kinectics Systems	4004	100000026-0	-	November 28, 2005	November 28, 2006	Recording Optic Ref & Test Meters
	Waveform Recorder	Lecroy	6810	A60497	0.5%	February 21, 2006	February 21, 2007	Recording Cable Temperatures
	Waveform Recorder	Lecroy	6810	A69503	0.5%	February 17, 2006	February 17, 2007	Recording Fault Current
	Current Instrumentation Transformer	Raccal-Decca	CT2463-2	Z014565	-	November 28, 2005	November 28, 2007	Resistive Shunt for Current Measurements
	Thermocouple Isolation Units	Kinectrics	KTh1-1	KTh1-1	-	November 2, 2005	November 2, 2006	Cable Components Temperatures
	Optical Power Sensor Module	HP	81633B	KIN-00148 #11	±0.15dB, ±1pW	March 18, 2004	March 18, 2006	Reference Meter
	Optical Power Sensor Module	HP	81637B	KIN-00147 #10	±0.15dB, ±1pW	March 18, 2004	March 18, 2006	Test Meter
Salt Spray	Digital Scale	Mettler	PC 4400	13875-0	±10 gram	March 3, 2005 **	March 3, 2006 **	Salt Weight
	Test Machine	Satec	120WHVL	11110-0	±1% of F.S.	April 29, 2005	April 29, 2006	Tensile Strength of Wires
	Digital Meter Thermocouple Thermocouple	Fluke Omega Omega	52 Type K Type K	KIN-00033 KIN-00035 KIN-00136	±1 degree	March 10, 2005 July 26, 2005 July 26, 2005	March 10, 2006 ** July 26, 2006 July 26, 2006	Exposure Zone & Tower Air Temperature
	PH Meter	Orion	EA 940	035238-0	±0.1	Calibrate before each use	Calibrate before each use	pH of Collected Solution

** Kinectrics Quality Assurance System allows for a one month extension on calibration due dates.

APPENDIX D

TEST RESULTS FROM UNDERWRITERS LABORATORY FOR EL SEWEDY CABLES LTD. OPGW CABLE (Ref. AA/ACS 79/33-14kA/0.5s, 14.5 mm, 48 fibres)

Underwriters Laboratories Inc.

Melville Division
1285 Walt Whitman Road
Melville, NY 11747-3081 USA
www.ul.com/lancable
Tel: 1 631 271 6200
Fax: 1 631 439 6029

Melville – March 16, 2006

Mr. Michael Kastelein
Kinectrics N.A. Inc.

800 Kipling Avenue
Toronto, Ontario, CANADA
M8Z 6C4

Reference: E302962, 06CA11615

Subject: Specific Optical Fiber Performance Testing
Single Mode Optical Ground Wire Cable
Product No.: SM-MFOA (AA/ACS 79/33 – 14kA/0.5s)

Mr. Kastelein,

This letter will serve as a report for the above project that was opened to test the subject sample described below:

Optical Ground Wire (OPGW), Product SM-MFOA (AA/ACS 79/33 – 14kA/0.5s)
See Appendix A for Manufacturer's Product Specification Sheet.

The submitted samples were tested in accordance with the requirements of the following documents:

a. Selected tests from1138-1994 IEEE Standard Construction of Composite Fiber Optic Groundwire (OPGW) for Use on Electric Utility Power Lines

b. TIA-455-176-A / IEC-60793-1-20 – Optical Fibres – Part 1-20: Measurement Methods and Test Procedures – Fibre Geometry

c. TIA-455-175-B / IEC-60793-1-42 – Optical Fibres – Part 1-42: Measurement Methods and Test Procedures – Chromatic Dispersion

d. TIA-455-78-B / IEC 60793-1-40 – Optical Fibres - Part1-40: Measurement Methods and Test Procedures – Attenuation

e. TIA-455-173 - Coating Geometry Measurement For Optical Fiber Side-View Method

Testing was conducted on March 13, 2006 at Underwriters Laboratories in Melville, New York, USA at the request of the client. Testing was witnessed by Mr. Michael Kastelein, Mr. Hassan Mohamed Refaat and Mr. Mohamed Ahmed Fouad Ahmed Soliman.

Underwriters Laboratories Inc.

Melville Division
1285 Walt Whitman Road
Melville, NY 11747-3081 USA
www.ul.com/lancable
Tel: 1 631 271 6200
Fax: 1 631 439 6029

Table 1 identifies the tests performed and the equipment used. Table 2 is a summary of the test results. The sample was compliant to the selected tests of IEEE Standard 1138-1994.

Table 1: List of Tests Performed and Equipment Used

Test	Equipment Used	Manufacturer	Model
Chromatic Dispersion	Chromatic Dispersion System	Photon Kinetics	2800
Concentricity Error	Fiber Geometry System	Photon Kinetics	2400
Cladding Diameter	Fiber Geometry System	Photon Kinetics	2400
Claddding Non-circularity	Fiber Geometry System	Photon Kinetics	2400
Coating Diameter	Fiber Geometry System	Photon Kinetics	2400
Attenuation Coefficient	Optical Fiber Analysis System	Photon Kinetics	2500

Table 2: Summary of Test Results

Attribute	Detail	Average Measured Value	Specification	Complies ?	Appendix
Chromatic Dispersion	Zero-Dispersion wavelength, λ_o	1313 nm	1295 nm –1322 nm	Yes	B
	Maximum value of dispersion slope, $S_o$max	0.086 ps/(nm^2•km)	0.095 ps/(nm^2•km)	Yes	B
Concentricity Error	Maximum	0.72 µm	≤1.0 µm	Yes	C
Cladding Diameter	Nominal	125.5 µm	125.0 ± 2.0 µm	Yes	C
Claddding Non-circularity	Maximum non-circularity	0.3%	≤ 2.0%	Yes	C
Coating Diameter	Nominal	240 µm	250 µm *	Yes*	D
Attenuation Coefficient	1310 nm	0.34 dB/km	≤ 0.38 dB/km	Yes	E
	1550 nm	0.20 dB/km	≤ 0.25 dB/km	Yes	E
Attenuation Variation	1285 nm - 1330 nm	0.04 dB/km	≤ 0.1 dB/km more than 1310 nm attenuation	Yes	E

*No tolerance stated in IEEE Std. 1138 – 1994. A similar standard, Telcordia GR-20-CORE, states a tolerance of ± 10.0 µm.

Underwriters Laboratories Inc.

Melville Division
1285 Walt Whitman Road
Melville, NY 11747-3081 USA
www.ul.com/lancable
Tel: 1 631 271 6200
Fax: 1 631 439 6029

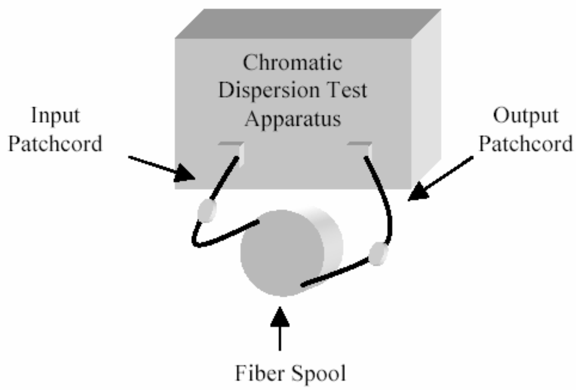
The submitted samples were tested as follows:

Chromatic Dispersion

Test Equipment:
Photon Kinetics Model 2800 Chromatic Dispersion/PMD System/Fiber Strain

Test Method:
a. Attach reference patchcords to the input and output of the PK 2800.
b. Record a reference Chromatic Dispersion reading using the 1310 nm and 1550 nm sources.
c. Attach the sample to the input and output reference patchcords of the PK 2800.
d. Record the Chromatic Dispersion readings at 1310 nm and 1550 nm.

Test Configuration:



Test Data:
See Appendix B for the Chromatic Dispersion measurement results.

Underwriters Laboratories Inc.

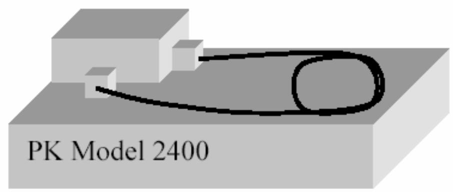
Melville Division
1285 Walt Whitman Road
Melville, NY 11747-3081 USA
www.ul.com/lancable
Tel: 1 631 271 6200
Fax: 1 631 439 6029

Fiber Geometry

Test Equipment:
Photon Kinetics Model 2400 Fiber Geometry System

Test Method
a. Load sample fiber ends into clips and cleave.
b. Mount each clip onto the PK Model 2400 input and output stages.
c. Follow on-screen instructions to obtain core and cladding diameters, noncircularities, and concentricities.

Test Configuration:



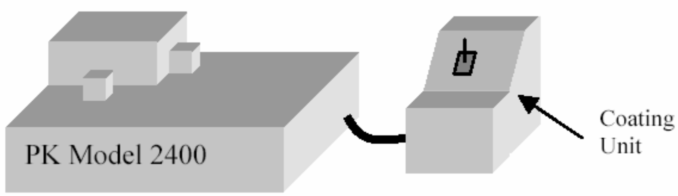
Test Data:
See Appendix C for the Fiber Glass Geometry Measurement results.

Coating Diameter

Test Equipment:
Photon Kinetics Model 2400 Fiber Geometry System
Fiber Coating Unit Measurement System

Test Method:
a. Use the PK Model 2400 in conjunction with the Fiber Coating Unit to measure the coating diameter.
b. Load sample fiber into clip and cleave.
c. Mount clip on measurement stage of fiber coating unit.
d. Follow the automated on-screen instructions to obtain coating diameter.

Test Configuration:



Test Data:
See Appendix D for the Fiber Coating Diameter measurement results.

Underwriters Laboratories Inc.

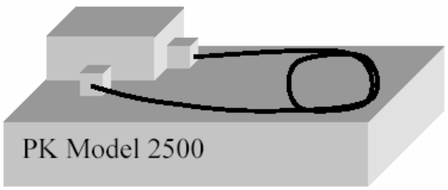
Melville Division
1285 Walt Whitman Road
Melville, NY 11747-3081 USA
www.ul.com/lancable
Tel: 1 631 271 6200
Fax: 1 631 439 6029

Spectral Attenuation

Test Equipment:
Photon Kinetics Model 2500

Test Method:
a. Load sample fiber ends into clips and cleave.
b. Mount each clip on Model 2500 input and output stages.
c. Center and focus fiber ends to take initial reading.
d. Perform a 2-m cutback off of the input stage.
e. Take final readings.

Test Configuration:



Test Data:
See Appendix E for test results.

It should be understood that these results apply only to the particular products submitted for testing. The test results indicated in this report are not intended to imply Listing, Verification or other Recognition of any product material. UL has not established a Factory Follow-Up Service Program to determine conformance to the subsequently produced material, nor has any provision been established to apply any registered mark of UL to such material.

In no event shall Underwriters Laboratories Inc. be responsible to any one for whatever use or non-use is made of the information contained in this Report and in no event shall Underwriters Laboratories Inc., its employees, or its agents incur any obligation of liability for damages, including but not limited to, consequential damages, arising out of or in connection with the use, or inability to use, the information contained in this Report.

Should you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

Jeanine Bogashewicz (Ext. 22684)
Sr. Project Engineer
Conformity Assessment Services

Reviewed By:

Kenneth R. Vessey Jr.
Staff Engineer
Conformity Assessment Services

E302962
05CA11615

Optical Ground wire (OPGW)

Product data sheet: AA/ACS 79/33 – 14kA/0.5s
SM-MFOA

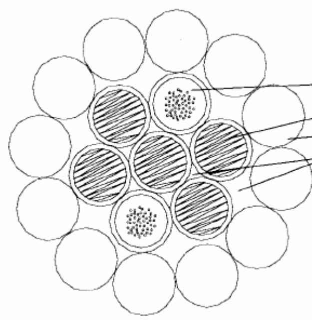
APPLICATION

These cables are suitable for installation as optical ground wire in powerline installations.
The cable acts as an normal ground wire protecting phase wires from lighting strikes and carries earth fault currents.
The cable provides also an optic path in powerline installations for telecommunication needs.

FEATURES

- Installation in the same way as normal ground wire with conventional machinery.
- Most reliable optic solution for fibre optic utilities.
- Best solution in old ground wire replacement and in new line constructions.
- Low cost

Cross Sectional Diagram



CONSTRUCTION

Optical fibre	: For fibre specification see optical characteristics.	
Secondary coating	: The secondary coating consists of one laser welded stainless steel tube. Every fibre is uniquely identified by a fibre colour and for fibre counts above 12 fibres with a coloured fibre bundle yarn. The tube is filled with a water-repellent filling compound.	
Central element	: 1 ACS wires (20SA)	: 2.9 mm
First layer	: 2 stainless steel tube 4 ACS wires (20SA) : Direction layer	: 2.85 mm : 2.9 mm : "Left "
Second layer	: 12 aluminium alloy (AA) wires : Direction layer	: 2.9 mm : "Right "
Grease	: The interstices of the cable core are filled with grease according to IEC 1089 ANNEX C figure C.2	

Product data sheet: AA/ACS 79/33 – 14kA/0.5s

All values in this product data sheet are nominal unless otherwise stated.

TECHNICAL CHARACTERISTICS

Number of tubes	2	
Number of fibres / tube	24	
Cable ∅	14.5	mm
Cable weight	485	kg/km
Supporting cross-section	112.29	mm^2
AA cross-section	79.26	mm^2
ACS cross-section	33.03	mm^2
Calculated breaking load (UTS)	61	kN
Modulus of elasticity	87.88	kN/mm^2
Coefficient of thermal expansion $.10^{-6}$	17.58	1/K
Permissible tensile stress acc.		
Everyday stress	90	N/mm^2
Maximum tensile stress	236	N/mm^2
Endurance tensile stress	404	N/mm^2
Nominal short-time current IEC 724 at		
Initial/Final temperature 40 / 200 °C	14.45	kA, 0.5 s.
D.C. resistance at 20 °C	0.360	Ω/km
Transport, storage, operation	- 40 to + 80	°C
Installation	- 10 to + 50	°C

Optical characteristics (cabled max. values)

Fibre type	Single mode			
Acc. to specification	ITU-T G.652			
Mode field diameter	9.2 ± 0.5			μm
Cladding diameter	125 ± 1			μm
Coating diameter	245 ± 10			μm
Wavelength	1310	1285-1330	1550	nm
Max. Attenuation coefficient	0.38	0.40	0.25	dB/km
Average Attenuation coefficient	0.35	0.36	0.22	dB/km
Dispersion	-	3.5	18.0	ps/nm.km
PMD	0.5			$ps.km^{-½}$

Fibre colouring

Fibre No.	1	2	3	4	5	6
Fibre colour	Blue	Orange	Green	Brown	Grey	White

Fibre No.	7	8	9	10	11	12
Fibre colour	Red	Black	Yellow	Violet	Rose	Turquoise

Customised colouring upon request

Product data sheet: AA/ACS 79/33 – 14kA/0.5s

E302962
05CA11615

Binder yarn colouring

Fibre bundle	1	2
Yarn colour	Blue	Orange

Testing and inspection

Testing will comprise the following:	
- Optical characteristics (each cable length)	Attenuation (Single mode at 1310 / 1550nm)
- Mechanical characteristics	Diameter of cable
- Electrical characteristics	DC resistance
- Visual inspection of cable	Colouring / markings of fibres / tubes
The mechanical characteristics and visual inspection shall be carried out with a frequency of 1 out of 10 drums, starting with the first drum. The first drum shall always be checked when the quantity is less than 10 drums. Certified test results are provided upon request. If testing and inspection to be carried out by third parties is required, such parties will be nominated and paid by the Purchaser.	

Packing

Standard length	≥ 3000	m
Length tolerance	+/-100, we reserve the right to deliver up to a maximum of 10 % of the ordered quantity in shorter lengths with a minimum of 2000 m / drum.	m
Sealing of cable ends	To prevent ingress of moisture the cable ends are sealed with heat shrinkable end caps.	
Protection / Packing	The reel shall be lagged with strong wooden battens so as to prevent the OPGW from damage in ordinary handling and shipping.	

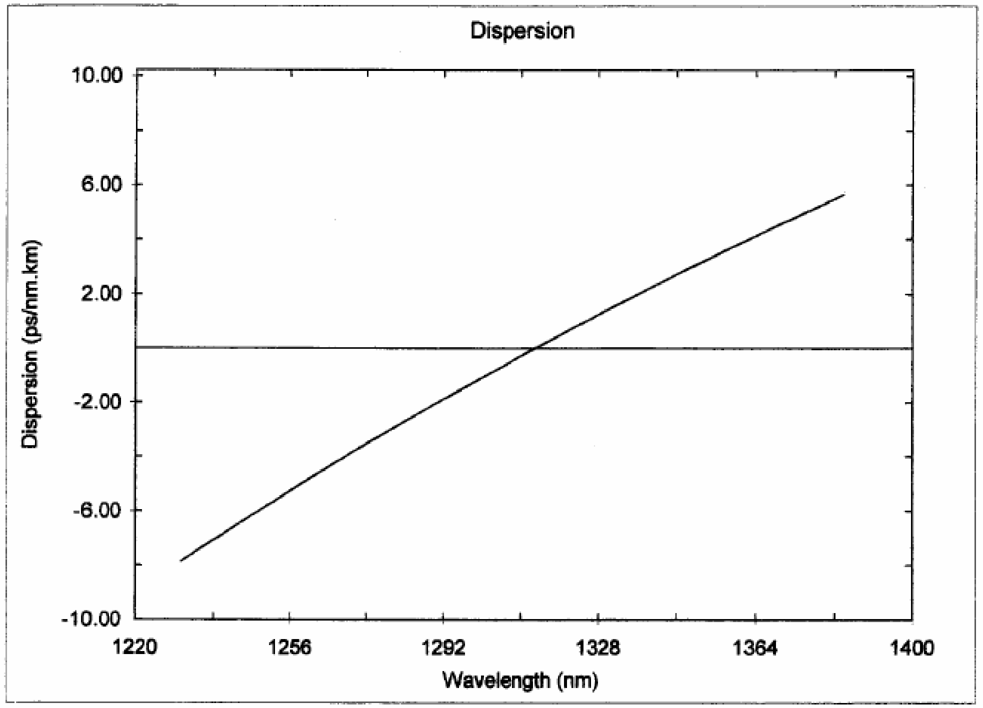
E302962
06CA11615

Instrument Type	: 2800 Dispersion
Serial Number	: 504844
Date of Measurement	: Mon Mar 13 2006
Time of Measurement	: 10:11:25
Sequence Title	: 1300 CD
Sequence File	: c:\apps\2800\disp\sequence\cd1300.seq
Sequence Last Modified Date	: Fri Nov 12 2004
Sequence Last Modified Time	: 11:07:01
Results File	: c:\apps\2800\disp\data\f18309u.csv
Operator Identification	: Supervisor
Fiber Type	: Single-mode
User ID	: 03-13-2006 -JB
Fiber ID	: Blue
Date of Calibration	: Thu Aug 25 2005
Time of Calibration	: 10:39:09

E302962
06CA11615

2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309u.csv
Supervisor

03-13-2006 -JB
Blue



Wavelength (nm)	Dispersion (ps/nm.km)
1310.0	-0.27180

User ID : 03-13-2006 -JB
Fiber Length (m) : 1176.962
Lambda Zero (nm) : 1313.15
Slope (ps/nm^2.km) : +0.08606
Curve Fit : 3-Term Sellmeier

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:11:25

2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309u.csv
Supervisor

03-13-2006 -JB
Blue

User ID : 03-13-2006 -JB
Date of Measurement : Mon Mar 13 2006 10:11:25
Fiber Length (m) : 1176.962

Raw Group Delay Data 1310 nm Standard

Measurement Wavelength (nm)	Measured Relative Group Delay (ns)
1235.5	+0.00000
1240.4	-0.04263
1245.4	-0.07967
1250.3	-0.11500
1255.2	-0.14780
1260.1	-0.17742
1265.0	-0.20433
1270.0	-0.22856
1274.9	-0.24950
1279.8	-0.26829
1284.8	-0.28397
1289.7	-0.29706
1294.7	-0.30786
1299.6	-0.31579
1304.6	-0.32172
1309.5	-0.32472
1314.5	-0.32520
1319.4	-0.32311
1324.4	-0.31907
1329.4	-0.31236
1334.4	-0.30336
1339.3	-0.29153
1344.3	-0.27727
1349.3	-0.26147
1354.3	-0.24211
1359.2	-0.22167
1364.2	-0.19971
1369.3	-0.17243
1374.2	-0.14438
1379.0	-0.11659

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:11:25

E3029692
06CA11615
2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309u.csv
Supervisor

03-13-2006 -JB
Blue

User ID	: 03-13-2006 -JB
Date of Measurement	: Mon Mar 13 2006 10:11:25
Fiber Length (m)	: 1176.962
Lambda Zero (nm)	: 1313.15
Slope (ps/nm^2.km)	: +0.08606
Curve Fit	: 3-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1235.0 to 1380.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^-2 +Cx^2]
Coefficient A (ns/km)	: -3.73755986655115E+01
Coefficient B (ns.nm^2/km)	: 3.19859110906803E+07
Coefficient C (ns.nm^-2/km)	: 1.07573528711708E-05
RMS Error (ns/km)	: 0.0004

Spot Checks

Wavelength (nm)	Dispersion (ps/nm.km)
1310.0	-0.27180

Result Table

Wavelength (nm)	Dispersion (ps/nm.km)	Slope (ps/nm^2.km)	Relative Group Delay (ns/km)
1235.0	-7.39092	+0.10401	+0.00306
1240.0	-6.87417	+0.10269	-0.03260
1245.0	-6.36397	+0.10139	-0.06569
1250.0	-5.86019	+0.10012	-0.09625
1255.0	-5.36270	+0.09888	-0.12431
1260.0	-4.87137	+0.09766	-0.14989
1265.0	-4.38608	+0.09646	-0.17303
1270.0	-3.90672	+0.09529	-0.19376
1275.0	-3.43317	+0.09414	-0.21211
1280.0	-2.96532	+0.09301	-0.22810
1285.0	-2.50305	+0.09190	-0.24177
1290.0	-2.04626	+0.09082	-0.25314
1295.0	-1.59484	+0.08975	-0.26224
1300.0	-1.14869	+0.08871	-0.26910
1305.0	-0.70771	+0.08769	-0.27374
1310.0	-0.27180	+0.08668	-0.27618
1315.0	+0.15913	+0.08570	-0.27646
1320.0	+0.58519	+0.08473	-0.27460
1325.0	+1.00645	+0.08378	-0.27062
1330.0	+1.42302	+0.08285	-0.26454
1335.0	+1.83497	+0.08194	-0.25640
1340.0	+2.24240	+0.08104	-0.24620
1345.0	+2.64539	+0.08016	-0.23398
1350.0	+3.04401	+0.07929	-0.21975
1355.0	+3.43836	+0.07845	-0.20355
1360.0	+3.82850	+0.07761	-0.18538
1365.0	+4.21452	+0.07680	-0.16527
1370.0	+4.59648	+0.07599	-0.14324
1375.0	+4.97448	+0.07521	-0.11931
1380.0	+5.34856	+0.07443	-0.09350

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:11:25

E302962

06CA11615

2800 Dispersion Serial No.:504844

c:\apps\2800\disp\data\f18309u.csv

Supervisor

03-13-2006 -JB

Blue

User ID	: 03-13-2006 -JB
Date of Measurement	: Mon Mar 13 2006 10:11:25
Fiber Length (m)	: 1176.962
Lambda Zero (nm)	: 1313.15
Slope (ps/nm^2.km)	: +0.08606
Curve Fit	: 3-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1235.0 to 1380.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^-2 +Cx^2]
Coefficient A (ns/km)	: -3.73755986655115E+01
Coefficient B (ns.nm^2/km)	: 3.19859110906803E+07
Coefficient C (ns.nm^-2/km)	: 1.07573528711708E-05
RMS Error (ns/km)	: 0.0004

Dispersion Statistics

1290 nm (ps/nm.km)	1300 nm (ps/nm.km)	1310 nm (ps/nm.km)	1320 nm (ps/nm.km)	1330 nm (ps/nm.km)	Lambda Zero (nm)	Slope (ps/nm^2.km)	RMS Error (ns/km)
-2.040	-1.143	-0.267	+0.589	+1.425	1313.10	+0.0860	0.0004
-2.037	-1.145	-0.274	+0.578	+1.411	1313.19	+0.0855	0.0007
-2.053	-1.156	-0.280	+0.576	+1.413	1313.25	+0.0860	0.0006
-2.052	-1.155	-0.278	+0.579	+1.416	1313.22	+0.0860	0.0005
-2.049	-1.144	-0.260	+0.605	+1.450	1312.98	+0.0868	0.0007

Average

-2.046	-1.149	-0.272	+0.585	+1.423	1313.15	+0.08606

Standard Deviation

0.0074	0.0064	0.0084	0.0119	0.0159	0.1090	0.000478

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:11:25

E302962
06CA11615
2800 Dispersion Serial No.:504844
F18309W.csv
Supervisor

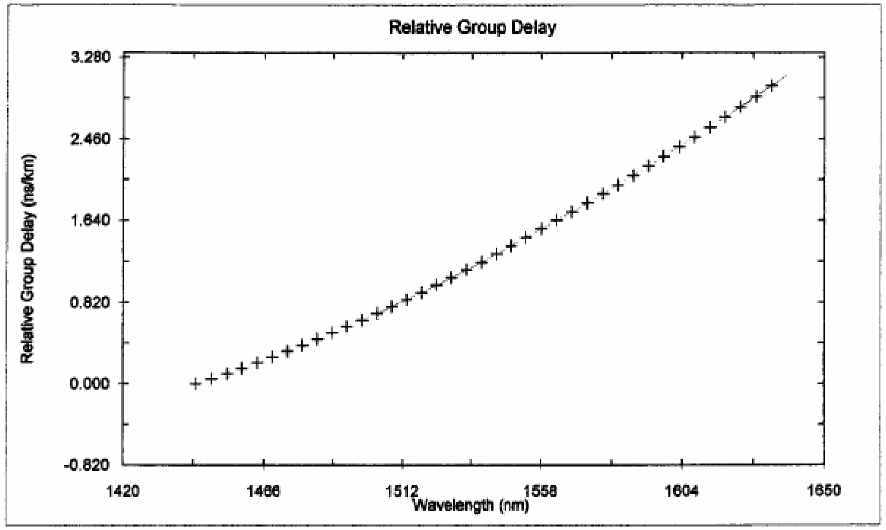
03-13-2006 - JB
Blue 1550

Instrument Type	: 2800 Dispersion
Serial Number	: 504844
Date of Measurement	: Mon Mar 13 2006
Time of Measurement	: 10:18:56
Sequence Title	: 1550 CD
Sequence File	: c:\apps\2800\disp\sequence\cd1550.seq
Sequence Last Modified Date	: Tue May 25 2004
Sequence Last Modified Time	: 10:22:13
Results File	: F18309W.csv
Operator Identification	: Supervisor
Fiber Type	: Single-mode
User ID	: 03-13-2006 - JB
Fiber ID	: Blue 1550
Date of Calibration	: Thu Aug 25 2005
Time of Calibration	: 10:39:09

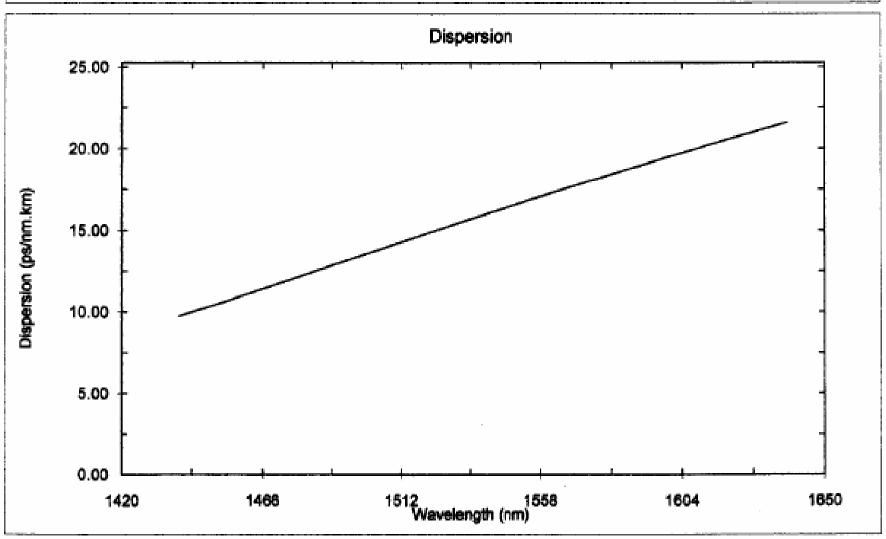
E302962
06CA11615

2800 Dispersion Serial No.:504844
F18309W.csv
Supervisor

03-13-2006 - JB
Blue 1550



User ID	: 03-13-2006 - JB
Fiber Length (m)	: 1176.654
Lambda Zero (nm)	: No Solutions Found
Slope (ps/nm^2.km)	: No Solutions Found
Curve Fit	: 5-Term Sellmeier
RMS Error (ns/km)	: 0.0005



Wavelength (nm)	Dispersion (ps/nm.km)
1490.0	12.91934
1550.0	16.60195
1625.0	20.88407

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:18:56

2800 Dispersion Serial No.:504844
F18309W.csv
Supervisor

03-13-2006 - JB
Blue 1550

User ID : 03-13-2006 - JB
Date of Measurement : Mon Mar 13 2006 10:18:56
Fiber Length (m) : 1176.654

Raw Group Delay Data

Measurement Wavelength (nm)	Measured Relative Group Delay (ns)
1443.9	+0.00000
1448.9	+0.05818
1453.9	+0.12059
1458.9	+0.18370
1463.8	+0.24861
1468.8	+0.31627
1473.7	+0.38490
1478.8	+0.45451
1483.7	+0.52701
1488.7	+0.60063
1493.6	+0.67730
1498.6	+0.75463
1503.6	+0.83427
1508.5	+0.91518
1513.5	+0.99871
1518.4	+1.08376
1523.4	+1.17027
1528.3	+1.25852
1533.3	+1.34881
1538.3	+1.43972
1543.2	+1.53359
1548.2	+1.62885
1553.2	+1.72704
1558.2	+1.82565
1563.1	+1.92784
1568.1	+2.03077
1573.1	+2.13495
1578.1	+2.24089
1583.1	+2.34871
1588.1	+2.45814
1593.1	+2.57130
1598.1	+2.68437
1603.1	+2.79798
1608.1	+2.91491
1613.1	+3.03317
1618.0	+3.15257
1623.0	+3.27285
1628.0	+3.39686
1633.0	+3.52081

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:18:56

E302962
06CA11612

2800 Dispersion Serial No.:504844
F18309W.csv
Supervisor

03-13-2006 - JB
Blue 1550

User ID	: 03-13-2006 - JB
Date of Measurement	: Mon Mar 13 2006 10:18:56
Fiber Length (m)	: 1176.654
Lambda Zero (nm)	: No Solutions Found
Slope (ps/nm^2.km)	: No Solutions Found
Curve Fit	: 5-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1445.0 to 1635.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^4 +Cx^2 +Dx^-2 +Ex^-4]
Coefficient A (ns/km)	: -1.04402069117474E+02
Coefficient B (ns.nm^-4/km)	: -1.61145746303833E-12
Coefficient C (ns.nm^-2/km)	: 2.80426990222387E-05
Coefficient D (ns.nm^2/km)	: 1.43158832774310E+08
Coefficient E (ns.nm^4/km)	: -6.83522486804281E+13
RMS Error (ns/km)	: 0.0005

Spot Checks

Wavelength (nm)	Dispersion (ps/nm.km)
1490.0	12.91934
1550.0	16.60195
1625.0	20.88407

Result Table

Wavelength (nm)	Dispersion (ps/nm.km)	Slope (ps/nm^2.km)	Relative Group Delay (ns/km)
1445.0	+10.09817	+0.06256	+0.01025
1450.0	+10.41120	+0.06265	+0.06152
1455.0	+10.72465	+0.06272	+0.11436
1460.0	+11.03837	+0.06276	+0.16877
1465.0	+11.35223	+0.06278	+0.22475
1470.0	+11.66610	+0.06277	+0.28229
1475.0	+11.97987	+0.06273	+0.34141
1480.0	+12.29340	+0.06268	+0.40209
1485.0	+12.60660	+0.06260	+0.46434
1490.0	+12.91934	+0.06250	+0.52816
1495.0	+13.23152	+0.06237	+0.59353
1500.0	+13.54303	+0.06223	+0.66047
1505.0	+13.85379	+0.06207	+0.72896
1510.0	+14.16370	+0.06189	+0.79901
1515.0	+14.47265	+0.06169	+0.87060
1520.0	+14.78058	+0.06148	+0.94373
1525.0	+15.08739	+0.06124	+1.01840
1530.0	+15.39300	+0.06100	+1.09460
1535.0	+15.69733	+0.06073	+1.17233
1540.0	+16.00032	+0.06046	+1.25157
1545.0	+16.30188	+0.06017	+1.33233
1550.0	+16.60195	+0.05986	+1.41459
1555.0	+16.90045	+0.05954	+1.49835
1560.0	+17.19734	+0.05921	+1.58359
1565.0	+17.49254	+0.05887	+1.67032
1570.0	+17.78600	+0.05851	+1.75851
1575.0	+18.07765	+0.05815	+1.84817
1580.0	+18.36745	+0.05777	+1.93929
1585.0	+18.65534	+0.05738	+2.03185
1590.0	+18.94127	+0.05699	+2.12584
1595.0	+19.22519	+0.05658	+2.22125
1600.0	+19.50706	+0.05617	+2.31809
1605.0	+19.78683	+0.05574	+2.41632
1610.0	+20.06445	+0.05531	+2.51595

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:18:56

2800 Dispersion Serial No.:504844
F18309W.csv
Supervisor

03-13-2006 - JB
Blue 1550

Result Table

Wavelength (nm)	Dispersion (ps/nm.km)	Slope (ps/nm^2.km)	Relative Group Delay (ns/km)
1615.0	+20.33989	+0.05487	+2.61696
1620.0	+20.61311	+0.05442	+2.71935
1625.0	+20.88407	+0.05396	+2.82309
1630.0	+21.15272	+0.05350	+2.92818
1635.0	+21.41905	+0.05303	+3.03461

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:18:56

2800 Dispersion Serial No.:504844
F18309W.csv
Supervisor

03-13-2006 - JB
Blue 1550

User ID	: 03-13-2006 - JB
Date of Measurement	: Mon Mar 13 2006 10:18:56
Fiber Length (m)	: 1176.654
Lambda Zero (nm)	: No Solutions Found
Slope (ps/nm^2.km)	: No Solutions Found
Curve Fit	: 5-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1445.0 to 1635.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^4 +Cx^2 +Dx^-2 +Ex^-4]
Coefficient A (ns/km)	: -1.04402069117474E+02
Coefficient B (ns.nm^-4/km)	: -1.61145746303833E-12
Coefficient C (ns.nm^-2/km)	: 2.80426990222387E-05
Coefficient D (ns.nm^2/km)	: 1.43158832774310E+08
Coefficient E (ns.nm^4/km)	: -6.83522486804281E+13
RMS Error (ns/km)	: 0.0005

Dispersion Statistics

1530 nm (ps/nm.km)	1540 nm (ps/nm.km)	1550 nm (ps/nm.km)	1560 nm (ps/nm.km)	1570 nm (ps/nm.km)	Lambda Zero (nm)	Slope (ps/nm^2.km)	RMS Error (ns/km)
+15.40	+16.00	+16.60	+17.19	+17.78	*****	*****	0.0006
+15.39	+16.01	+16.61	+17.21	+17.80	*****	*****	0.0006
+15.39	+16.00	+16.60	+17.20	+17.79	*****	*****	0.0008
+15.39	+16.00	+16.60	+17.19	+17.78	*****	*****	0.0007
+15.39	+16.00	+16.60	+17.19	+17.78	*****	*****	0.0006

Average

+15.39	+16.00	+16.60	+17.20	+17.79	*****	*****

Standard Deviation

0.0031	0.0032	0.0058	0.0083	0.0100	0.0000	0.000000

Measurement Date : Mon Mar 13 2006
Measurement Time : 10:18:56

E302962
06CA11615
2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309x.csv
Supervisor

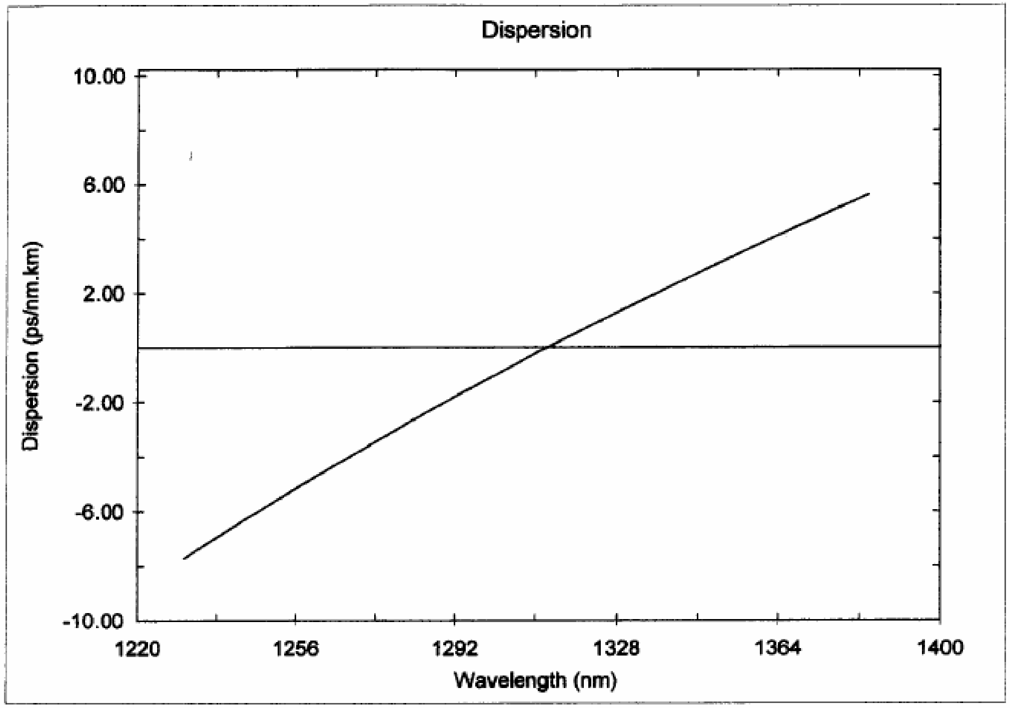
3-13-2006 DR
red

Instrument Type	: 2800 Dispersion
Serial Number	: 504844
Date of Measurement	: Mon Mar 13 2006
Time of Measurement	: 11:05:25
Sequence Title	: 1300 CD
Sequence File	: c:\apps\2800\disp\sequence\cd1300.seq
Sequence Last Modified Date	: Fri Nov 12 2004
Sequence Last Modified Time	: 11:07:01
Results File	: c:\apps\2800\disp\data\f18309x.csv
Operator Identification	: Supervisor
Fiber Type	: Single-mode
User ID	: 3-13-2006 DR
Fiber ID	: red
Date of Calibration	: Thu Aug 25 2005
Time of Calibration	: 10:39:09

E302962
06CA11615

2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309x.csv
Supervisor

3-13-2006 DR
red



Wavelength (nm)	Dispersion (ps/nm.km)
1310.0	-0.22770

User ID	: 3-13-2006 DR
Fiber Length (m)	: 1176.817
Lambda Zero (nm)	: 1312.67
Slope (ps/nm^2.km)	: +0.08502
Curve Fit	: 3-Term Sellmeier

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:05:25

2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309x.csv
Supervisor

3-13-2006 DR
red

User ID : 3-13-2006 DR
Date of Measurement : Mon Mar 13 2006 11:05:25
Fiber Length (m) : 1176.817

Raw Group Delay Data 1310 nm Standard

Measurement Wavelength (nm)	Measured Relative Group Delay (ns)
1235.5	+0.00000
1240.4	-0.03867
1245.4	-0.07452
1250.3	-0.10998
1255.2	-0.14196
1260.1	-0.17074
1265.0	-0.19760
1270.0	-0.22152
1274.9	-0.24222
1279.8	-0.26003
1284.8	-0.27567
1289.7	-0.28823
1294.7	-0.29886
1299.6	-0.30672
1304.6	-0.31230
1309.5	-0.31477
1314.5	-0.31488
1319.4	-0.31289
1324.4	-0.30820
1329.4	-0.30130
1334.4	-0.29211
1339.3	-0.27977
1344.3	-0.26601
1349.3	-0.25012
1354.3	-0.23012
1359.2	-0.21007
1364.2	-0.18811
1369.3	-0.16162
1374.2	-0.13350
1379.0	-0.10643

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:05:25

E302962
06CA11615

2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309x.csv
Supervisor

3-13-2006 DR
red

User ID	: 3-13-2006 DR
Date of Measurement	: Mon Mar 13 2006 11:05:25
Fiber Length (m)	: 1176.817
Lambda Zero (nm)	: 1312.67
Slope (ps/nm^2.km)	: +0.08502
Curve Fit	: 3-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1235.0 to 1380.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^-2 +Cx^2]
Coefficient A (ns/km)	: -3.68941952898998E+01
Coefficient B (ns.nm^2/km)	: 3.15555106722433E+07
Coefficient C (ns.nm^-2/km)	: 1.06280372658587E-05
RMS Error (ns/km)	: 0.0005

Spot Checks

Wavelength (nm)	Dispersion (ps/nm.km)
1310.0	-0.22770

Result Table

Wavelength (nm)	Dispersion (ps/nm.km)	Slope (ps/nm^2.km)	Relative Group Delay (ns/km)
1235.0	-7.25334	+0.10264	+0.00504
1240.0	-6.74339	+0.10134	-0.02995
1245.0	-6.23991	+0.10006	-0.06241
1250.0	-5.74275	+0.09881	-0.09236
1255.0	-5.25180	+0.09758	-0.11984
1260.0	-4.76693	+0.09637	-0.14489
1265.0	-4.28802	+0.09519	-0.16752
1270.0	-3.81495	+0.09404	-0.18778
1275.0	-3.34762	+0.09290	-0.20568
1280.0	-2.88590	+0.09179	-0.22126
1285.0	-2.42970	+0.09070	-0.23455
1290.0	-1.97890	+0.08963	-0.24557
1295.0	-1.53340	+0.08858	-0.25435
1300.0	-1.09310	+0.08755	-0.26091
1305.0	-0.65790	+0.08654	-0.26529
1310.0	-0.22770	+0.08555	-0.26750
1315.0	+0.19759	+0.08457	-0.26757
1320.0	+0.61806	+0.08362	-0.26553
1325.0	+1.03381	+0.08268	-0.26140
1330.0	+1.44493	+0.08177	-0.25520
1335.0	+1.85149	+0.08086	-0.24696
1340.0	+2.25359	+0.07998	-0.23669
1345.0	+2.65131	+0.07911	-0.22443
1350.0	+3.04472	+0.07826	-0.21019
1355.0	+3.43392	+0.07742	-0.19399
1360.0	+3.81896	+0.07660	-0.17586
1365.0	+4.19994	+0.07579	-0.15581
1370.0	+4.57693	+0.07500	-0.13386
1375.0	+4.94999	+0.07422	-0.11004
1380.0	+5.31919	+0.07346	-0.08437

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:05:25

2800 Dispersion Serial No.:504844
c:\apps\2800\disp\data\f18309x.csv
Supervisor

3-13-2006 DR
red

User ID	: 3-13-2006 DR
Date of Measurement	: Mon Mar 13 2006 11:05:25
Fiber Length (m)	: 1176.817
Lambda Zero (nm)	: 1312.67
Slope (ps/nm^2.km)	: +0.08502
Curve Fit	: 3-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1235.0 to 1380.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^-2 +Cx^2]
Coefficient A (ns/km)	: -3.68941952898998E+01
Coefficient B (ns.nm^2/km)	: 3.15555106722433E+07
Coefficient C (ns.nm^-2/km)	: 1.06280372658587E-05
RMS Error (ns/km)	: 0.0005

Dispersion Statistics

1290 nm (ps/nm.km)	1300 nm (ps/nm.km)	1310 nm (ps/nm.km)	1320 nm (ps/nm.km)	1330 nm (ps/nm.km)	Lambda Zero (nm)	Slope (ps/nm^2.km)	RMS Error (ns/km)
-1.975	-1.090	-0.225	+0.620	+1.446	1312.64	+0.0849	0.0006
-1.984	-1.095	-0.227	+0.622	+1.452	1312.65	+0.0853	0.0007
-1.979	-1.094	-0.230	+0.614	+1.439	1312.71	+0.0849	0.0008
-1.982	-1.098	-0.233	+0.611	+1.437	1312.74	+0.0849	0.0007
-1.975	-1.089	-0.223	+0.623	+1.450	1312.61	+0.0851	0.0005

Average

-1.979	-1.093	-0.226	+0.618	+1.445	1312.67	+0.08502

Standard Deviation

0.0041	0.0037	0.0041	0.0052	0.0065	0.0513	0.000184

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:05:25

E302962

06CA11615

2800 Dispersion Serial No.:504844

F18309Y.csv

Supervisor

3-13-2006 DR

red

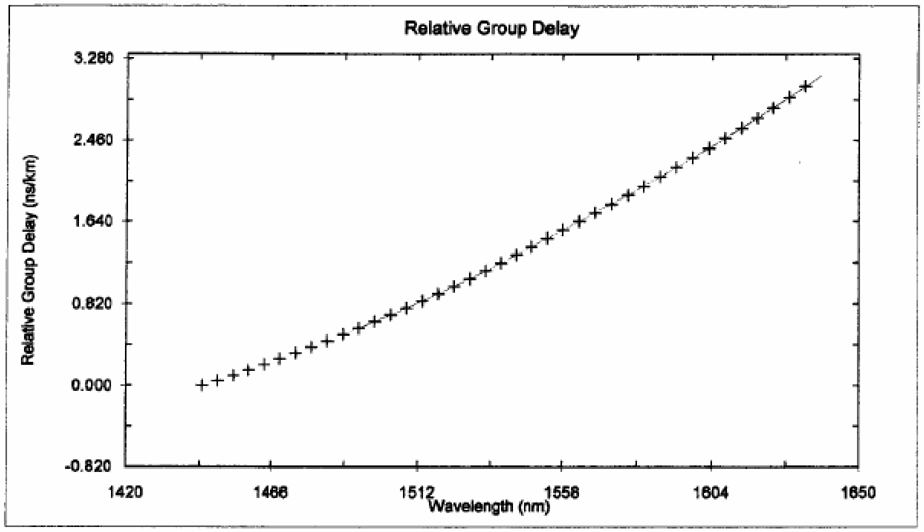
Instrument Type	: 2800 Dispersion
Serial Number	: 504844
Date of Measurement	: Mon Mar 13 2006
Time of Measurement	: 11:10:38
Sequence Title	: 1550 CD
Sequence File	: c:\apps\2800\disp\sequence\cd1550.seq
Sequence Last Modified Date	: Tue May 25 2004
Sequence Last Modified Time	: 10:22:13
Results File	: F18309Y.csv
Operator Identification	: Supervisor
Fiber Type	: Single-mode
User ID	: 3-13-2006 DR
Fiber ID	: red
Date of Calibration	: Thu Aug 25 2005
Time of Calibration	: 10:39:09

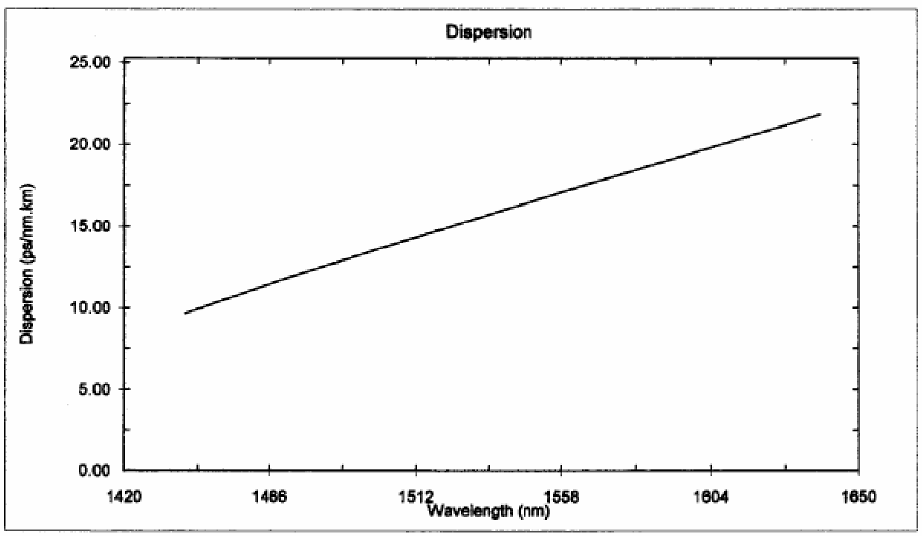
Measurement Date : Mon Mar 13 2006
Measurement Time : 11:10:38

E302962
06CA11615

2800 Dispersion Serial No.:504844
F18309Y.csv
Supervisor

3-13-2006 DR
red





User ID	: 3-13-2006 DR
Fiber Length (m)	: 1176.514
Lambda Zero (nm)	: No Solutions Found
Slope (ps/nm^2.km)	: No Solutions Found
Curve Fit	: 5-Term Sellmeier
RMS Error (ns/km)	: 0.0007

Wavelength (nm)	Dispersion (ps/nm.km)
1490.0	12.97752
1550.0	16.62069
1625.0	21.04753

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:10:38

2800 Dispersion Serial No.:504844
F18309Y.csv
Supervisor

3-13-2006 DR
red

User ID : 3-13-2006 DR
Date of Measurement : Mon Mar 13 2006 11:10:38
Fiber Length (m) : 1176.514

Raw Group Delay Data

Measurement Wavelength (nm)	Measured Relative Group Delay (ns)
1443.9	+0.00000
1448.9	+0.05497
1453.9	+0.11810
1458.9	+0.18307
1463.8	+0.24758
1468.8	+0.31559
1473.7	+0.38430
1478.8	+0.45415
1483.7	+0.52718
1488.7	+0.60039
1493.6	+0.67742
1498.6	+0.75508
1503.6	+0.83490
1508.5	+0.91613
1513.5	+1.00017
1518.4	+1.08544
1523.4	+1.17224
1528.3	+1.26079
1533.3	+1.35138
1538.3	+1.44226
1543.2	+1.53630
1548.2	+1.63199
1553.2	+1.72985
1558.2	+1.82895
1563.1	+1.93082
1568.1	+2.03386
1573.1	+2.13783
1578.1	+2.24454
1583.1	+2.35237
1588.1	+2.46212
1593.1	+2.57561
1598.1	+2.68875
1603.1	+2.80342
1608.1	+2.91983
1613.1	+3.03873
1618.0	+3.15800
1623.0	+3.27936
1628.0	+3.40327
1633.0	+3.53216

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:10:38

2800 Dispersion Serial No.:504844 — 3-13-2006 DR
F18309Y.csv — red
Supervisor

User ID	: 3-13-2006 DR
Date of Measurement	: Mon Mar 13 2006 11:10:38
Fiber Length (m)	: 1176.514
Lambda Zero (nm)	: No Solutions Found
Slope (ps/nm^2.km)	: No Solutions Found
Curve Fit	: 5-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1445.0 to 1635.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^4 +Cx^2 +Dx^-2 +Ex^-4]
Coefficient A (ns/km)	: 2.61690116598375E+01
Coefficient B (ns.nm^-4/km)	: 2.37970150800588E-12
Coefficient C (ns.nm^-2/km)	: -9.26675977986128E-06
Coefficient D (ns.nm^2/km)	: -5.95219898271656E+07
Coefficient E (ns.nm^4/km)	: 4.93561401531102E+13
RMS Error (ns/km)	: 0.0007

Spot Checks

Wavelength (nm)	Dispersion (ps/nm.km)
1490.0	12.97752
1550.0	16.62069
1625.0	21.04753

Result Table

Wavelength (nm)	Dispersion (ps/nm.km)	Slope (ps/nm^2.km)	Relative Group Delay (ns/km)
1445 0	+10.05701	+0.06761	+0.00917
1450 0	+10.39334	+0.06693	+0.06030
1455 0	+10.72633	+0.06627	+0.11310
1460 0	+11.05614	+0.06566	+0.16756
1465 0	+11.38295	+0.06507	+0.22366
1470 0	+11.70693	+0.06452	+0.28138
1475 0	+12.02822	+0.06400	+0.34072
1480 0	+12.34698	+0.06351	+0.40166
1485 0	+12.66336	+0.06305	+0.46419
1490 0	+12.97752	+0.06262	+0.52829
1495 0	+13.28958	+0.06221	+0.59396
1500 0	+13.59969	+0.06183	+0.66118
1505 0	+13.90797	+0.06148	+0.72995
1510 0	+14.21456	+0.06116	+0.80026
1515 0	+14.51959	+0.06086	+0.87210
1520 0	+14.82317	+0.06058	+0.94545
1525 0	+15.12542	+0.06033	+1.02033
1530 0	+15.42646	+0.06009	+1.09671
1535 0	+15.72640	+0.05989	+1.17459
1540 0	+16.02535	+0.05970	+1.25397
1545 0	+16.32341	+0.05953	+1.33484
1550 0	+16.62069	+0.05938	+1.41720
1555 0	+16.91728	+0.05926	+1.50105
1560 0	+17.21329	+0.05915	+1.58637
1565 0	+17.50880	+0.05906	+1.67318
1570 0	+17.80392	+0.05899	+1.76146
1575 0	+18.09872	+0.05893	+1.85122
1580 0	+18.39329	+0.05890	+1.94245
1585 0	+18.68773	+0.05888	+2.03515
1590 0	+18.98210	+0.05887	+2.12933
1595 0	+19.27650	+0.05889	+2.22497
1600 0	+19.57100	+0.05891	+2.32209
1605 0	+19.86567	+0.05896	+2.42068
1610 0	+20.16058	+0.05901	+2.52075

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:10:38

E302962
06CA11615
2800 Dispersion Serial No.:504844
F18309Y.csv
Supervisor

3-13-2006 DR
red

Result Table

Wavelength (nm)	Dispersion (ps/nm.km)	Slope (ps/nm^2.km)	Relative Group Delay (ns/km)
1615.0	+20.45582	+0.05908	+2.62229
1620.0	+20.75145	+0.05917	+2.72531
1625.0	+21.04753	+0.05927	+2.82980
1630.0	+21.34414	+0.05938	+2.93578
1635.0	+21.64133	+0.05950	+3.04325

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:10:38

E302962
06CA11615

2800 Dispersion Serial No.:504844
F18309Y.csv
Supervisor

3-13-2006 DR
red

User ID	: 3-13-2006 DR
Date of Measurement	: Mon Mar 13 2006 11:10:38
Fiber Length (m)	: 1176.514
Lambda Zero (nm)	: No Solutions Found
Slope (ps/nm^2.km)	: No Solutions Found
Curve Fit	: 5-Term Sellmeier (Phase-Shift)
Wavelength Range (nm)	: 1445.0 to 1635.0
Wavelength Step (nm)	: 5.0
Equation Format	: ITU [A +Bx^4 +Cx^2 +Dx^-2 +Ex^-4]
Coefficient A (ns/km)	: 2.61690116598375E+01
Coefficient B (ns.nm^-4/km)	: 2.37970150800588E-12
Coefficient C (ns.nm^-2/km)	: -9.26675977986128E-06
Coefficient D (ns.nm^2/km)	: -5.95219898271656E+07
Coefficient E (ns.nm^4/km)	: 4.93561401531102E+13
RMS Error (ns/km)	: 0.0007

Dispersion Statistics

1530 nm (ps/nm.km)	1540 nm (ps/nm.km)	1550 nm (ps/nm.km)	1560 nm (ps/nm.km)	1570 nm (ps/nm.km)	Lambda Zero (nm)	Slope (ps/nm^2.km)	RMS Error (ns/km)
+15.43	+16.03	+16.63	+17.22	+17.81	*****	*****	0.0008
+15.43	+16.02	+16.62	+17.21	+17.80	*****	*****	0.0009
+15.43	+16.03	+16.62	+17.22	+17.81	*****	*****	0.0007
+15.43	+16.02	+16.61	+17.20	+17.79	*****	*****	0.0009
+15.42	+16.02	+16.62	+17.22	+17.81	*****	*****	0.0009

Average

+15.43	+16.03	+16.62	+17.21	+17.80	*****	*****

Standard Deviation

0.0052	0.0058	0.0075	0.0091	0.0097	0.0000	0.000000

Measurement Date : Mon Mar 13 2006
Measurement Time : 11:10:38

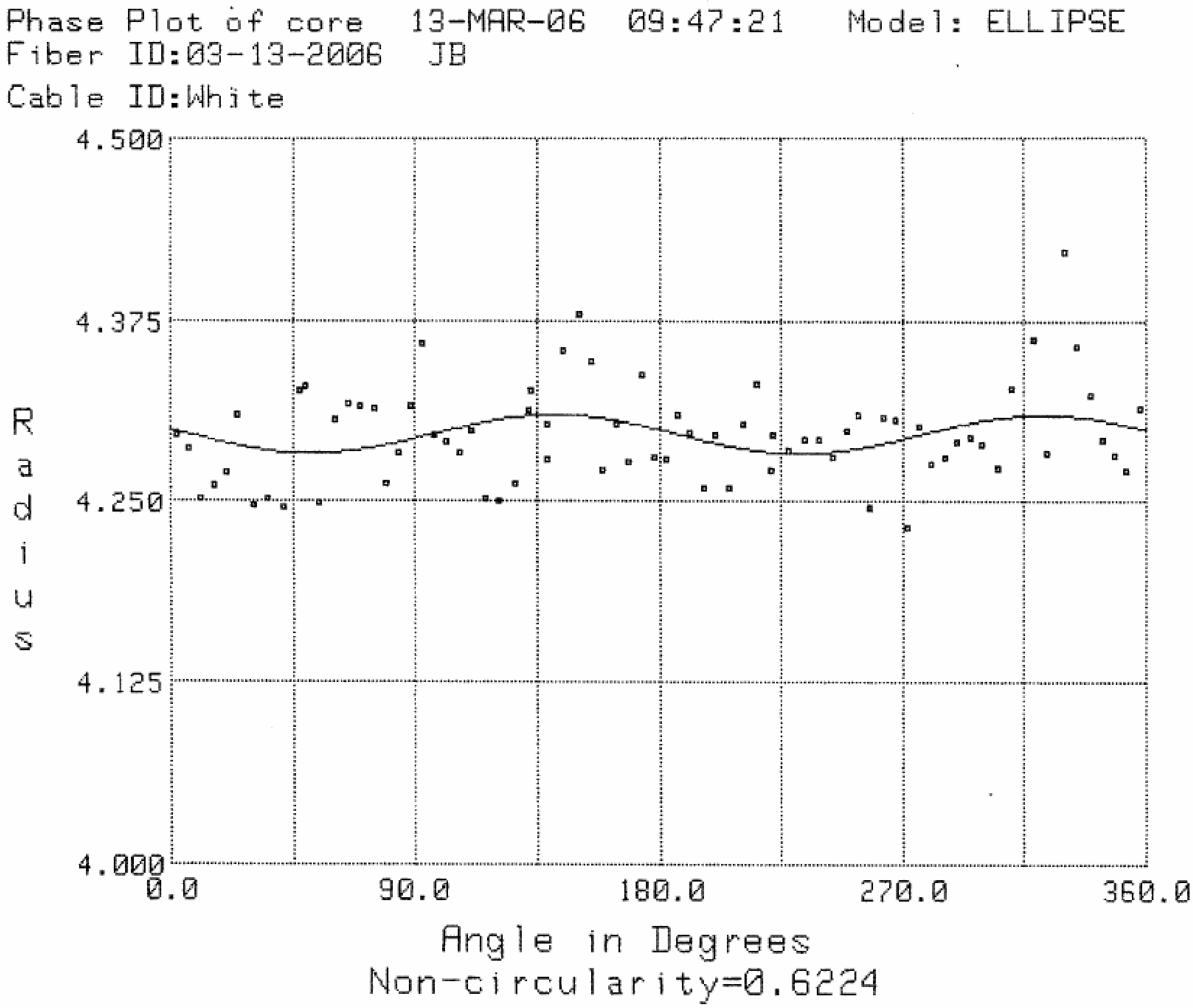
E302962
06CA11615

fiberid = 03-13-2006 JB
logtime = 13-MAR-06 09:47:21

Fiber Glass Geometry Measurement Results Table		
layer	diameter	noncirc
core	8.59	0.62
clad	125.47	0.33

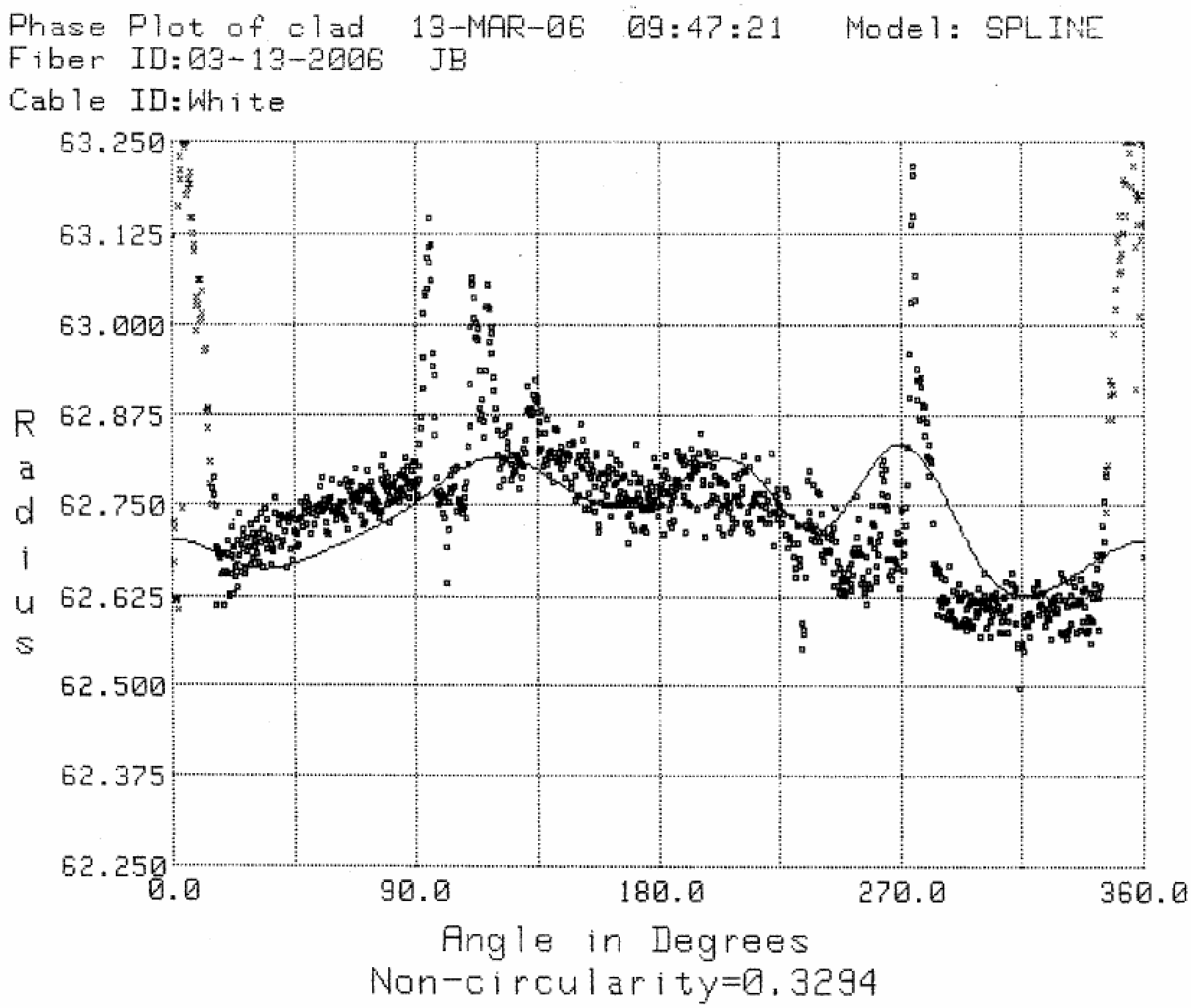
concentricity of clad to core = 0.72 um

E302962
06CA11615



Appendix C Page 2 of 6

E302962
06CA11615



Appendix C Page 3 of 6

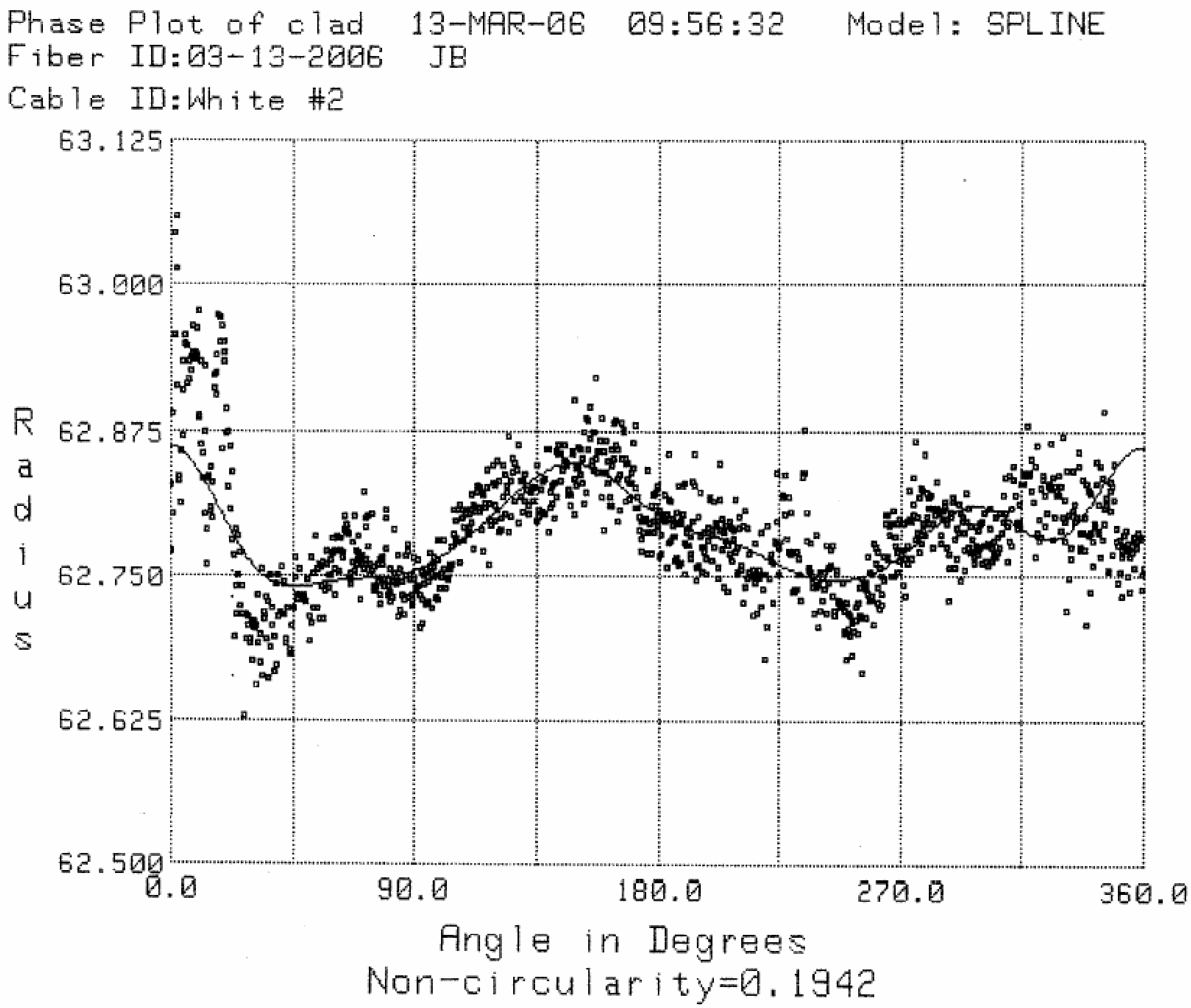
E302962
06CA11615

fiberid = 03-13-2006 JB
logtime = 13-MAR-06 09:56:32

Fiber Glass Geometry Measurement Results Table		
layer	diameter	noncirc
core	8.62	1.33
clad	125.58	0.19

concentricity of clad to core = 0.58 um

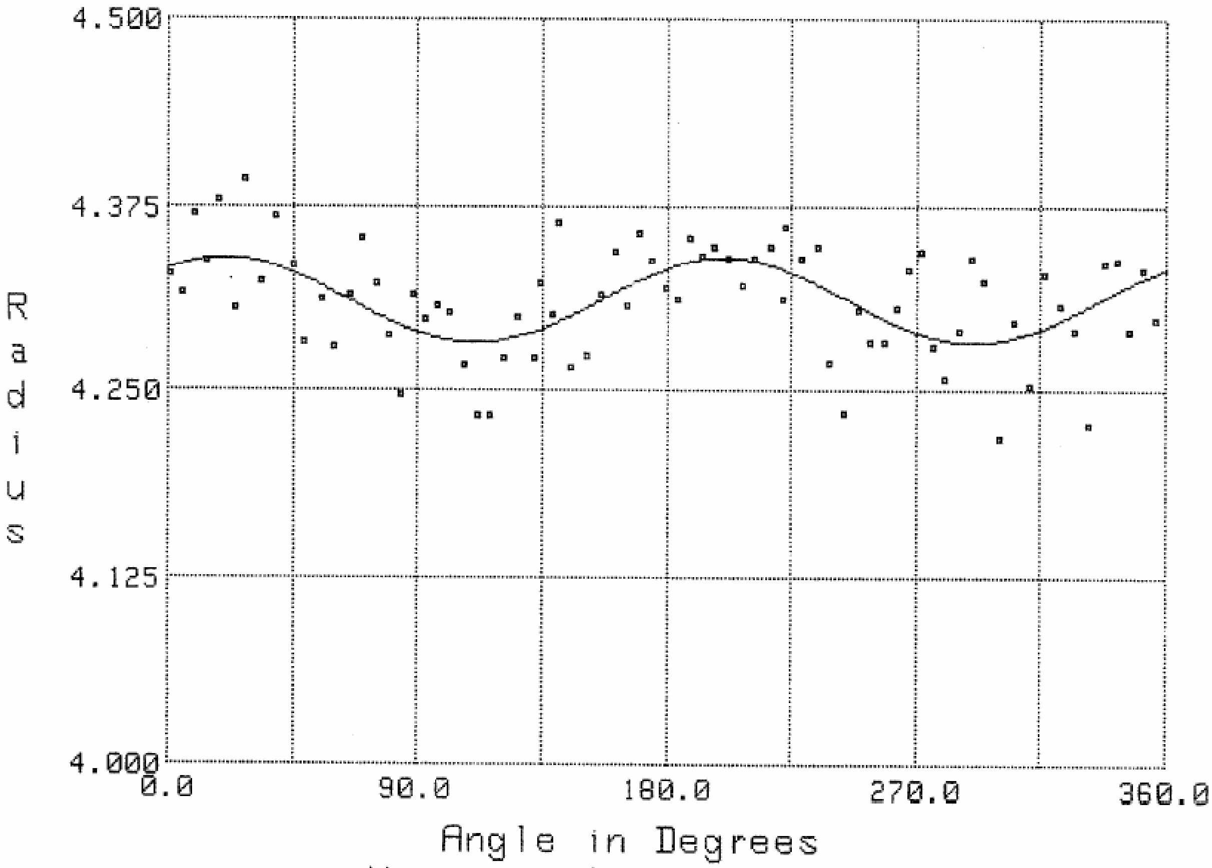
E302962
06CA11615



Appendix C Page 5 of 6

E302962
06CA11615

Phase Plot of core 13-MAR-06 09:56:32 Model: ELLIPSE
Fiber ID:03-13-2006 JB
Cable ID:White #2



Non-circularity=1.3323

Appendix C Page 6 of 6

E302962
06CA11615

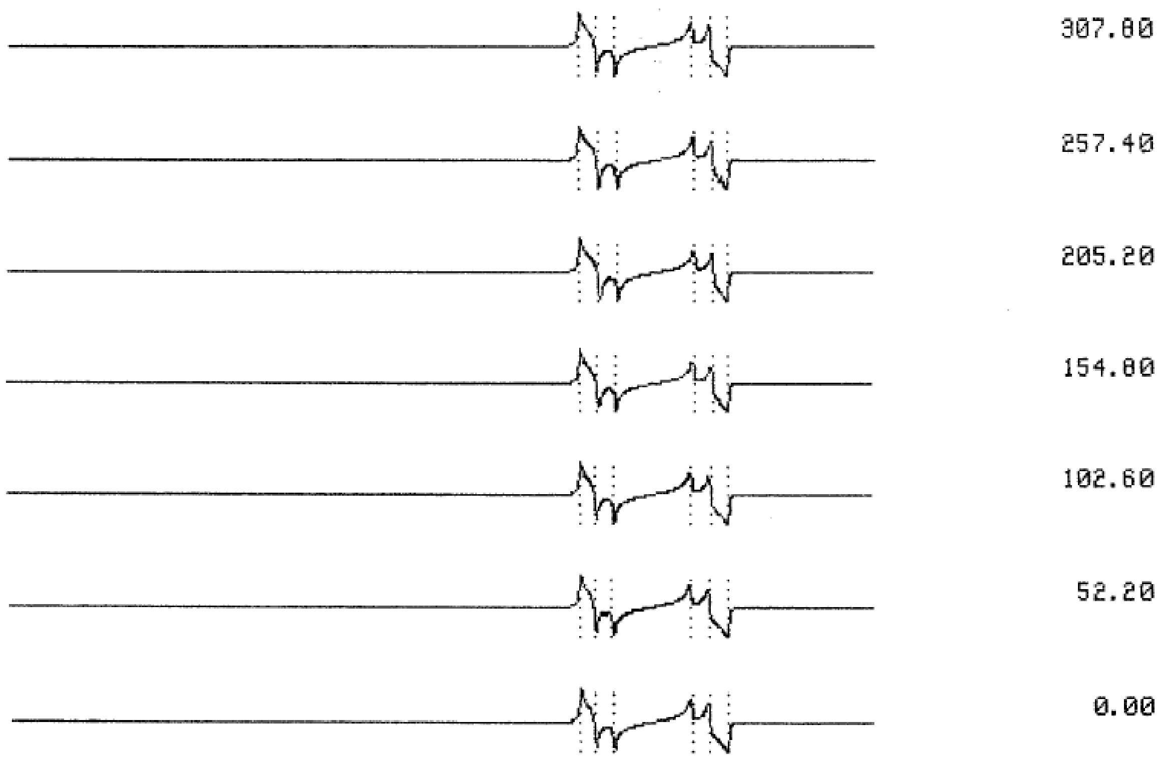
COATING GEOMETRY (7 deflections, 3 layers)
Fiber ID:Violet
Cable ID:03-13-2006 JB
Time: 13-MAR-06 10:21:51

LAYER	INDEX	DIAM um	CONC um	MIN WALL um	MAX WALL um	NON-CIRC
=====	=====	====	====	========	========	========
Secondary	1.5300	240.21	3.93	25.54	33.32	0.16
Primary	1.5100	181.36	0.83	26.06	27.71	
Cladding	1.4600	127.60	0.00	52.38	60.24	

Appendix D Page 1 of 4

E302962
06CA11615

Deflection Functions 13-MAR-06 10:21:51
Fiber ID:Violet
Cable ID:03-13-2006 JB



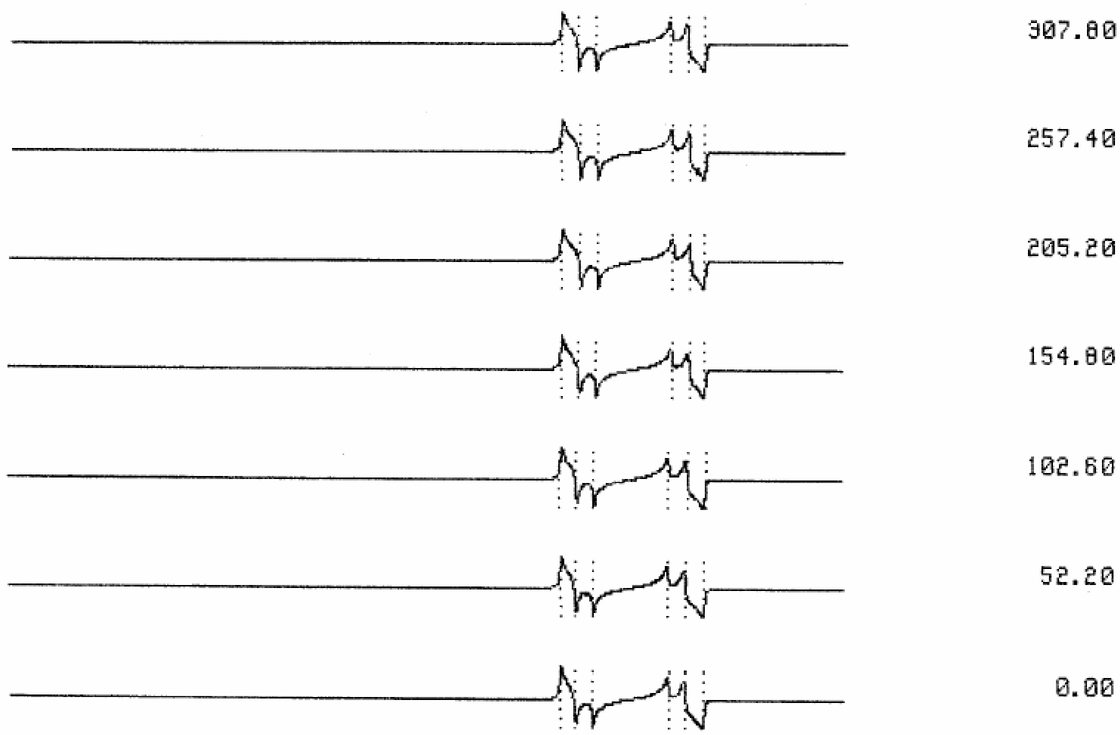
E302962
06CA11615

COATING GEOMETRY (7 deflections, 3 layers)
Fiber ID:Violet#2
Cable ID:03-13-2006 JB
Time: 13-MAR-06 10:28:11

LAYER	INDEX	DIAM um	CONC um	MIN WALL um	MAX WALL um	NON-CIRC
Secondary	1.5300	240.17	3.85	25.57	33.23	0.17
Primary	1.5100	181.38	0.84	26.06	27.74	
Cladding	1.4600	127.58	0.00	52.45	60.15	

E302962
06CA11615

Deflection Functions 13-MAR-06 10:28:11
Fiber ID:Violet #2
Cable ID:03-13-2006 JB



Appendix D Page 4 of 4

E302962
06CA11615

SPECATRESULT
Cable ID:03-13-2006 JB
Fiber ID:Green
Length=1.1760 km
Time of Test:13-MAR-06 12:56:25
Number of Entries:64

(nm)	dB/km	(nm)	dB/km	(nm)	dB/km	(nm)	dB/km
1000	1.021	1160	4.286	1320	0.334	1480	0.223
1010	1.020	1170	4.207	1330	0.332	1490	0.217
1020	1.075	1180	4.080	1340	0.327	1500	0.210
1030	1.242	1190	3.960	1350	0.327	1510	0.203
1040	1.652	1200	3.737	1360	0.327	1520	0.201
1050	2.493	1210	3.358	1370	0.384	1530	0.194
1060	3.709	1220	2.683	1380	0.555	1540	0.195
1070	4.541	1230	1.634	1390	0.503	1550	0.190
1080	4.673	1240	0.932	1400	0.410	1560	0.192
1090	4.641	1250	0.642	1410	0.353	1570	0.192
1100	4.611	1260	0.432	1420	0.309	1580	0.192
1110	4.568	1270	0.393	1430	0.285	1590	0.192
1120	4.517	1280	0.377	1440	0.271	1600	0.192
1130	4.477	1290	0.359	1450	0.252	1610	0.201
1140	4.426	1300	0.356	1460	0.240	1620	0.204
1150	4.353	1310	0.341	1470	0.231	1625	0.206

E302962
06CA11615

1310 nm	0.341 dB/km	
1490 nm	0.217 dB/km	difference=-0.124
1550 nm	0.190 dB/km	difference=-0.027
1625 nm	0.206 dB/km	difference=0.017

E302962
06CA11615

SPECATRESULT
Cable ID:03-13-2006 JB
Fiber ID:Black
Length=1.1760 km
Time of Test:13-MAR-06 13:18:10
Number of Entries:64

(nm)	dB/km	(nm)	dB/km	(nm)	dB/km	(nm)	dB/km
1000	0.980	1160	4.364	1320	0.332	1480	0.221
1010	0.955	1170	4.299	1330	0.324	1490	0.219
1020	0.950	1180	4.186	1340	0.310	1500	0.215
1030	0.986	1190	4.039	1350	0.304	1510	0.212
1040	1.122	1200	3.883	1360	0.299	1520	0.208
1050	1.478	1210	3.608	1370	0.293	1530	0.204
1060	2.226	1220	3.227	1380	0.296	1540	0.199
1070	3.409	1230	2.590	1390	0.290	1550	0.199
1080	4.405	1240	1.575	1400	0.272	1560	0.199
1090	4.630	1250	0.761	1410	0.267	1570	0.197
1100	4.614	1260	0.425	1420	0.257	1580	0.198
1110	4.576	1270	0.384	1430	0.251	1590	0.199
1120	4.537	1280	0.370	1440	0.244	1600	0.202
1130	4.502	1290	0.361	1450	0.239	1610	0.204
1140	4.452	1300	0.347	1460	0.233	1620	0.211
1150	4.411	1310	0.342	1470	0.227	1625	0.215

E302962
06CA11615

1310 nm	0.342 dB/km	
1490 nm	0.219 dB/km	difference=-0.123
1550 nm	0.199 dB/km	difference=-0.020
1625 nm	0.215 dB/km	difference=0.016

DISTRIBUTION

Mr. Hassan Refaat(2)	El Sewedy Cables Ltd. 16 Baghdad Street, Kourba, Heliopolis, P.O. Box: 288 Helioplolis. Cairo, Egypt
Mr. C.J. Pon	Transmission and Distribution Technologies Business, KB104