SATS Certification

Report of Performance

Long Term Test of an XLPE Cable,
24 kV 1 x 300 mm2 Cu

RoP 11-E06

Certification Body for High Voltage Equipment
Accredited according to EN 45011 - ISO/IEC Guide 65
Member of the Short-Circuit Testing Liaison (STL)

Report of Performance No. 11-E06

Long Term 500 Hz Test of an XLPE Cable, 24 kV 1 x 300 mm^2 Cu

Trondheim, 2011-11-11

SATS Certification: Mr. Rolf Hegerberg

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REPORT OF PERFORMANCE No. 11-E06

Client	LG Chem., Ltd. LG Twin Towers, 20, Yeouido-dong, Yeongdeungpo-gu, Seoul, 150-721, KOREA
Test object	12/20 (24) kV XLPE Cable
Designation	24 kV, 1 x 300 mm^2 Cu
Manufacturer	National Cables Industry (NCI), Sharjah, UAE
Materials	XLPE insulation: XL8080TR Conductor screen material: XL2808BKTR Insulations screen material: XL2700BKTR
Ratings assigned by the manufacturer	Voltage: 12/20 (24) kV Conductor cross section: 300 mm^2 Conductor material: Stranded copper
Tests performed	Preconditioning High voltage AC withstand test Long term ageing at 500 Hz AC breakdown testing after ageing
Standards	CENELEC HD 605 S2:2008 and CENELEC HD 620 S2:2010
Testing stations	SINTEF Energy Research, NO-7465 Trondheim, NORWAY
Date of tests	2011-05-09 to 2011-10-24
Test results	The cable fulfilled the requirements of the standards.
The documents forming this report	Title page and 14 numbered pages

Trondheim 2011-11-11

Acting Laboratory Manager Jan T Benjaminsen

SATS Inspector Hallvard Faremo

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The tests were witnessed by Mr. Hallvard Faremo representing SATS Certification, NORWAY

TEST OBJECT

The 90 m cable cores {12/20 (24) kV XLPE cables, 300 mm^2 Cu stranded conductor and strippable insulation screen} tested is schematically shown in Figure 1. For more material data see Appendix 1.

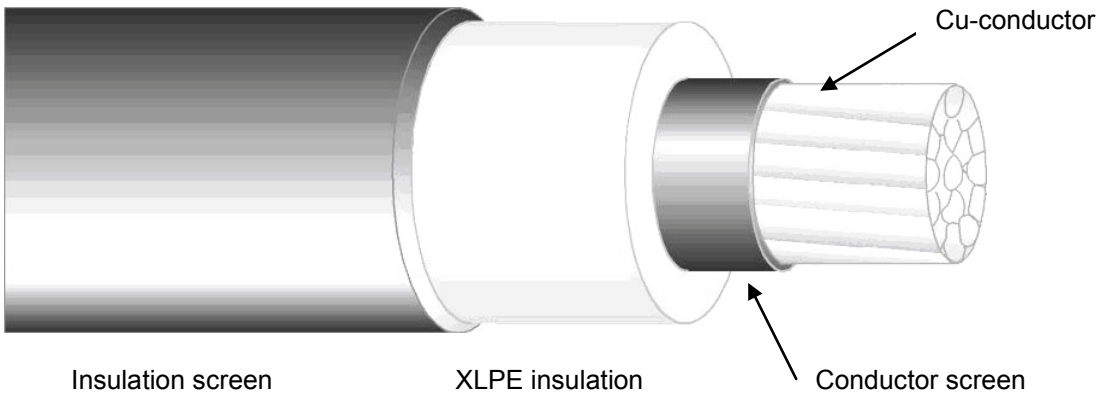

Figure 1: Cross section of the test cable 1 x 300 mm^2 12/20 (24) kV

XLPE insulation:	XL8080TR
Conductor screen:	XL2808BKTR
Insulation screen:	XL2700BKTR

SUMMARY OF TEST RESULTS

LONG TERM AGEING TEST AT 500 Hz			
Tests performed in accordance with CENELEC HD 605 S2:2008 Test No 5.4.6			
Test object: 90 m 12/20 (24) kV XLPE cable, 1x300 mm^2 Cu conductor and strippable insulation screen			*Date(s) of test:* 2011-05-09 - 2011-10-24
Test requirements			**Corresponding tests**
Preconditioning:			
Temperature	(°C)	55±5	53 - 57
Duration	(h)	500	500
Water quality		Tap water [1]	
High voltage AC withstand test:			
Voltage	(kV)	$10U_o$	120 ± 1
Frequency	(Hz)	50	50
Duration	(min)	1	1
Temperature	(°C)	Ambient	22
Ageing parameters:			
Voltage	(kV_{rms})	$3U_0$	36 ± 0.5
Frequency	(Hz)	500	500
Temperature [2]	(°C)	40 ± 5	40 ± 1
Water Quality		Tap water [1]	
- Acidity	(pH)	6.0 – 7.5	6.5 – 7.5
Test duration	(h)	3 000	3 010
Test requirement	No BD [3] during ageing		No BD
Evaluation after ageing:			
Number of samples		6	6
Test procedure (50 Hz, Ambient):	AC step test; start $3U_0$		36 kV
	Increment U_0 every 5 min		12 kV
Test requirements:			
BD field all samples [4]	(kV/mm)	> 14	> 25.5
BD field ≥ 4 samples	(kV/mm)	> 18	> 28.0
BD field ≥ 2 samples	(kV/mm)	> 22	> 30.6

Notes to the table:
1) Added 0.3 g NaCl per liter
2) Isothermal ageing
3) BD = Breakdown
4) Maximum electric field at conductor screen

DETAILED TEST RESULTS

PRECONDITIONING

The preconditioning at 55 ^{0}C was carried out in a 2 m^3 stainless steel water tank with 800 ℓ tap water added NaCl; 0.3 g/ℓ.

HIGH VOLTAGE AC WITHSTAND TEST

A high voltage AC withstand test at $10U_0$ (120 kV) for 1 minute was performed in a grounded tap-water bath.

The test was performed at room temperature.

No breakdown occurred.

AGEING

The ageing was performed in a polyester tank as shown in Figure 2. The 500 Hz resonance circuit is schematically shown in Figure 5. The bath temperature was kept at 40 ^{0}C by self regulating heating cables placed in the bottom of the tank.

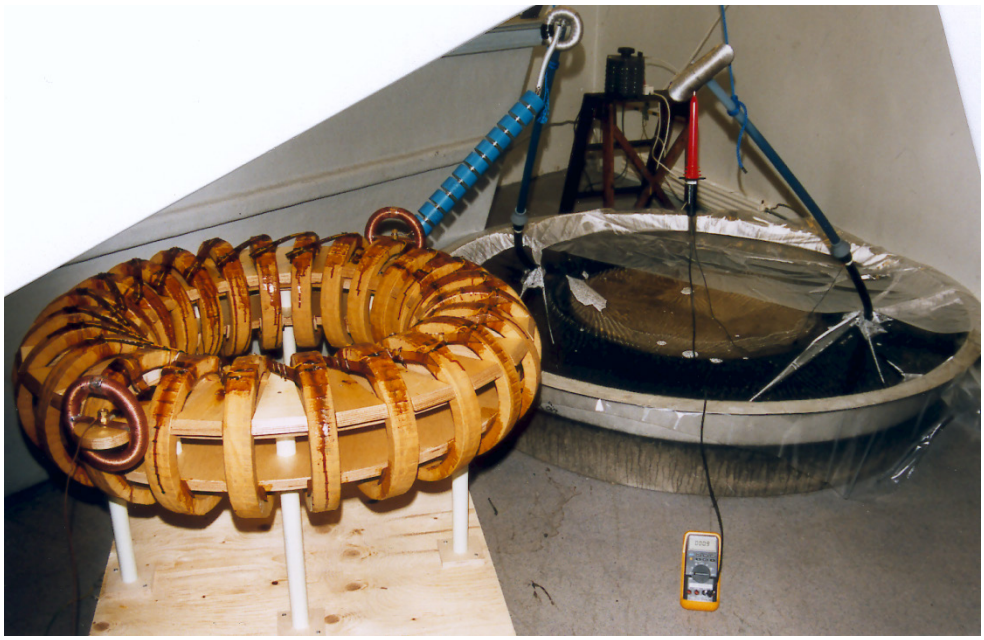

Figure 2: Ageing set-up.

BREAKDOWN TEST AFTER AGEING

Six test objects were prepared from the aged cable. The two ends of the aged cable (2 – 3 m) which had not been totally submerged during the ageing were cut off and discarded. De-ionized water terminations were fitted to the samples before breakdown testing (see Figure 3). The tests are performed at room temperature. The results of the AC step test are shown in Table 1. The computed maximum electrical breakdown field stress at the conductor is also included for each sample.

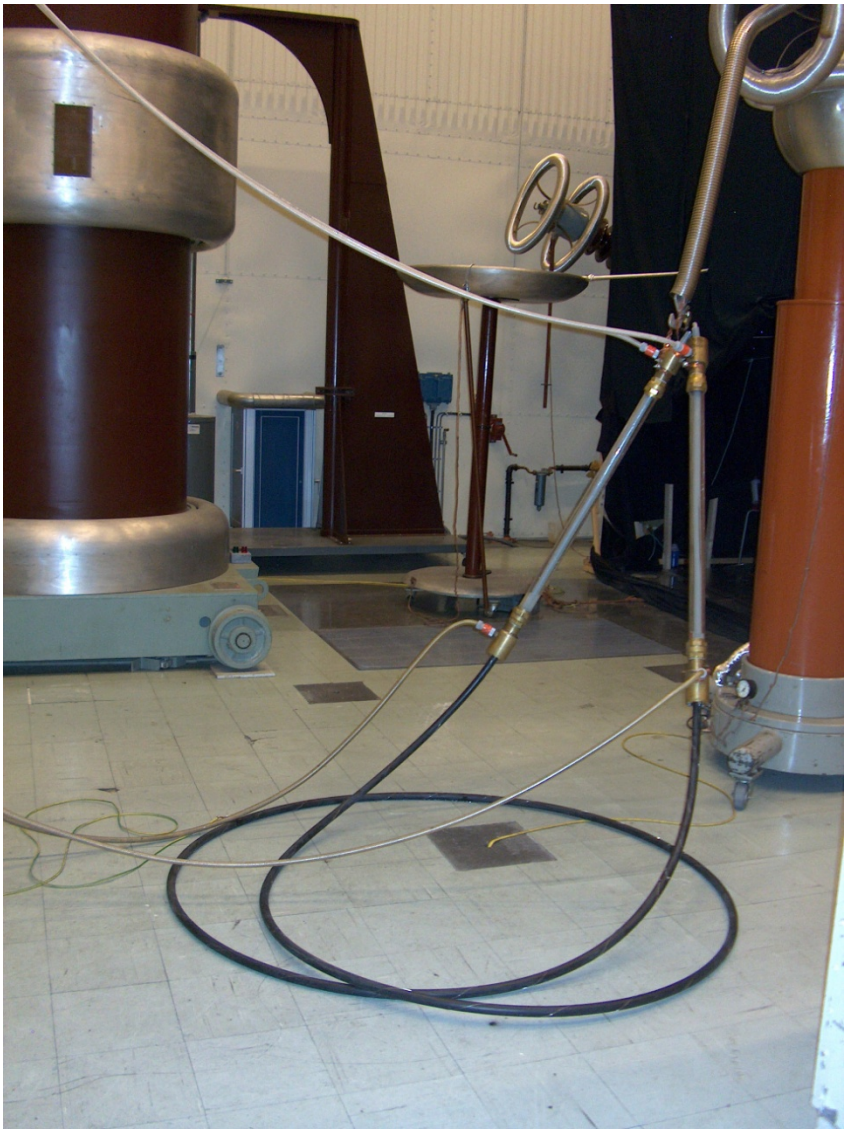

Figure 3: A cable mounted for AC breakdown strength tests. 1 m long de-ionized water terminations were used.

Table 1: AC step test breakdown values for the NCI cable after ageing. The test objects are numbered in the order they were cut from the cable.

Test Object	Breakdown Voltages		Breakdown Stress (Max field at the conductor screen)
	kV	U / U_o	kV/mm
NCI-1	132	11	28.0
NCI-2	144	12	30.6
NCI-3	120	10	25.5
NCI-4	132	11	28.0
NCI-5	132	11	28.0
NCI-6	144	12	30.6

$$E_{max} = \frac{U}{\frac{d}{2} \cdot \ell n \frac{D}{d}}$$

E_{max} = Breakdown stress at the conductor screen [kV/mm]
U = Breakdown voltage [kV]
d = Diameter over the conductor screen = 22.9 mm
D = Diameter over the XLPE insulation = 34.55 mm

Ageing performance is usually presented applying extreme value statistics of the Weibull type to analyze the breakdown data. In Figure 4, the Weibull curve for the breakdown values are presented and compared with the required breakdown field stress values (CENELEC HD620 S2:2010 Part 10 Section I).

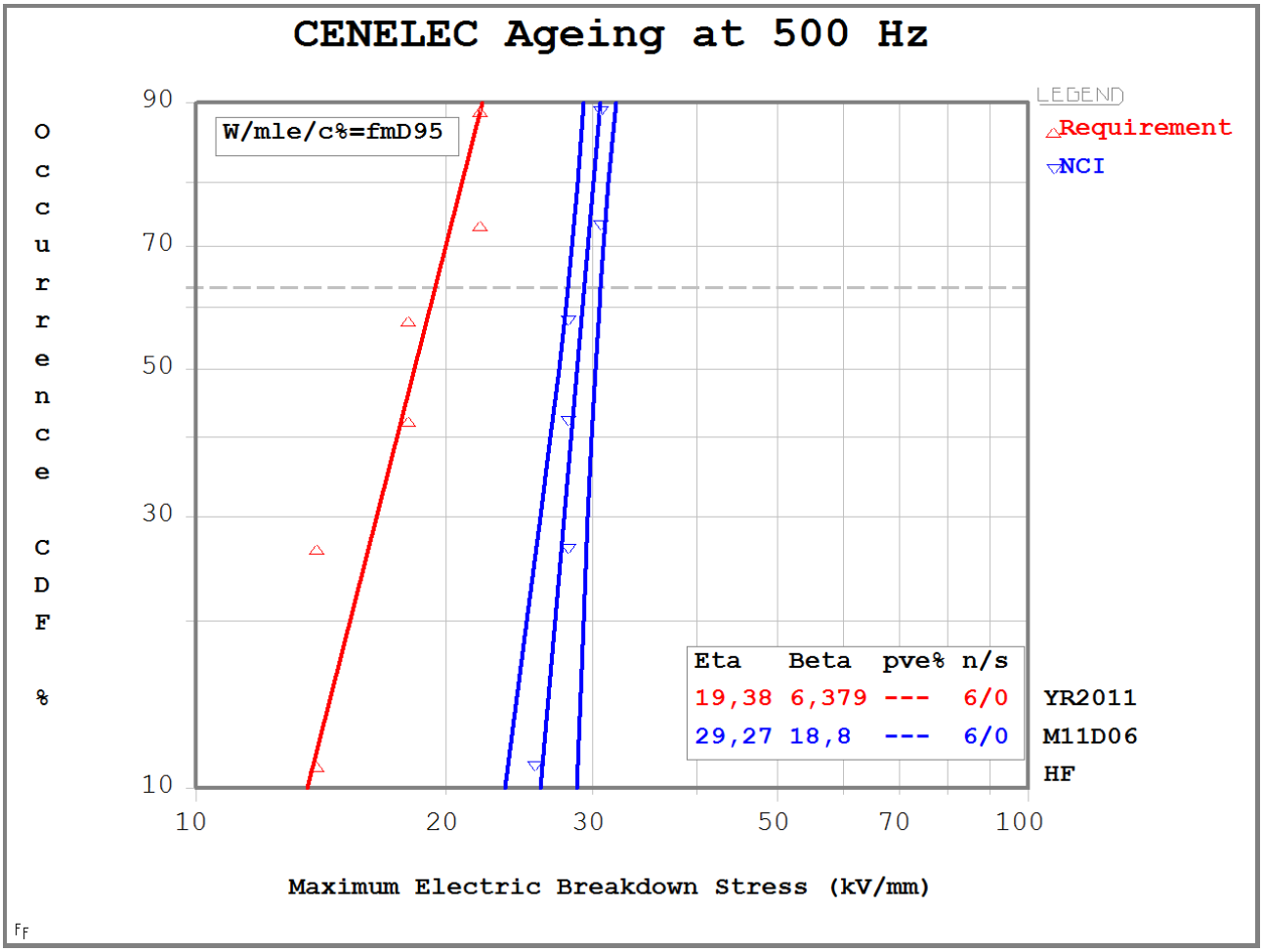

Figure 4: AC breakdown values (maximum electric field at the conductor screen) for the NCI cable according to Weibull Statistics, 95% confidence level.

Eta: 63.2% breakdown stress
Beta: Shape factor
n / s: Number of test objects / Number of suspensions

500 Hz TEST CIRCUIT

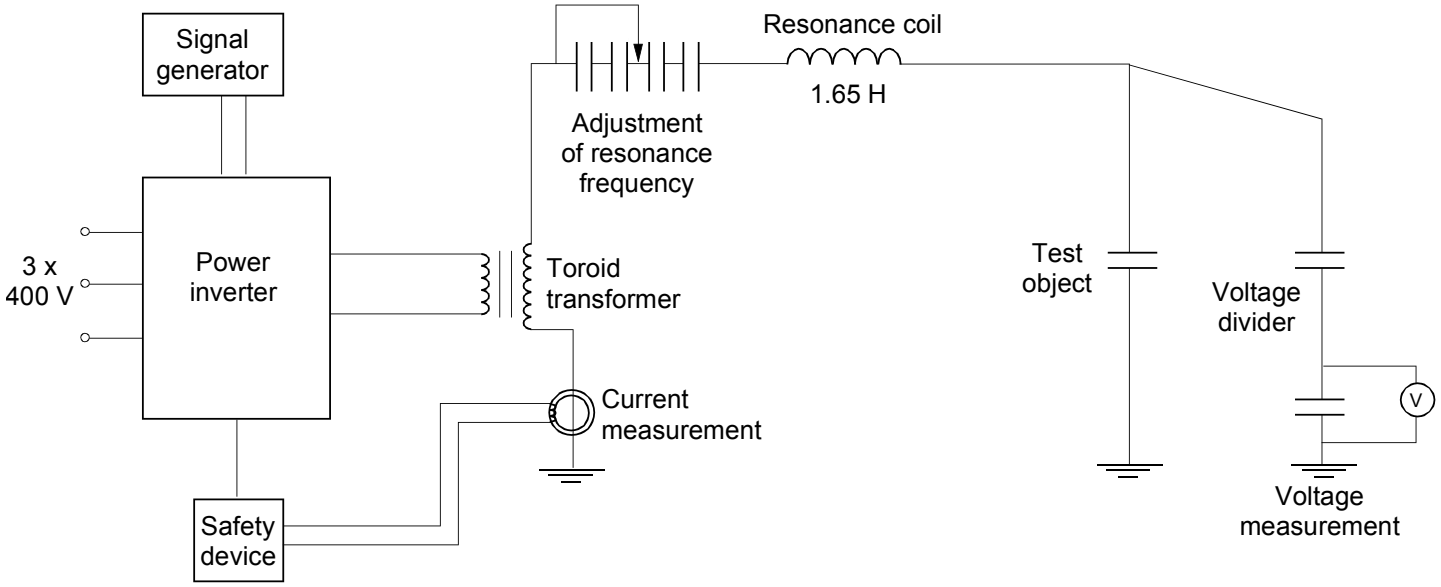

Figure 5: Schematic 500 Hz ageing test set-up.

EQUIPMENT

<u>500 Hz Long Term Ageing Test</u>

Voltage regulator (3 x 400 V)	B01-0363
Universal power inverter	B03-0364
Resonance coil	L02-0044
Toroid transformer	B01-0716
Voltage divider	K03-0136
Voltmeter (500 Hz)	S03-0341
Temperature control unit	N02-0085

Calibrated 2011-02; next calibration spring 2012.

<u>AC Breakdown Tests</u>

Transformer	B1-437
Control desk	B1-437-3
Voltmeter	C6-033
Measuring capacitor	M2-29
Deionised Water Terminations	SINTEF

Calibrated: 2010-08-27; next calibration autumn 2012.

CONCLUSIONS

90 m of 12/20 (24) kV XLPE cable with a 300 mm^2 copper conductor manufactured by National Cables Industries, Sharjah, in UAE, has been tested according to Cenelec HD 605 S2: 2008, test no 5.4.6 Long duration test at 500 Hz.

The cable fulfilled the test requirements of HD 620 S2:2010 to the 500 Hz long duration test.

According to HD 605 / HD 620, this qualification test covers MV cables with the actual insulation and screen materials up to and including 42 kV.

APPENDIX 1

Material Data sheets

- XLPE insulation
- Conductor screen
- Insulation screen

LUTENE® XL8080TR

Applications

Crosslinkable polyethylene compound for waer tree retardant medium voltage power cable Insulation

Description

LUTENE® XL8080TR has excellent electrical properties for medium voltage power cable insulation and especially it shows improved water tree resistance and has thermal aging property.

Specification

LUTENE® XL8080TR meets the property requirement of the following material specifications.

① AEIC CS 8-00
② ICEA S-94-649, S-93-639/NEMA WC74
③ IEC 60502
④ CENELEC HD620 S1

Package

· Standard package : 600kg Carton Box, 1,000kg Carton Box
  - Other package to customer needs are also available.

Processing Condition

LUTENE® XL8080TR provides excellent surface finish and outstanding output rates over a broad range of extrusion conditions. When LUTENE® XL8080TR is processed at melt temperature of 125 to 135℃, optimum results can be obtained.

Properties	Test Method	Test Condition	Unit	Value
Physical				
Density, Base Resin	ASTM D1505	23℃	g/㎤	0.92
Mechanical				
Tensile Strength	ASTM D638	-	kg/㎠	200
			MPa	19.7
			psi	2844
Elongation at Break	ASTM D638	-	%	500
Tensile Strength Retension	ASTM D638	135℃,168hr	%	>95
Elongation Retension	ASTM D638	135℃,168hr	%	>95
Hot Set Test	IEC 60811-2-1	200℃, 0.2 Mpa	-	-
Elongation under Load			%	< 100
Permanent Deformation			%	< 10
Electrical				
Dielectric Constant	ASTM D150	1MHz	-	2.25
Dissipation factor	ASTM D150	1MHz	-	0.0006
DC Volume Resistivity	ASTM D257	23℃	Ω·cm	$>10^{16}$
Dielectric Strength	ASTM D149	-	kV/mm	>22
Other				
Degree of Closslinking	ASTM D2765A	-	%	>80

* Measured on compression molded specimen
NOTE : Values given above should only be used as a guide and should not be considered as a firm specification

LUTENE® XL2808BK TR

Application

Crosslinkable semiconductive conductor and bonded insulation shielding compound for medium voltage power cable.

Description

LUTENE® XL2808BK TR is specially designed crosslinkable semiconductive compound for conductor shielding of medium voltage power cables.
LUTENE® XL2808BK TR is compatible with both copper and aluminum conductors. LUTENE® XL2808BK TR specifically developed to provide an excellent -smoothness surface yielding a more perfect interface extruded shield and the insulation. As a result, significantly improved cable performance can be expected.
LUTENE® XL2808BK TR has excellent tree retardant property.

Characteristics

① Excellent Surface Smoothness
② Excellent Electrical Properties
③ Excellent Physical and Thermal Properties
④ Long-run Extrusion without Scorch
⑤ Excellent tree retardance

Specification

LUTENE® XL2808BK TR meet the property requirement of the following material specifications.
① AEIC CS 8-00
② ICEA S-94-649, S-93-639/NEMA WC74
③ IEC 60502
④ CENELEC HD620 S1

Package

· Standard package : 500kg carton Box
- other package to customer needs are also available.

Processing Condition

LUTENE® XL2808BK TR provides excellent surface finish and outstanding output rates, when processing conditions are optimised for the actual processing equipment and cable dimension.
For optimum results, use melt extrusion temperatures in the suggested range of 100 to 125℃.
Dehumidified hopper drying at 60~70℃ for 4 hours before extrusion is recommended to remove moisture.

Properties	Test Method	Test Condition	Unit	Value
Physical				
Density	ASTM D1505	23℃	g/㎤	1.12
Tensile Strength	ASTM D638	200mm/min	kg/㎠	180
Elongation at Break	ASTM D638	200mm/min	%	200
Tensile Strength Retension	ASTM D638	135℃,168hr	%	>90
Elongation Retension	ASTM D638	135℃,168hr	%	>90
Low Temperature Brittleness	ASTM D746	-	℃	<-50
Heat deformation	JIS C3005	121℃×2kg	%	< 18
Metal Ion content	ICP	-	ppm	< 300
Moisture Content	Karl Fischer	max. 1000	ppm	< 500
Electrical				
DC Volume Resistivity	ASTM D991	23℃	Ω·cm	<50
	ASTM D991	90℃	Ω·cm	<500
	ASTM D991	135℃	Ω·cm	<1,000

1) Tests are conducted on compression molded slabs. Cure times were 15minutes at 180℃
NOTE : Values given above should only be used as a guide and should not be considered as a firm or guarantee.

LUTENE® XL2700BK TR

Application

Crosslinkable, easy strippable semiconductive insulation shielding compound for medium voltage power cable

Description

LUTENE® XL2700BK TR was specially designed crosslinkable semi-conductive compound for easy strippable insulation shielding of medium and high voltage power cable.

LUTENE® XL2700BK TR provides an excellent stripping property, lower and consistent stripping force over a wide temperature range without tearing, leaving a clean insulation surface. Especially LUTENE® XL2700BK TR has an excellent tree retardant propety.

Specification

LUTENE® XL2700BK TR meet the property requirement of the following material specifications.

① AEIC CS 8-00
② ICEA S-94-649, S-93-639/NEMA WC74
③ IEC 60502
④ CENELEC HD620 S1

Package

· Standard package : 500kg carton Box
– other package to customer needs are also available.

Processing Condition

LUTENE® XL2700BK TR requires melting temperatures of approximately 80 to 120℃ for best result. Specific machine settings will depend on the extruder design and must be established through conventional practices.

We recommend not to use hopper dryer with LUTENE® XL2700BK TR to avoid fusion at hopper feed section.

But when necessary, drying should be done at max. 40℃ with dehumidified air under agitation.

Properties	Test Method	Test Condition	Unit	Value
Physical				
Density	ASTM D1505	23℃	g/㎤	1.16
Tensile Strength	ASTM D638	–	kg/㎠	150
Elongation at Break	ASTM D638	–	%	300
Tensile Strength Retension	ASTM D638	121℃,168hr	%	>90
Elongation Retension	ASTM D638	121℃,168hr	%	>90
Low Temperature Brittleness	ASTM D746	–	℃	<-50
Metal Ion Content	ICP	–	ppm	<1,000
Moisture Content	Karl Fischer	max. 1000	ppm	< 500
Hot creep test	ICEA T-28-562	–		
Hot			%	< 100
Set			%	< 5
Electrical				
DC Volume Resistivity	ASTM D991	23℃	Ω·cm	<100
	ASTM D991	90℃	Ω·cm	<1,000
Other				
Stripping Force at Cable [2)]	LGCTM	–	kg/12.7mm	3.5 ~ 7.0

1) Measured on compression molded specimen. Cure times were 15min at 180℃
2) Stripping force at cable values are typical for dry cure at room temp. Values will vary with cable size, insulation type, type of cure, temp., speed of test, etc.

NOTE : Values given above should only be used as a guide and should not be considered as a firm or guarantee.

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1. Type Test Certificate
A type test certificate contains a record of a series of type tests strictly in accordance with one or more IEC standards or Regional or National Standards aligned with IEC. The tested equipment has fulfilled the requirements of the standard(s) and therefore the relevant ratings assigned by the manufacturer are justified

2. Certificate of Type Conformity
A certificate of type conformity granted by SATS Certification attests, with adequate confidence, that the product identified exhaustively and physically available at the time of certification, confirms to IEC, ANSI/IEEE and/or other regional or national standards.

3. Report of Type Test Conformity
A report of type test conformity attests, with adequate confidence, that the applicant's product identified in it and physically available at the time of certification, confirms to the specifications and/or other documents referred to in the report.

4. Report of Performance
A report of performance contains a record of one or more tests which have been carried out according to the client's instructions. The test(s) may be in accordance with a recognized standard. The results do not necessarily verify the ratings assigned by the manufacturer.

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