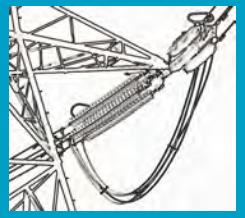

WBH ENGINEERING

IEC 60502-4, IEC 60840, IEC 62067 in Context to IEEE 48 & 404

13.03.2008 Cable accessories for rated Voltages U_m = 1.2 kV up to U_m = 550 kV

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Abstract

- The intention of this presentation is to explore the IEC standards for testing and qualification of cable accessories supplied and installed on extruded and laminated power cable.
  Test methods and procedures examples will be brought into context with the current IEEE 404 and 48 standards.

Structure

- Status of current status
  - Range of approvals
  - Test program
  - Comparison
- Comments
- Conclusions

Standards and Requirements

Current Standard Status

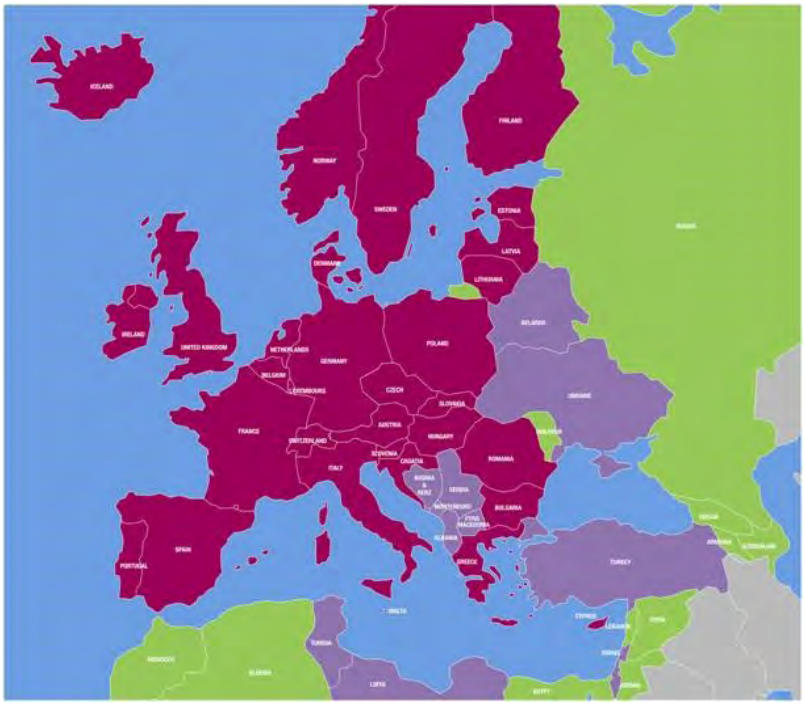
- **IEC Standards covering rated Voltages**
  - **U_m = 1.2 kV- 500 kV by three different papers divided into three different Voltage application ranges.**

- **IEEE 48-2008 and IEEE 404 2006 covering rated Voltage U_m = 2.5 kV – 500 kV in one document each.**

Standards: MV-Application

	Termination & Splices	Transformer & GIS
IEC	IEC 60502-4 $U_m \leq 42$ kV	IEC 60502-4 Um ≤ 42 kV
CENELEC EN	HD 629 $U_m \leq 42$ kV EN 61442 $U_m \leq 42$ kV	HD 629 $U_m \leq 42$ kV EN 61442 $U_m \leq 42$ kV
IEEE	IEEE 48 $U_m \leq 46$ kV	IEEE 386 $U_m \leq 36.6$ V

CENELEC ?



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members affiliates EU neighbouring countries

- European Committee for Electrotechnical Standardisation
  - Founded in 1973 as a merger of two previous European Organizations CENEL and CENELCOM
  - The aim is harmonizing the national standards into harmonized standards
    - e. g VDE , BS, SEN etc.

Standards: HV Application

	Termination	Transformer & GIS
IEC	IEC 60840 U_m ≤ 170kV IEC 60815 U_m ≤ 170kV IEC 62067 U_m ≤ 500kV	IEC 60859 U_m ≤ 170kV IEC 60840 U_m ≤ 170kV IEC 62067 U_m ≤ 500 kV
CENELEC	HD 632 U_m ≤ 145 kV EN 61442	HD 632 U_m ≤ 145 kV EN 61442
IEEE	IEEE 48 U_m ≤ 550kV	IEEE 1300 U_m ≤ 550 kV

Standards: HV Application

	Splices
IEC	IEC 60840 $U_m \leq 170$ kV IEC 62067 $U_m \leq 500$ kV
CENELEC	HD 632 $U_m \leq 145$kV
IEEE	IEEE 404 $U_m \leq 500$ kV

IEC Titles

- **IEC 60502-4 ed. 2.0 2005**
  Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um= 1.2 kV) up to 30 kV(Um = 36kV)
  - **HD 629.1 S2: 2006 (harmonized)**
    Test requirements on accessories for use on power cables of rated voltage from 3.6/6(7.2)kV up to 20.8/36(42kV) -Test method requirements
- **IEC 60840 ed. 3.0 2004**

  Power cables with extruded insulation and their accessories for rated voltages above 30kV (U_m = 170kV) up to 500 kV (U_m = 550kV) -Test method requirements
- **IEC 62067 ed. 1.1 2006**

  Power cables with extruded insulation and their accessories for rated voltages above 150 kV (U_m = 170kV) up to 500 kV (U_m = 550kV) -Test method requirements

IEC 60504 basis structure

- The IEC60504 is divided in four parts
  - *Part 1:* Cables for rated voltages of 1kV (U_m = 1.2 kV) up to 3 kV (U_m = 3.6kV)
  - *Part 2:* Cables for rated voltages from 6kV (U_m= 7.2 kV) up to 36 kV (U_m = 42kV)
  - *Part 3:* reserved
  - *Part 4:* Test requirements on accessories for cables with rated voltages from 6kV (U_m= 7.2 kV) up to 36 kV (U_m = 42kV)
    - **This standard is the base root for the harmonized HD 629.1 S2:2006 and is the fourth part of the IEC 60504.**

Grand father clause etc.

- IEC 60502-2 / HD 629-1
  - This standard determines the test requirements for accessories used on power cable with rated voltages from 3.6/6 (7.2) kV up to 18/30 (36) kV, complying with IEC 60502-2.
  - Formerly, approvals of products now covered by this IEC standard have been achieved on basis of national standards demonstration of satisfactory service performance. This issue does not invalidate existing approvals.
  - After testing examination has added to the test sequence
  - Short circuit on conductor and shield is mandantory at ambient and elevated temperature

Range of approval IEC 60502-4

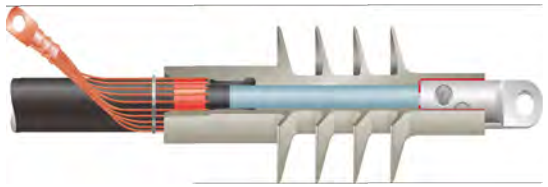
- Approval requirements:
  - Range of a conductor cross-sectional area 95 mm² -300 mm²
    - Test cross -section can be selected either 120 mm², 150 mm² or 185 mm²
      - In case the range of the accessories is extending the given range, additional test samples have to applied with the extended crosssections in addition to the test cross section as mentioned above
  - Approval is depending on the cable insulation material

Table 2 – Range of approval for cable insulation

Insulation of test cable	Range of approval
XLPE	XLPE, EPR, HEPR and PVC
EPR or HEPR	EPR, HEPR and PVC
PVC	PVC

Product coverage IEC 60502-4

- The specification covers
  - Termination
    - Indoor
    - Outdoor
  - Splices
    - Inline straight / branch /stopp
    - Transition straight / branch
  - Separable connectors / screened / unscreend
    - Rating
      200/250A; 400A
      600 / 630 A; 800A; 1250 A



Range of approval IEC 60502-4 (continued)

- Different insulation screens require extension tests getting approval of the complete product range
- Single core cable test results do not approve 3 core application
- Approval of accessories tested for a specified U_0 shall extend the accessory for the lower U_0

Listed Tests IEC 60502-4

Table 12 – Summary of tests

Tests	Terminations		Straight and branch-joints	Stop ends	Separable connectors		
	Indoor	Outdoor			Deadbreak		Loadbreak[1]
					Screened	Un-screened	
AC voltage							
4,5 U_0/5 min dry	x	x	x	x	x	x	
2,5 U_0/15 min dry	x	x	x	x	x	x	
2,5 U_0/500 h dry				x			
4 U_0/1 min wet		x					
DC voltage							
4 U_0/15 min dry	x	x	x	x	x	x	
Partial discharge							
at θ_t	x	x	x		x	x	
at ambient temperature	x	x	x	x	x	x	
Impulse							
at θ_t	x	x	x		x	x	
at ambient temperature	x	x	x	x	x	x	
Thermal cycles							
in air	x	x	x		x	x	
under water			x		x	x	
Thermal short-circuit							
screen	x	x	x		x	x	
conductor	x	x	x		x	x	
Dynamic short-circuit	x	x	x		x	x	
Humidity	x					x	
Salt fog		x					
Disconnect/connect					x	x	
Operating eye					x		
Screen resistance					x		
Screen leakage current					x		
Fault current initiation					x		
Operating force					x		
Capacitive test point					x		
Examination	x	X	x	x	x	x	

NOTE The purpose of this table is to list tests, and not sequences.

[1] Under consideration.

© IEC 60502-4

- Outdoor termination will be tested wet 1 min and dry 5 min at 4 U_0:
  - require different test time than IEEE #48-2009 at dry and wet. Test level are ~25% lower
- DC level is lower than from IEEE #48-2009 >30%, timing is the same.
- BIL is one rating level different
  - Rating voltage U_r = 15kV
    - IEC 60504-4: 95 kV 1.2/50 µs
    - IEEE 48/404: 110 kV 1.2/50µs
- Thermal Cycling 1000h
  - Test voltage 2.5 U_0

    max conductor temp 90°C +5°K

    timing 8h in total >2h steady heating > 3 h cooling

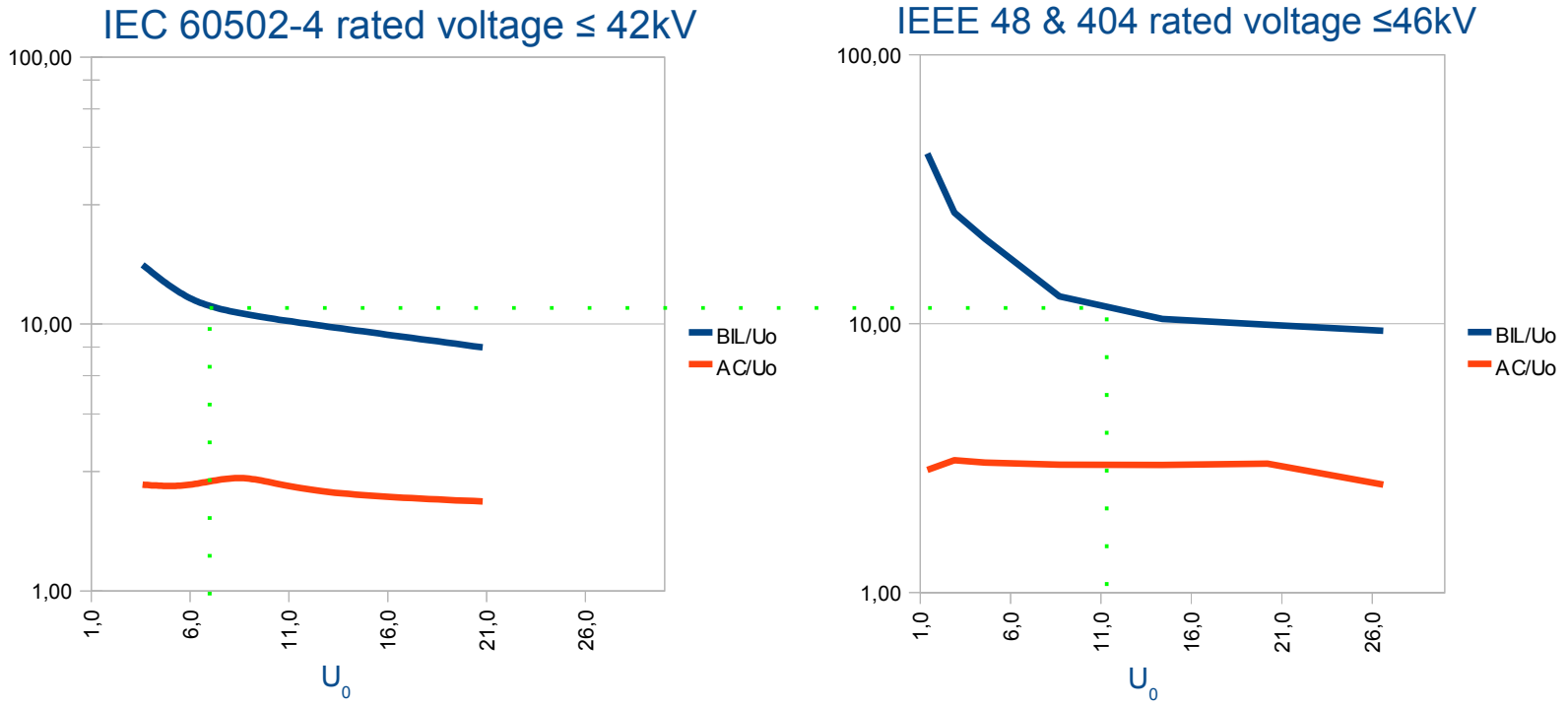
Table 4 – Test sequences and requirements for terminations

	Tests[1]	Requirements	Test methods of IEC 61442	Test sequences (see Figure 1)				
				1.1	1.2	1.3	1.4	1.5
1	AC or d.c. voltage	AC for 5 min at 4,5 U_0 or d.c. for 15 min at 4 U_0	Clause 4 or 5	x	x	x		
	AC (wet)	1 min at 4 U_0 [2]	Clause 4	x				
2	Partial discharge[3]	10 pC max. at 1,73 U_0	Clause 7	x				
3	Impulse at θ_t[4]	10 impulses of each polarity	Clause 6	x				
4	Heating cycles in air	60 cycles[5] at θ_t[4] and 2,5 U_0	Subclauses 9.1 and 9.2	x				
5	Partial discharge[3] at θ_t[4], [6] and ambient temperature	10 pC max. at 1,73 U_0	Clause 7	x				
6	Thermal short-circuit (screen)[7]	Two short-circuits at I_{sc} of the cable screen. No visible deterioration	Clause 10		x	x[8]		
7	Thermal short-circuit (conductor)	Two short-circuits to raise conductor to θ_{sc} of the cable. No visible deterioration	Clause 11		x	x[8]		
8	Dynamic short-circuit[9]	One short-circuit at I_d No visible deterioration	Clause 12			x		
9	Impulse	10 impulses of each polarity	Clause 6	x	x	x		
10	AC voltage	15 min at 2,5 U_0	Clause 4	x	x	x		
11	Humidity[10], [11]	300 h at 1,25 U_0, see Table 13	Clause 13				x	
12	Salt fog[2], [11]	1 000 h at 1,25 U_0, see Table 13	Clause 13					x
13	Examination	For information only[12]	–	x	x	x	x	x

- 4 samples sec. 1.1 AC or DC as start-up
- 3 samples for thermal and dynamik short current test.

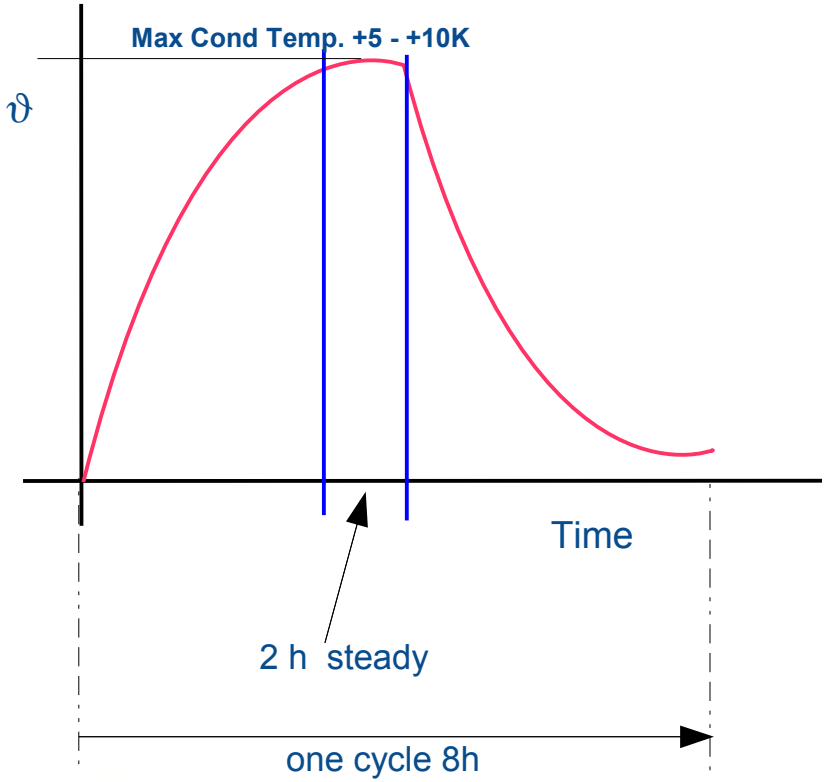
Weathering tested on different set-ups

Comparison of IEC and IEEE Testlevels



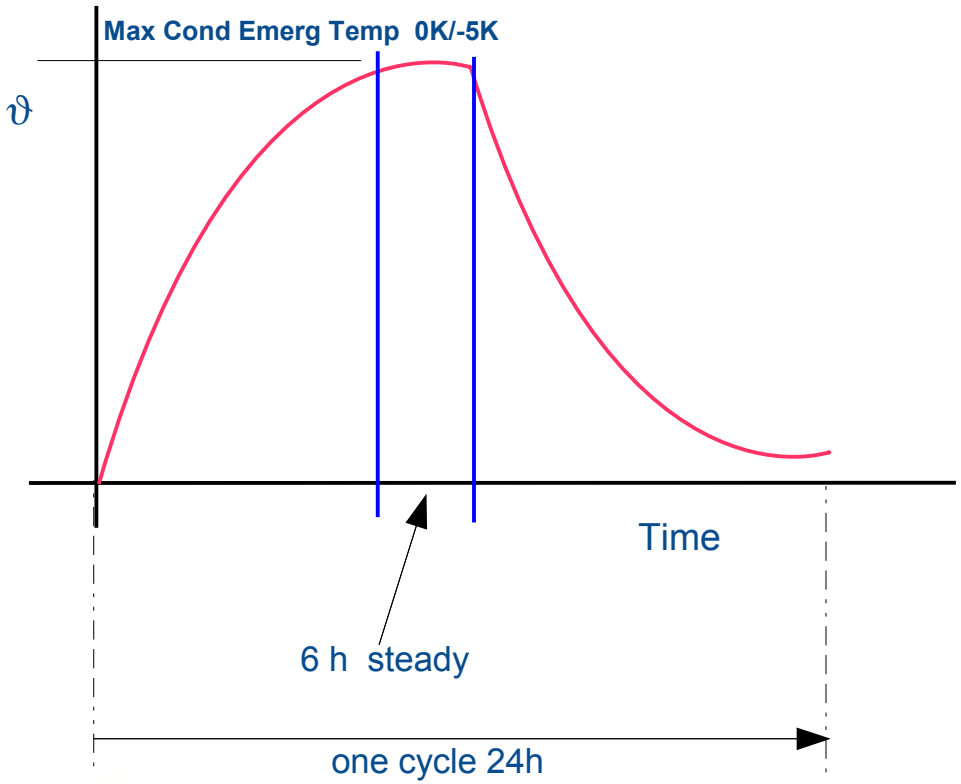
The diagrams show the different values for Bil and AC-Withstand based on phase to ground voltage U_0

Thermal Cycling MV Application IEC 60502-4



- **Load cycling**: 4 test samples
  - Cycle time 8h
  - 1000 h (126 cycles) total means 500h dry in air and 500h immersed in water (joints only) at max conductor temperature +5K – 10K for 2 h steady heating.
  - The conductor temperature calibration.
    - Separate calibration cable loop carrying the same current load, but no voltage applied
    - Connected calibration cable loop isolated
    - Temperature monitoring

Thermal Cycling MV Application IEEE 48 & 404



- **Load cycling**: 3 splices & 3 splices
  - Cycle time 24 h
  - 3 splices 720 h (30 cycles) total dry in air and 3 splices 720h immersed in water (joints only) at max conductor emerging temperature 0K -5K for 6 h steady heating.
  - The conductor temperature must be calibrated before.
    - Separate calibration cable loop with thermal couples bonded to the cable Jacket, carrying the same current load, but no voltage applied and
    - Connected calibration cable loop isolated

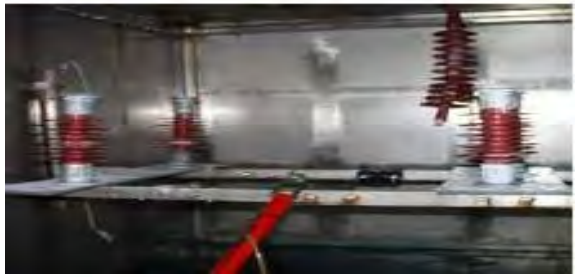
Other differences

- IEEE 404
  - Short circuit tests
    - 170ms I ≤ 35 kA,
    - One shot plus AC withstand afterwards
  - Shield testing IEEE Std. 592

- IEC 60502-4
  - Short circuit tests
    - reaching max permissble conductor temperature (XLPE 250°C) in the range t = 1s -5s
      defined in IEC 61442 clause 11
      two shots
    - Shield testing at max shield current I_d for t = 1s-5s declared by the manufacturer
      one shot
    - Dynamic short circuit test
      - 3 categories t = 10 ms < 60 ms
        I_p>63kA,
        I_p>80 kA,
        I_p>125 kA

More differences.....

- IEEE 48
  - No weathering
  - It is advised that sufficient tests are available, which could be used, when required by the client



- IEC 60502-4
  - Indoor termination only
    - Humidity testing
      - **300 h @ 1.25 U0**
        (0.4 ±0.1) l/h/m³ Water
        (70 ± 10) mS/m
    - Salt Fog testing
      - **1000 h @ 1.25 U0**
        (0.4 ±0.1) l/h/m³ Water
        (1600 ± 200) mS/m

IEC 60840

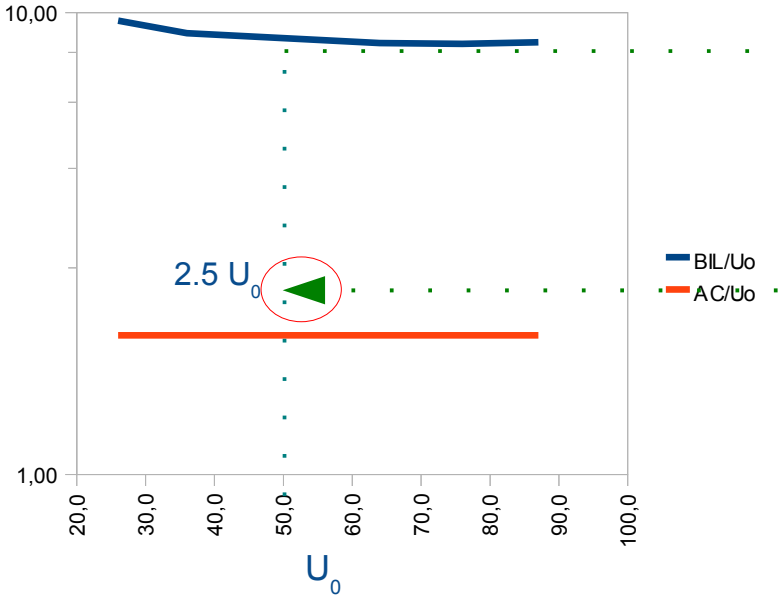
- Differences according to the IEC 60502-4 structure
  - The WG TC 20 of IEC Org. had well understood, that cable and accessories are building a cable system and therefore will be charged with the same requirements during its service time
    - This specification provides test requirements for **cable and the respected accessories**.
    - It differentiates in
      - Routine test
      - Sample test ('Fingerprinting')
      - Type test
      - After installation test

Table C.1 – Type tests on cable systems, on cables and on accessories

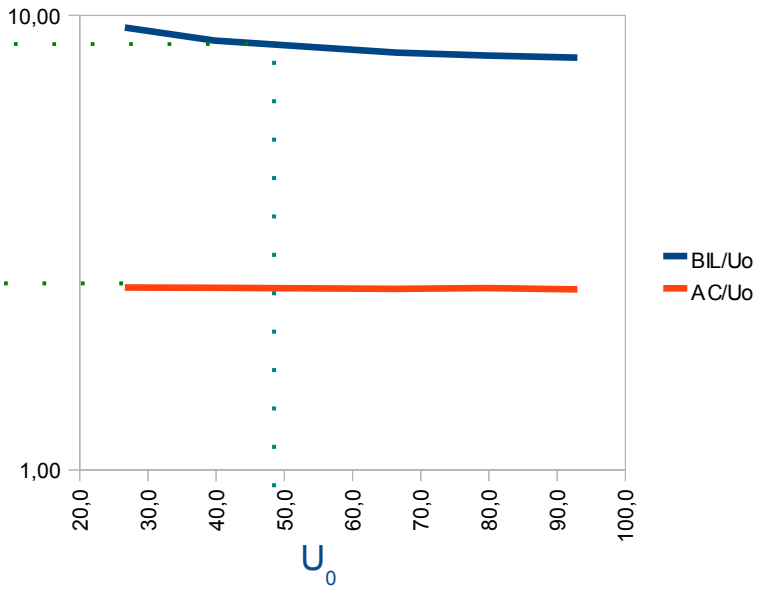
Item	Test	Clauses		
		Cable systems	Cables	Accessories
a	Range of type approval	12.1	13.1	14.1
b	Electrical type tests	12.3	13.3	14.3
c	Test voltage values	12.3.1	12.3.1	12.3.1
d	Bending test Partial discharge test at ambient temperature	12.3.3 12.3.4	12.3.3 12.3.4	- 12.3.4
e	Tan δ measurement	12.3.5	12.3.5	-
f	Heating cycle voltage test	12.3.6	12.3.6	12.3.6
g	Partial discharge test at high temperature Partial discharge test at ambient temperature (after final cycle or after lightning impulse voltage test in item i)	12.3.4 12.3.4	- 12.3.4	12.3.4 12.3.4
h	Lightning impulse voltage test followed by power frequency voltage test	12.3.7	12.3.7	12.3.7
i	Partial discharge test at high temperature (if not carried out after item f above) Partial discharge test at ambient temperature (if not carried out after item f above)	12.3.4 12.3.4	- 12.3.4	12.3.4 12.3.4
j	Tests of outer protection of buried joints	Annex H	-	Annex H
k	Examination	12.3.8	12.3.8	12.3.8.1
l	Resistivity of semi-conducting screens	12.3.9	12.3.9	-
m	Non-electrical type tests on cable components and on completed cable	12.4	12.4	-

Comparison of IEC and IEEE Testlevels

IEC 60840 rated Voltage $U_m \leq 170kV$



IEEE 48 & 404 rated Voltage $U_m \leq 170kV$



The diagrams show the different values for Bil and AC- Withstand based on phase to ground voltage U_0.

The BIL due to insulation coordination IEEE 1313.1 & IEC 60071-1-2 is nearly equivalent.

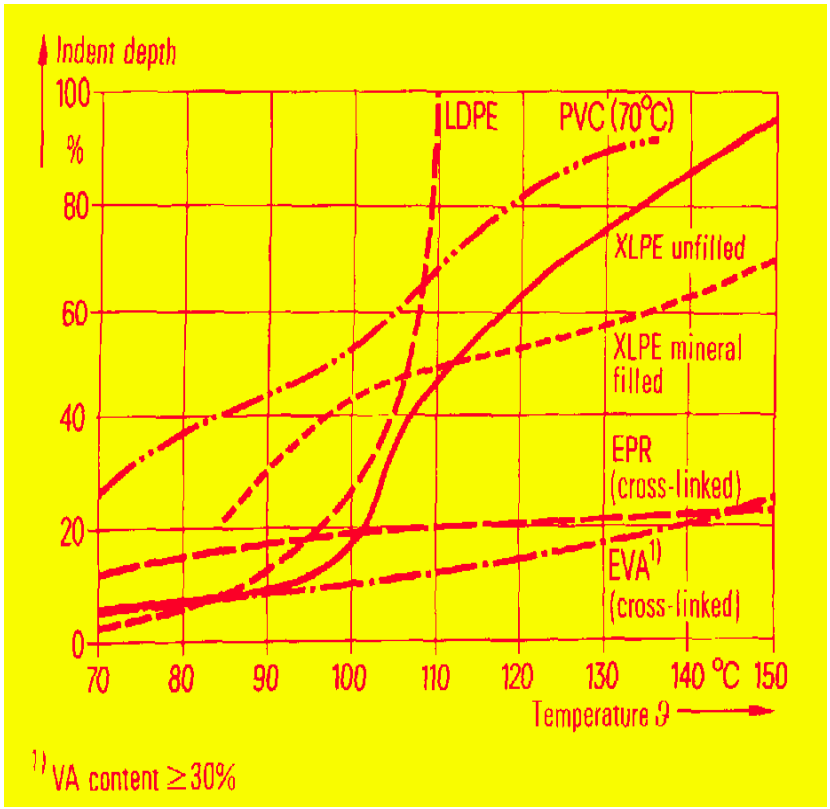
Thermal Cycling

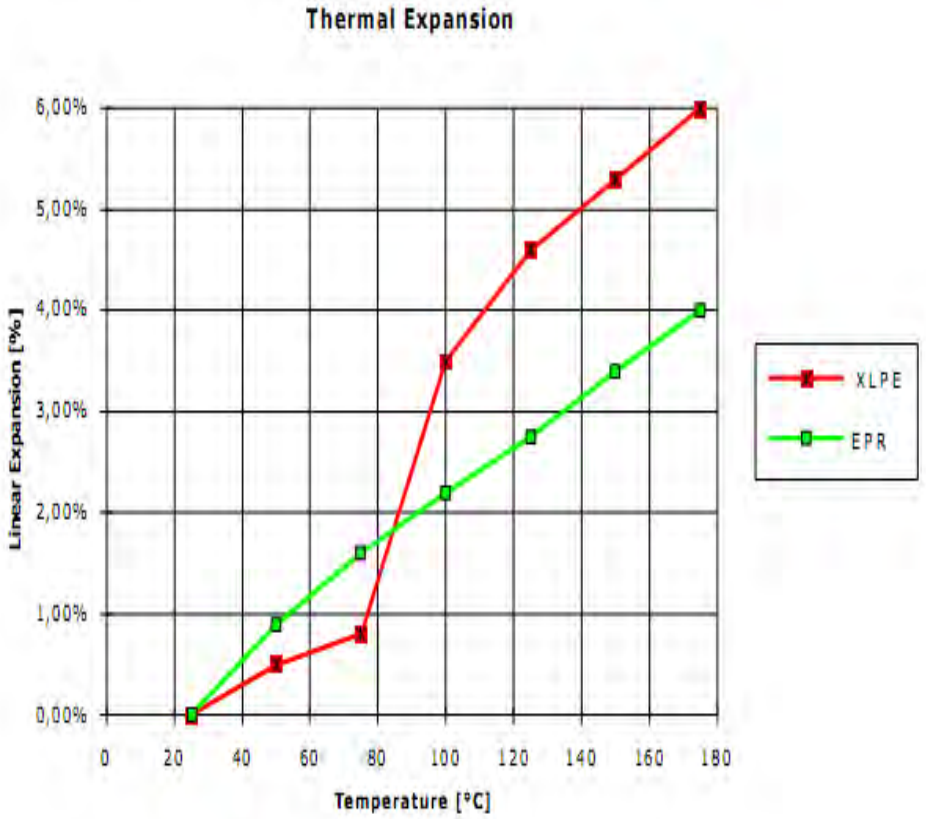
Table of comparison for CENELEC HD 632 S1:2005 (IEC 60840) and IEEE 48/404 2006/2009
Cable and Splice System rated voltage U_0 = 138kV cable systems

No	Test-description Per HD 632 S1/IEC60840	Requirements	Test-description IEEE 404-2006	Requirements
1.	Before PDs bending test is requested followed by accessory installation Partial discharge	1.75Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 10 sec then 114 kV PD)	Partial discharge	2 U0 for 30 sec, then decreased to 1.75U0 PD @ q ≤3pC (140kV 30sec 120 kV PD)
2.	Tan δ	At Uo and elevated temperature 90°C +5°C ≤ 10°C conductor temperature @ 1x U_0 = 76kV	AC Voltage withstand	15 Min. @ 240kV rms (ph to grd)
3.	AC Voltage withstand	30 min @190 kV rms (ph to grd)	DC Voltage withstand	15Min. @ 200kV DC (+ph to grd)
4.	N. A.		Impulse test	@ room temperature ± 10 shots BIL 650kV 1.2/50µs
5.	N. A.		Impulse test	@ 130°C +5°C temperature ± 10 shots BIL 650kV 1.2/50µs
6.	Heat cycle test	20 heat cycles: 8hrs 90°C +5°C ≤ 10°C @ 2hrs plateau, then 16hrs cooling at ambient temperature Continuous test-voltage applied U = 152kV AC (2U_0)	Heat cycle test	30 heat cycles: 12hrs 130°C +0°C ≤ 5°C @ 6 hrs plateau, then 12hrs cooling at ambient temperature Continuous test-voltage applied U = 160kV AC (2 U_0)
7.	Partial discharge	1.75Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 10 sec then 114 kV PD)	Partial discharge	2 U_0 for 30 sec, then decreased to 1.75U0 PD @ q ≤3pC (140kV 30sec 120kV PD)
8.	Impulse test	@ 90°C +5°C ≤ 10°C temperature ± 10 shots BIL 650kV 1.2/50µs	AC Voltage withstand	6hrs @ 200kV rms (ph to grd)
9.	N. A.		Heat cycle test under 1.2 m water in 65 mm wide conduit	30 heat cycles: 12hrs 130°C +0°C ≤ 5 °C @ 6hrs plateau cooling at ambient temperature Continuous test-voltage applied U = 160kV AC (2.0U_0)
10.			Impulse Test	@ 130°C +0°C ≤ 5 °C temperature ± 10 shots BIL 650 kV 2.5/50ps
11.	Partial Discharge	1.75 Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 10sec then 114 kV PD)	Partial discharge	2 U_0 for 30 sec, then decreased to 1.75U0 PD @ q ≤3pC (140kV 30sec 120kV PD)
12.	Sectionalizer Test	20 kV D.C. 1 min Sheath to sheath Sheath to ground between ± 10 shots BIL 60 – 75 kV earth to bond ± 10 shots BIL 30-37.5 kV	Sectionalizer test	1 min 20kV AC rms submersed in water followed by ± 10 shots BIL 60 kV 1.2/50µs across ± 10 shots BIL 30kV 1.2/50µs to ground
13	Examination			

IEC 60840	Test	IEEE 48 /404
20 heat cycles: 8hrs 90°C +5°C ≤ 10°C @ 2hrs plateau, then 16hrs cooling at ambient temperature Continuous test-voltage applied U = 152kV AC (2U_0)	**Heat cycle test**	**30 heat cycles: 12hrs 130°C +0°C ≤ 5°C @ 6 hrs plateau, then 12hrs cooling at ambient temperature Continuous test-voltage applied U = 160kV AC (2 U_0)**
1.75Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 5sec then 114kV PD)	**Partial discharge**	**U_0 for 30 sec, then decreased to 1.75U0 PD @ q ≤ 3pC (140kV 30sec 120kV PD)**

Mechanics of Polymers under Temperature Strain





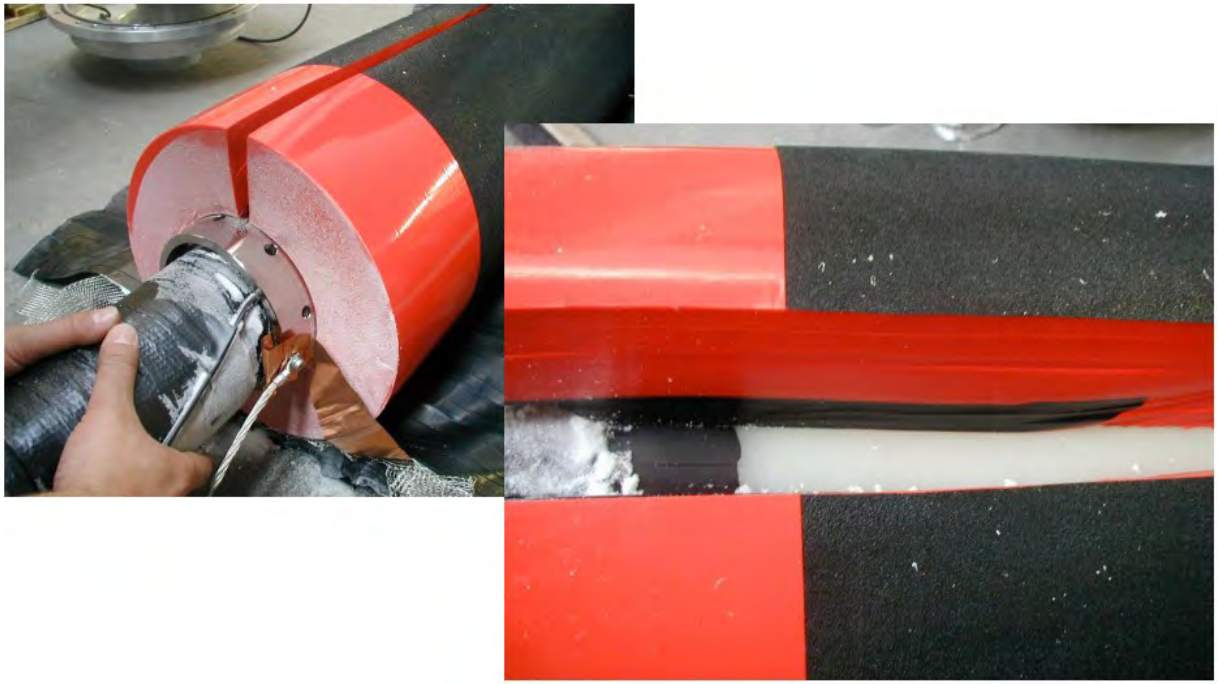
BIL and Sectionalizer

Table of comparison for CENELEC HD 632 S1:2005 (IEC 60840) and IEEE 48/404 2006/2009
Cable and Splice System rated voltage U_0 = 138kV cable systems

No.	Test description Per HD 632 S1/IEC60840	Requirements	Test description IEEE 404-2006	Requirements
1.	Before Pds bending test is requested followed by accessory installation Partial discharge	1.75Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 10 sec then 114 kV PD)	Partial discharge	2 U0 for 30 sec, then decreased to 1.75U0 PD @ q ≤ 3pC (140kV 30s ec 120 kV PD)
2.	Tan δ	At Uo and elevated temperature 90°C +5°C ≤ 10°C conductor temperature @ 1x U_0 = 76kV	AC Voltage withstand	15 Min. @ 240kV rms (ph to grd)
3.	AC Voltage withstand	30 min @190 kV rms (ph to grd)	DC Voltage withstand	15Min. @ 200kV DC (+ ph to grd)
4.	N. A.		Impulse test	@ room temperature 10 shots BIL 650kV 1.2/50µs
5.	N. A.		Impulse test	@ 130°C +5°C temperature 10 shots BIL 650kV 1.2/50µs
6.	Heat cycle test	20 heat cycles: 8hrs 90°C +5°C ≤ 10°C @ 2hrs plateau, then 16hrs cooling at ambient temperature Continuous test-voltage applied U = 152kV AC (2U$_0$)	Heat cycle test	30 heat cycles: 12hrs 130°C +0°C ≤ 5°C @ 6 hrs plateau, then 12hrs cooling at ambient temperature Continuous test-voltage applied U = 160kV AC (2.0 U_0)
7.	Partial discharge	1.75Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 10 sec then 114 kV PD)	Partial discharge	2 U_0 for 30 sec, then decreased to 1.75U0 PD @ q ≤ 3pC (140kV 30 sec 120kV PD)
8.	Impulse test	@ 90°C +5°C ≤ 10°C temperature 10 shots BIL 650kV 1.2/50µs	AC Voltage withstand	6hrs @ 200kV rms (ph to grd)
9.	N. A.		Heat cycle test under 1.2 m water in 65 mm wide conduit	30 heat cycles: 12hrs 130°C +0°C ≤ 5 °C @ 6hrs plateau cooling at ambient temperature Continuous test-voltage applied U = 160kV AC (2.0U_0)
10.			Impulse Test	@ 130°C +0°C ≤ 5 °C temperature 10 shots BIL 650 kV 2.5/50µs
11.	Partial Discharge	1.75 Uo for 10 sec, then decreased to 1.5 U0 PD q ≤ 5pC (133kV 10 sec then 114 kV PD)	Partial discharge	2 U_0 for 30 sec, then decreased to 1.75U0 PD @ q ≤ 3pC (140kV 30s ec 120kV PD)
12.	Sectionalizer Test	20 kV D.C. 1 min Sheath to sheath Sheath to ground between 10 shots BIL 60 – 75 kV earth to bond 10 shots BIL 30-37.5 kV	Sectionalizer test	1 min 20kV AC rms submersed in water followed by 10 shots BIL 60 kV 1.2/50µs across 10 shots BIL 30kV 1.2/50µs to ground

IEC 60840	Test	IEEE 48 /404
BIL 650 kV 1.2/50µs ± 10 shots Conductor Temperature 90° C +5 ≤ 10°C **AC Voltage Withstand 2.5 U_0 = 190 kV 30 min**	**Heat cycle test**	**BIL 650 kV 1.2/50µs ± 10 shots Conductor Temperature 130° C +0 ≤ 5°C** **AC Voltage Withstand 2.5 U_0 = 200 kV 360 min**
1.75Uo for 10 sec, then decreased to 1.5 U0 **PD q ≤ 5pC (133kV 5sec then 114kV PD)**	Partial Discharge	**2 Uo for 30 sec, then decreased to 1.75 U0** **PD q ≤ 3pC (140kV 5sec then 124kV PD)**
20kV D.C. 1min Sheath -Sheath ± 10 shots 60-75 kV Sheath – Ground ± 10 shots 30-37.5 kV	**Sectionalizer**	**20kV A.C. 1min Sheath -Sheath ± 10 shots 60 kV Sheath – Ground ± 10 shots 30 kV**

After test examination



IEC 60840 (IEC 62067)
requires
after prequalification test
an examination and visual inspection.

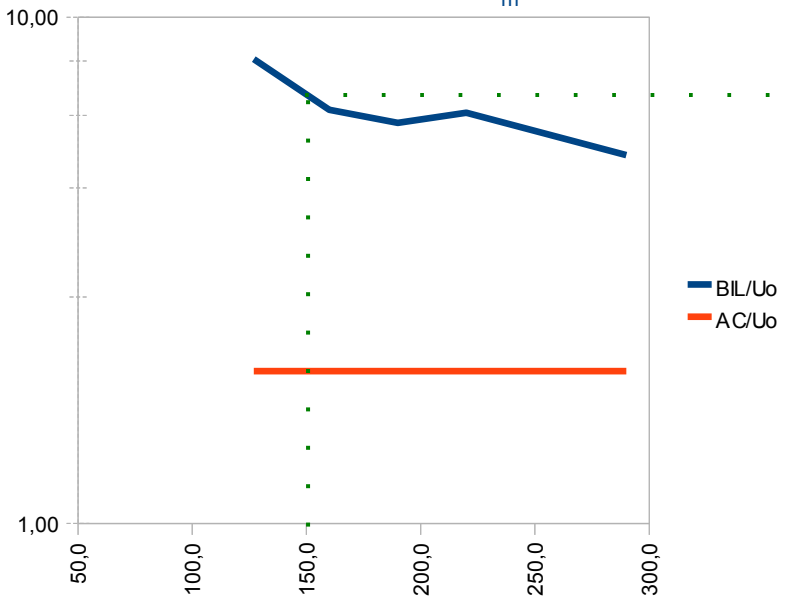
IEC 62067 extruded power cables and prefabricated accessories U_m = 170 kV – U_m =550 kV

Table 3 – Test voltages

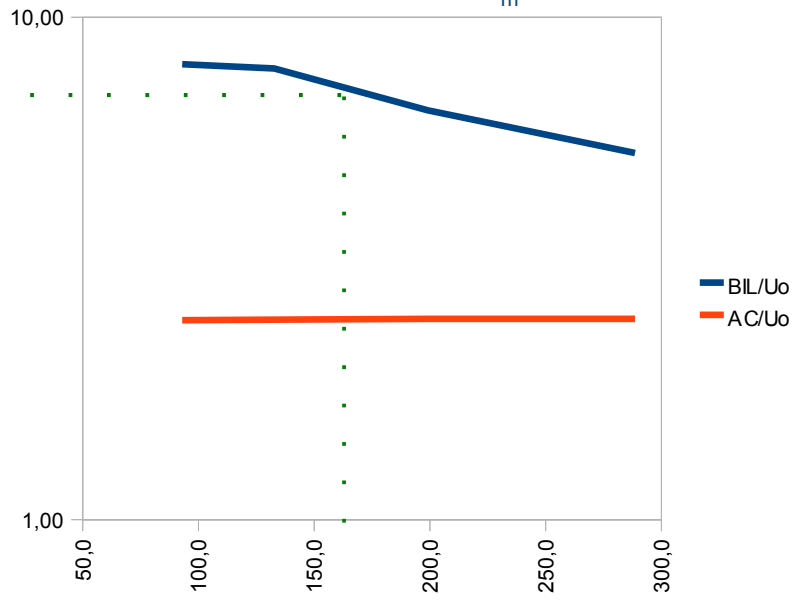
1	2	3	4		5	6	7	8	9
Rated voltage	Highest voltage for equip-ment	Value of U_0 for determinati-on of test voltages	Voltage test of 9.3		Partial discharge test of 9.2 and 12.4.5	Heating cycle voltage test of 12.4.7	Impulse voltage test of 10.12, 12.4.9 and 13.2.4	Voltage test after impulse voltage test of 10.12 and 12.4.9	Switching impulse voltage test of 12.4.8
U	U_m	U_0	Voltage[1)]	Duration[1)]	1,5 U_0	2 U_0		2 U_0	
kV	kV	kV	kV	min	kV	kV	kV	kV	kV
220 to 230	245	127	318	30	190	254	1 050	254	–
275 to 287	300	160	400	30	240	320	1 050	320	850
330 to 345	362	190	420	60	285	380	1 175	380	950
380 to 400	420	220	440	60	330	440	1 425	440	1 050
500	550	290	580	60	435	580	1 550	580	1 175

Test levels at rated Voltage > 150kV

IEC 62067 rated Voltage U_m >150kV



IEEE 404 rated Voltage U_m >150kV



The diagrams show the different values for BIL and AC- Withstand based on phase to ground voltage U_0.

The BIL due to insulation coordination IEEE 1313.1 & IEC 60071-1-2 is is different, since the IEEE uses different categories.

Comments

- Up to $U_m \leq$ 46 kV accessories can be qualified independently (IEC) from cables
- Beyond this voltage level accessory qualification is linked to particular cable types supplied.

Prequalification is a must!

- BIL test levels of IEC are rather different at rated Voltages below $U_0 \leq$ 7 kV compared with rated levels in IEEE
- The comparison demonstrate with regard to BIL that IEC and IEEE required value are similar by rated voltages

Comments

- The AC test voltages however vary between 2 U_0 (IEC) and 2.5 U_0 (IEEE).
- The major different is the thermal cycling conductor temperature 90°C and 130°C
  - XLPE thermal expansion behavior and changes in crystallization at temperatures T < 110 will loose its mechanical resistance.
  - Cable system thermal short circuit tests are not covered in the IEEE 404 & 48. The I^2t based on level $I_k \leq 35$ kA for 170 ms does provide conductor temperatures ϑ << 250°C (XLPE) lower as requested.

Conclusion

- Since the so shown differences as in some cases notified a possible platform should be created in harmonizing and/or adapting the standard requirements with in IEEE and IEC on insulated conductors for power applications.
- It is well accepted by consumer and suppliers that products qualified either to IEC or to IEEE qualification standards has provided decent operation service history records up today.

Thank you for your attention!