Testing of (E)HV extruded cable systems, a necessary step to achieve system reliability

ICC Educational Program

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Willem Boone, Nico van Schaik

KEMA

Testing of extruded cable systems

- Introduction
- Standardization
- Why (type) testing?
- IEC HV and EHV cable system standards
- Comparison with IEEE P1539/D9
- Conclusion

Introduction

Cable system reliability and testing:

	manufacturer/user	*in standards*
• Development	development tests	
• Design		(PQ Test,) type tests
• Production	production tests,	routine, sample tests
• Installation		tests after installation
• Operation	(thermal) monitoring	

Type test program:

- **Simulation of operating conditions and aging to check the design**

Purpose of Wold wide Standardization on Testing

- Accumulation of Knowledge and Experience
- Improvement of component/system reliability
- Reduction of cost
- Transparancy of the market
- Facilitation of international trade

Standardization (1)

CIGRE (International Council on Large Electric Systems)

- Collects K&E and advices IEC with “1rst draft”

- IEC (International Electrotechnical Committee)
  - Worldwide
  - Lowest common denominator of standards (National standards are usually more severe)
  - Cooperates effectively with CIGRE
- CENELEC (European Union)
  - IEC + national conditions

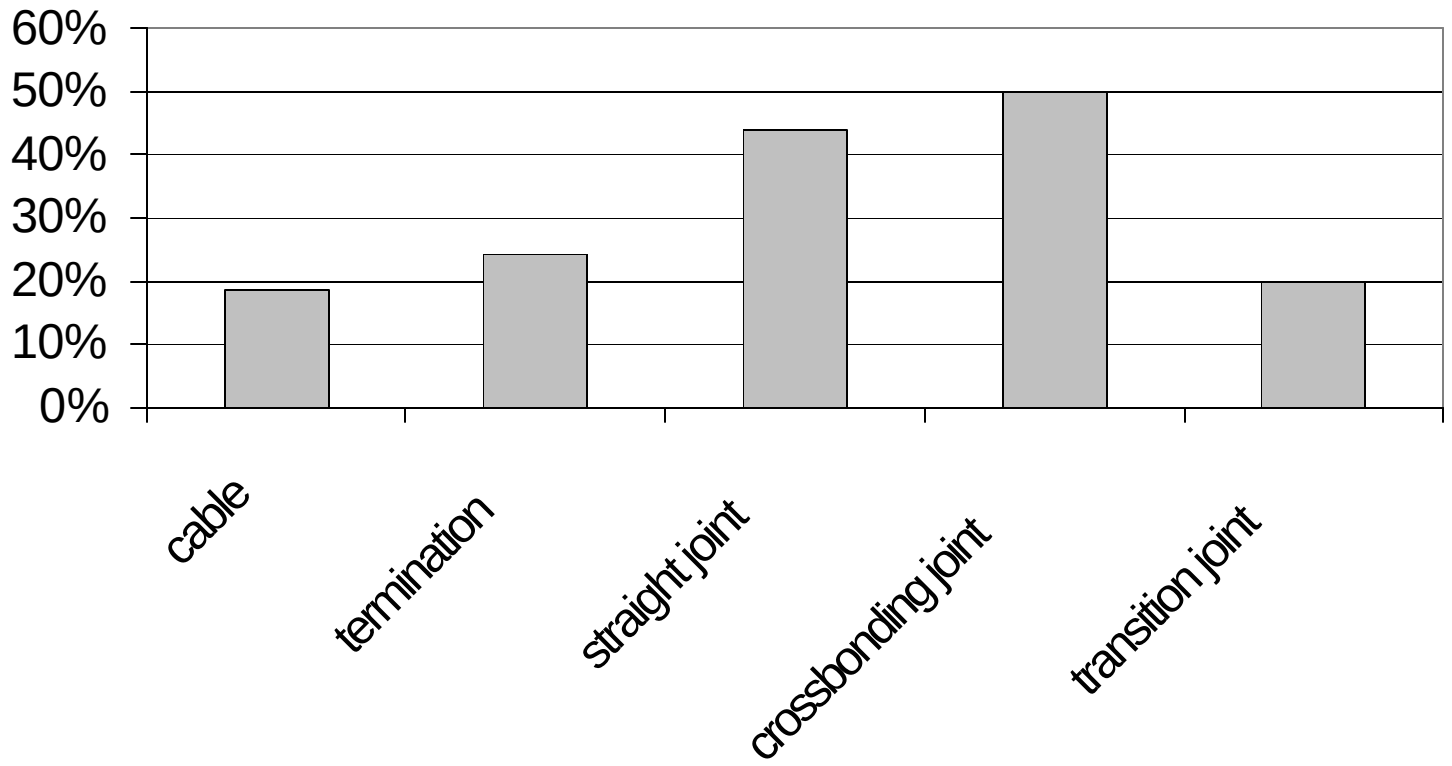
Standardization (2)

IEC standards:

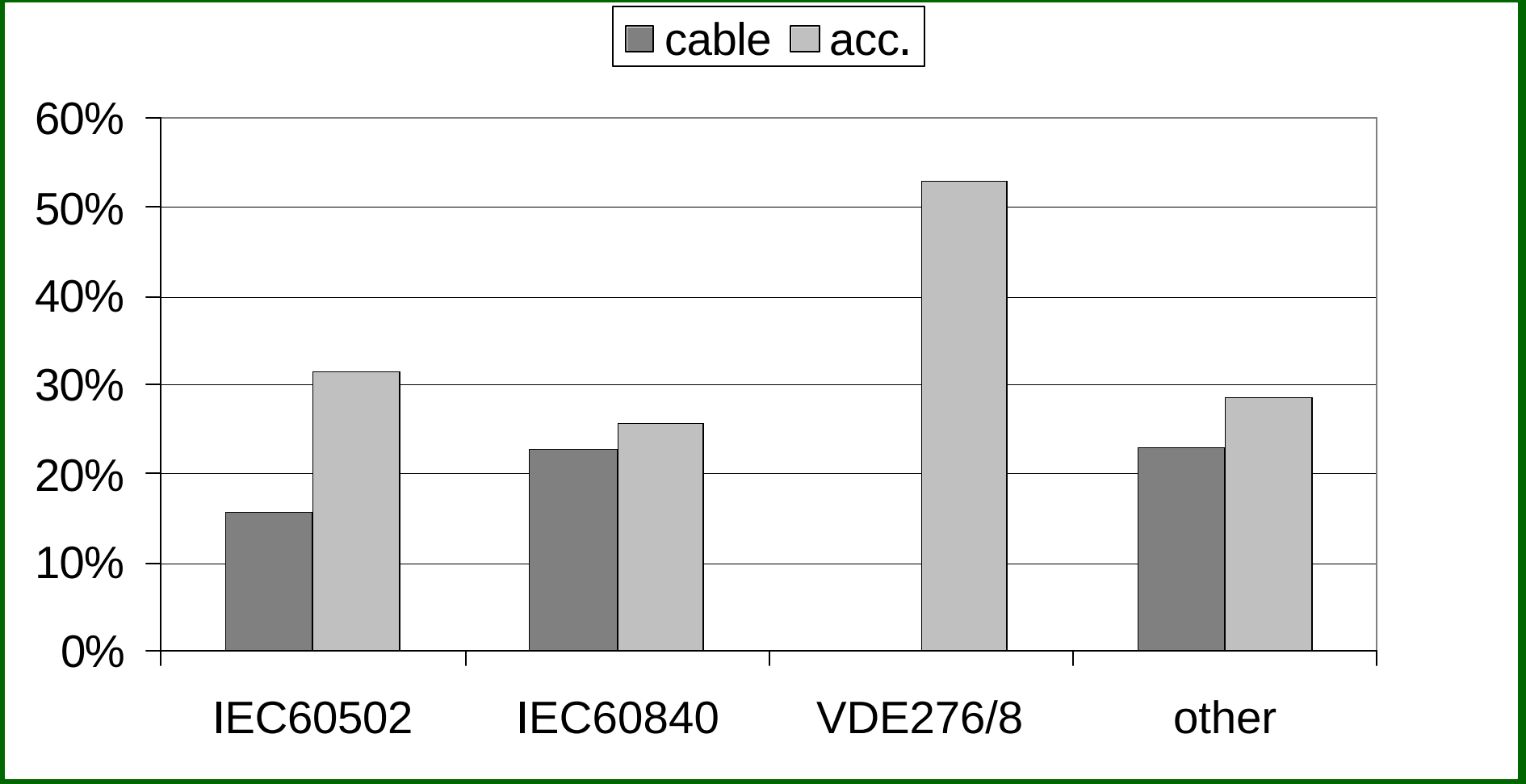
- ***Polymeric cables and accessories*** **(MV, *HV and EHV*)**
- **Paper cables and accessories (MV, HV and EHV)**
- **LV cables and special cables**
- **Guide, conductors, test methods**
- **Calculation of ratings**
- **Fire characteristics**
- **Material tests and other matters**

Why type testing (1)

Failure rate experiences KEMA lab. 1993 – 2002 over 250



Why type testing (2), failure rate experiences

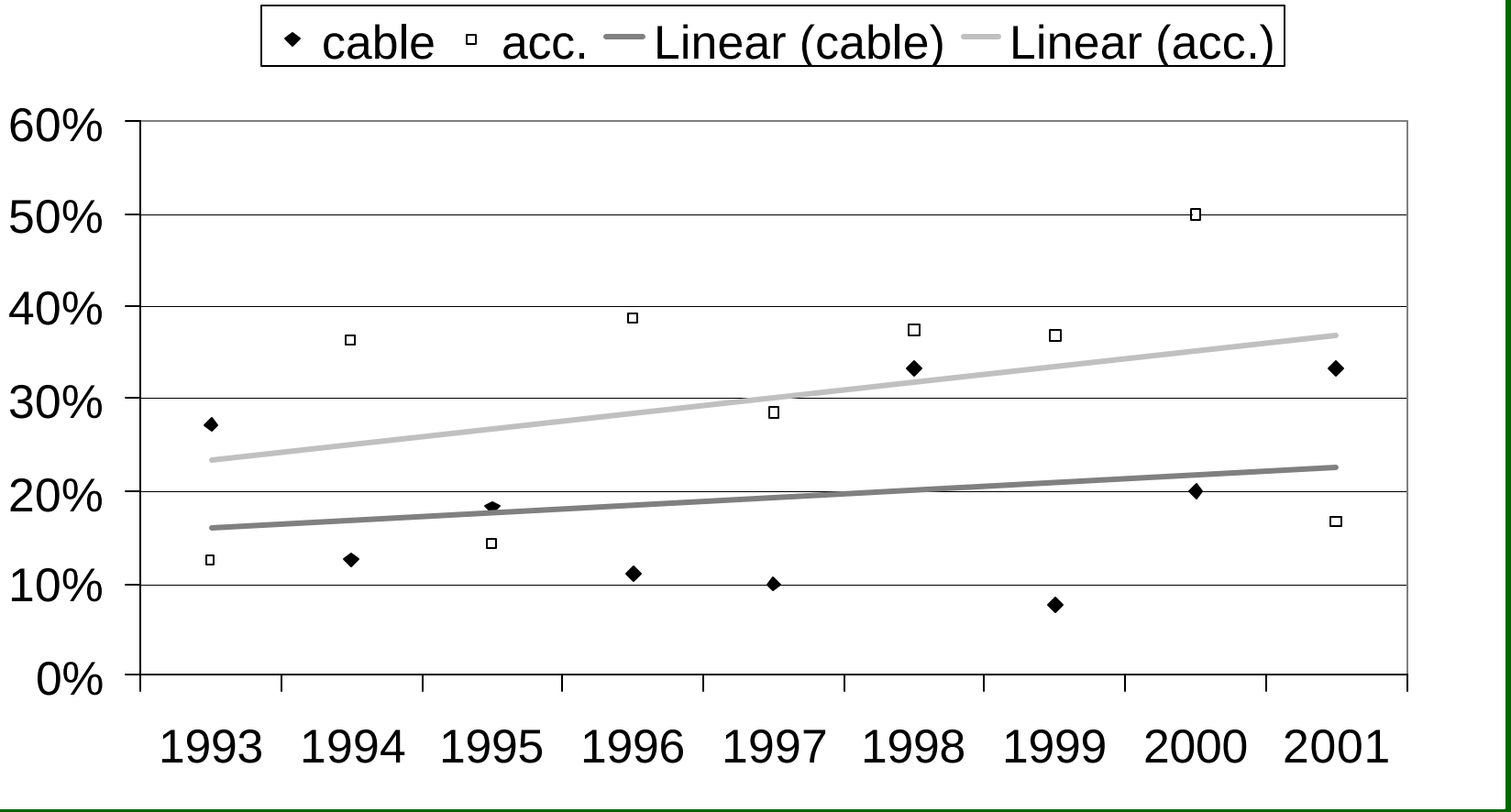


Why type testing (3), experiences

Reasons for failure:

	cables	*accessories*
• Non-electrical tests	43%	6%
• PD before heat cycling	25%	30%
• PD during heat cycling	20%	26%
– Heat shrink difference		15%
– Other reasons		11%
• After heat cycling	12%	38%

Why type testing (4), increasing failure rate over the last decade



IEC HV and EHV standards (polymeric) (1)

IEC 60840/Ed.3 (draft, 2004 publication):

- **Cable systems preferred, cables, accessories**
- **36 kV < Um ≤ 170 kV**

IEC 62067/Ed.1:

- **Cable systems only**
- **Prequalification test (1 year) included**
- **170 kV < Um ≤ 550 kV**

C HV and EHV standards (polymeric) (2)

ructure of these standards compared with IEEE P1539/

6. Cable characteristics (Not in IEEE)
7. Accessory characteristics (Not in IEEE)
8. Test conditions (=)
9. Routine tests on cables and prefab. Accessories (Not in IEE
10. Sample test on cables (Not in IEEE)
11. Sample tests on accessories (Not in IEEE)
12. Type tests on cable systems (=)
13. Type tests on cables (not in IEEE)
14. Type tests on accessories (not in IEEE)
15. Electrical tests after installation (Not in IEEE)

Comparison type test details IEC/IEEE

- Bending test
- PD test amb.
- Diel. loss test
- Heating cycle test
- PD hot and PD amb.
- Impulse test hot
- AC test
- PD amb if not done before

- PD test amb
- Heat cycle test
- PD test amb and PD hot
- Impulse test hot
- Impulse test amb.
- AC test
- PD test amb.

Comparison type test details IEC/IEEE

- Tests of joints under water
- Resistivity of semicon layers
- Non-electrical test
- Examination after test

- Examination after test

IEC HV and EHV standards (polymeric) (4)
Prequalification test for EHV systems only

100 m cable + accessories

- **practical installation (directly buried, tunnel, duct)**
- **at least 1 year**
- **$1.7 \times U_o$**
- **$\geq$ 180 thermal cycles $\geq$ 90 ºC, $\geq$ 2 hours at T_{max}**
- **no failures allowed**
- **after ageing: $\geq$ 1-3 cable samples (30 m impulse tested)**
- **examination after test; no signs of deterioration**

IEC HV and EHV standards (polymeric) (5) Developments

Partial discharges (IEC):

- **Inclusion of a "NOTE – Any partial discharges from the test object may be harmful"**
- **Sensitivity better than a *declared* value (5 or 10 pC)**
- **No partial discharge exceeding the *declared* sensitivity**

Revision of (pre)qualification procedures (CIGRE WG B1-06):

- **Programs evaluated on the base of a functional analysis**
- **Future developments**

Conclusions (1)

- Type testing is needed as design check on the system:
  - 20% failed in cable part
  - 30% failed in accessory part
- IEC HV and EHV standards:
  - World-wide acceptance
  - Improvement on partial discharge requirements
  - Effective cooperation with CIGRE

Conclusions (2)

- IEC standards also cover routine test, sample tests and test after installation
- The IEEE draft standard P1539/D9 has more solid test program than the comparable IEC test
- Development in IEC is the further improvement of the partial discharge requirements
- CIGRE WG B1-06: revision of (pre)qualification procedures (IEC will follow after 2006)
- More synergy between IEC and IEEE is recommendable