KEMA Labs

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Trends & Lessons from Laboratory Testing of Power Cables

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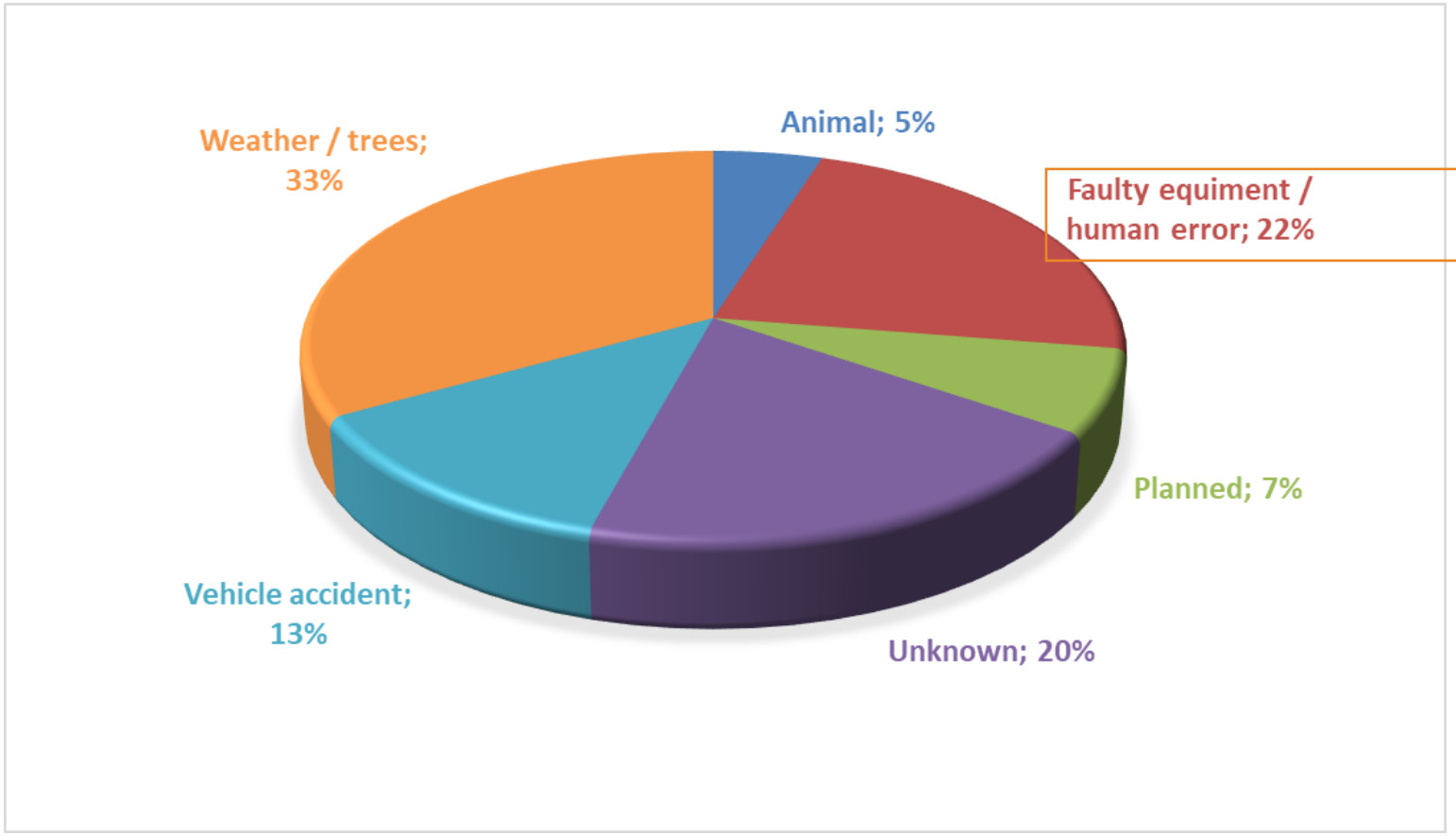
CESI

Outages in Power Networks

Statistics on network outages in US, with 3.525 outages in 2017:

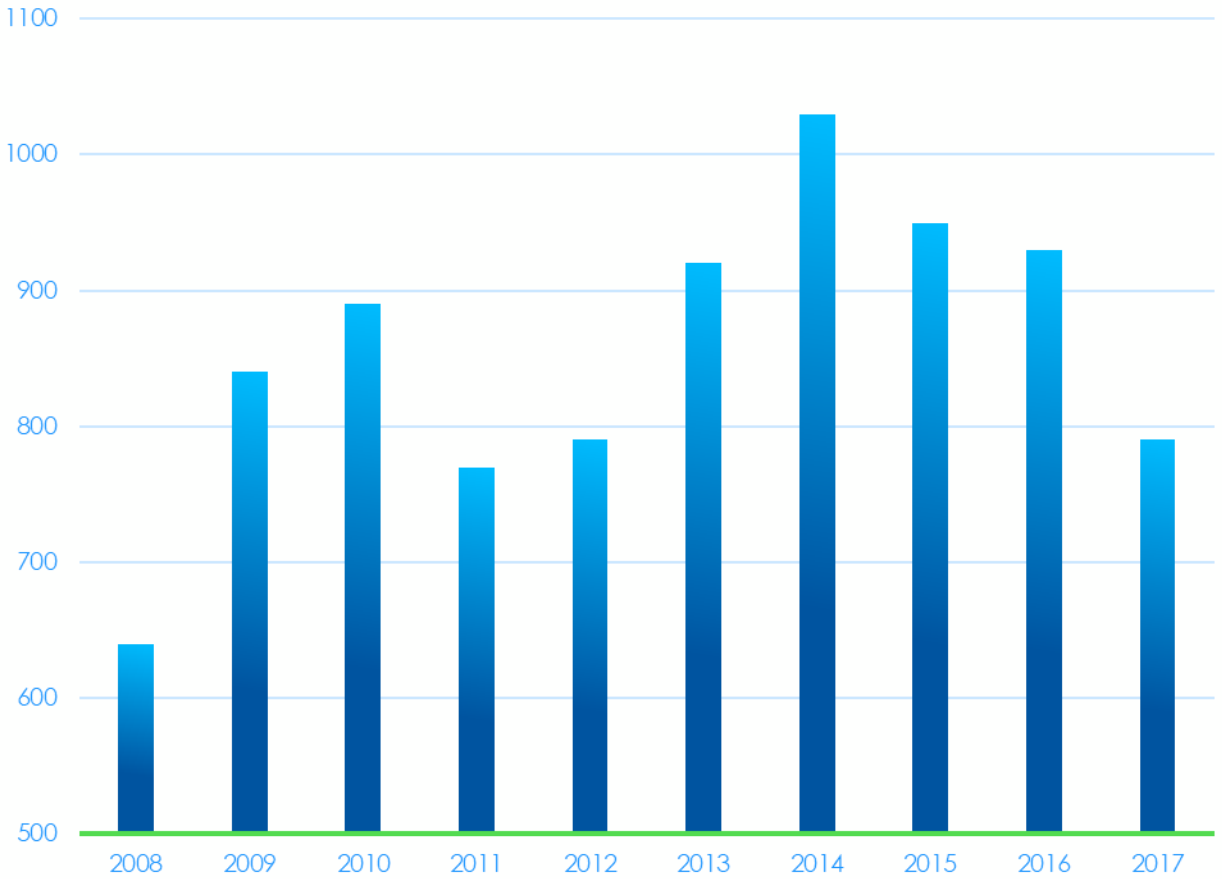


This can be reduced by maintenance and the use of tested and certified network components.

Souce: Eaton Black Out Tracker
(no data beyond 2017)

Outages in Power Networks

Number of outages in subsection ‘Equipment failure / human’.



Souce: Eaton Black Out Tracker

Use of tested and certified T&D components has a direct positive effect on network performance.

Internation Standards for Power Cables

AC Power Cables

- IEC 60502-2 for Cables 6kV–30kV
- IEC 60502-4 for Cables Accessories 6kV–30kV
- IEC 60840 for Cables & Accessories 30kV–150kV
- IEC 62067 for Cables & Accessories 150kV–500kV

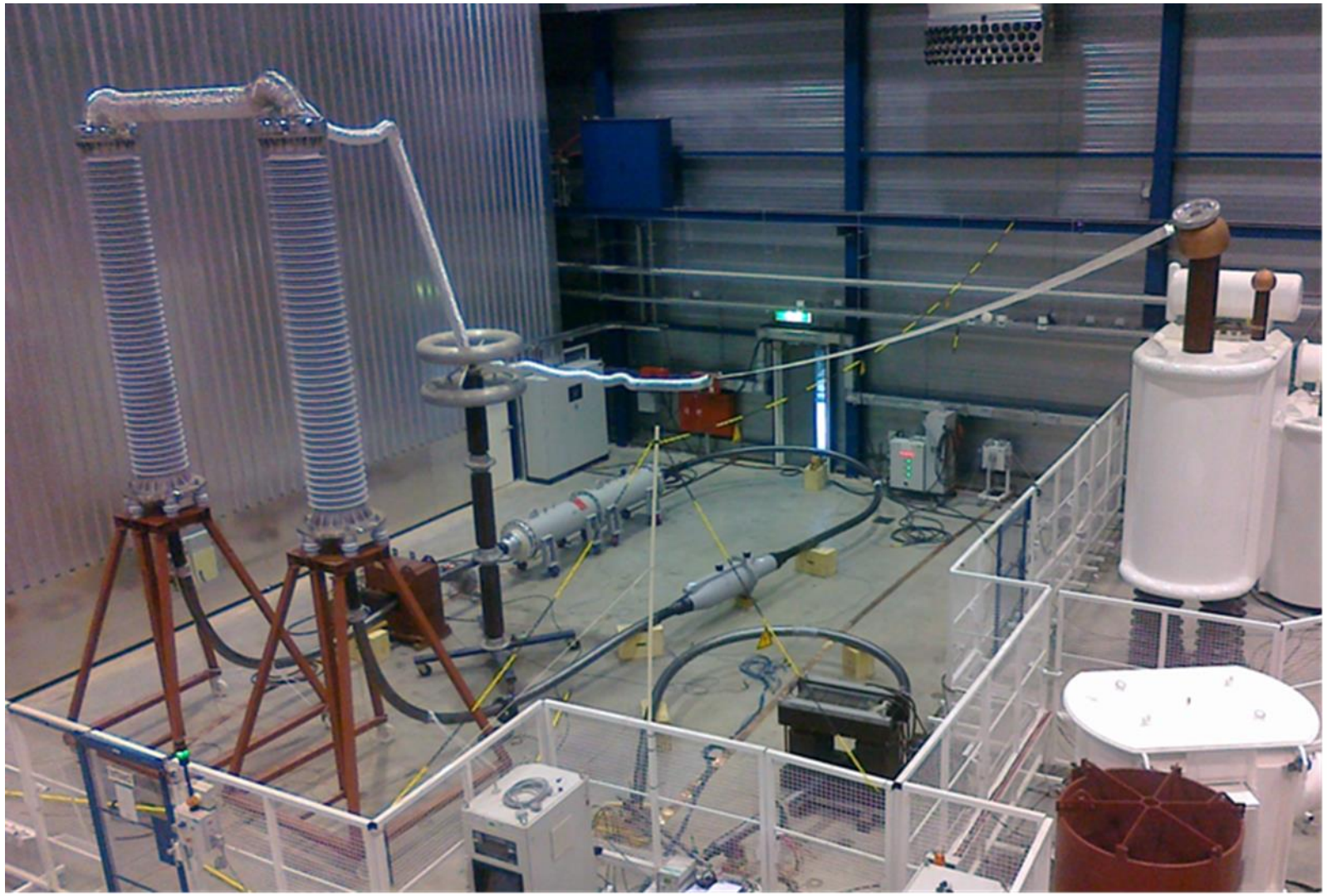
STL Guides for IEC 60840 and IEC 62067 have been re-issued in 2022 to harmonize interpretation of these standards.

DC Power Cables

- CIGRE 496
- IEC 62895
- GTSO

Typical type test program for HV AC Cables

- Bending test
- Tan δ measurement
- Heating cycle voltage test
- Partial discharge test at ambinent and high temperature
- Switching impulse test (>300kV)
- Lightning impulse voltage test
- Power frequency voltage test
- Examination
- Resistivity of semi-conductor screens
- Non-electrical type tests on cable
- Water immersion test for joint



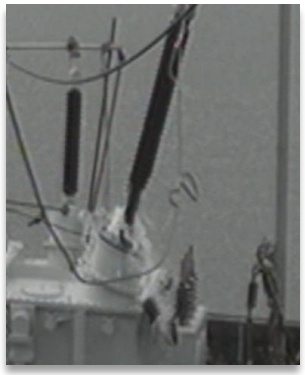
Pre-Qualification test for HV AC Cables

- Heating cycle voltage test for 1 year
- Lighning impulse voltage test
- Examination

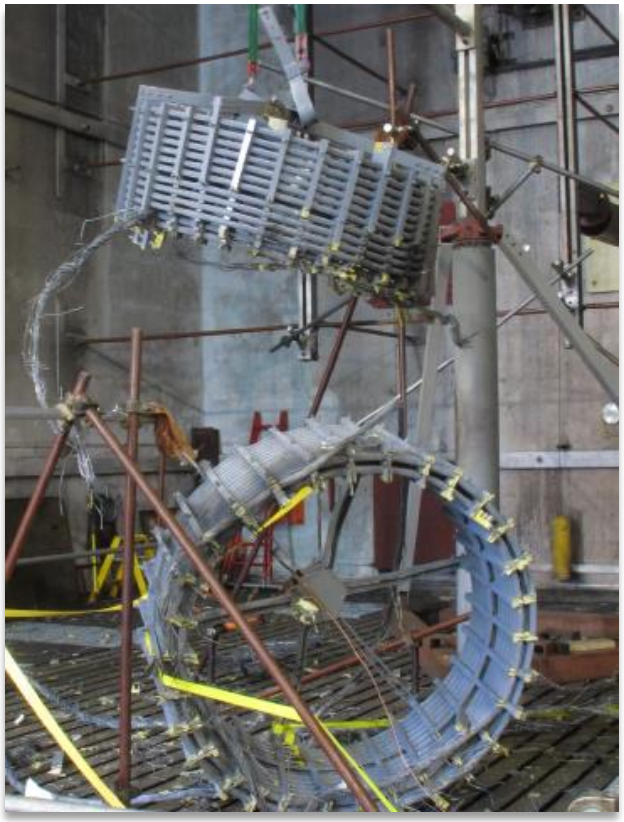
Statistics on initial failure rate during type testing

Around 25% of test-objects initially fail to pass type-tests

Line trap



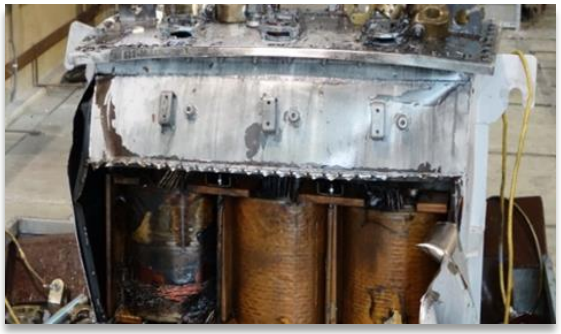
Broken bushing



Line trap

Disconnector

Switchgear panel

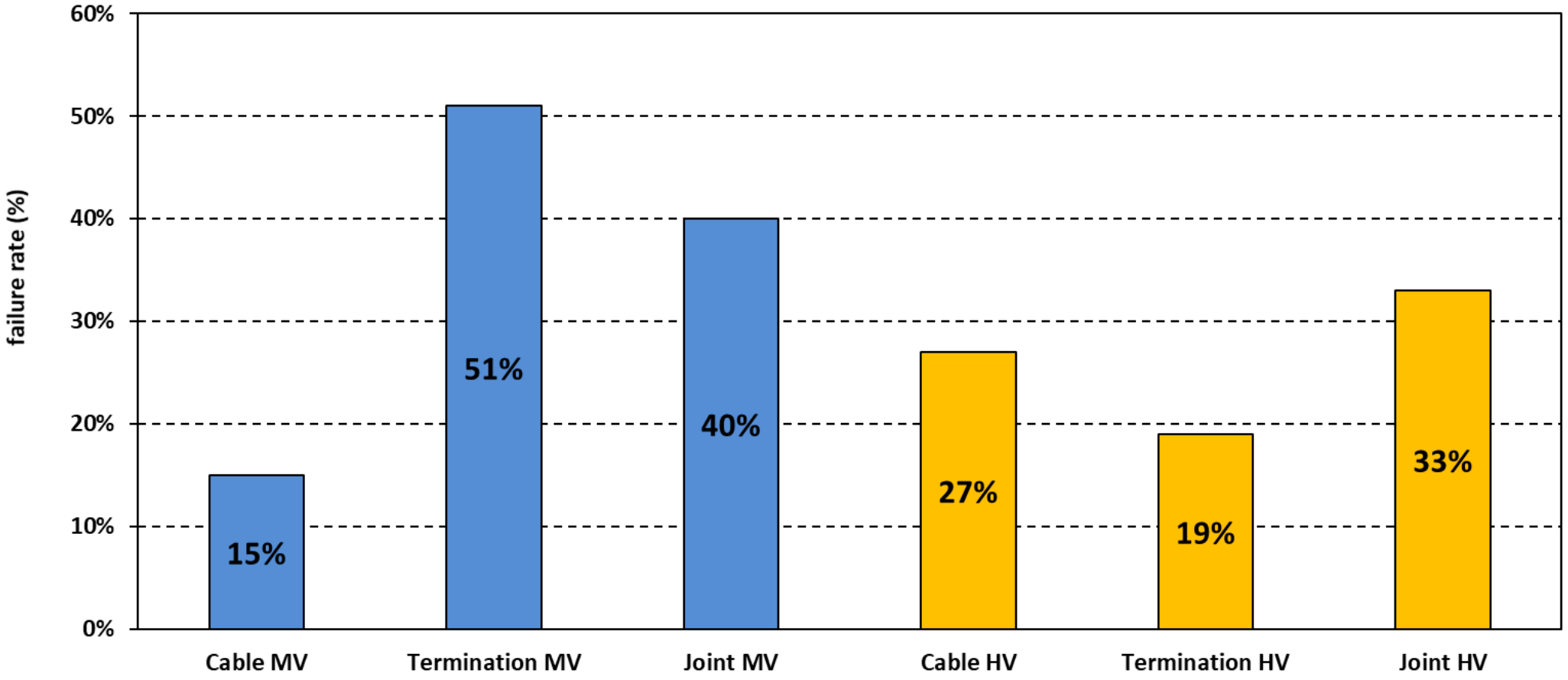


Distribution transformer

Oil spill

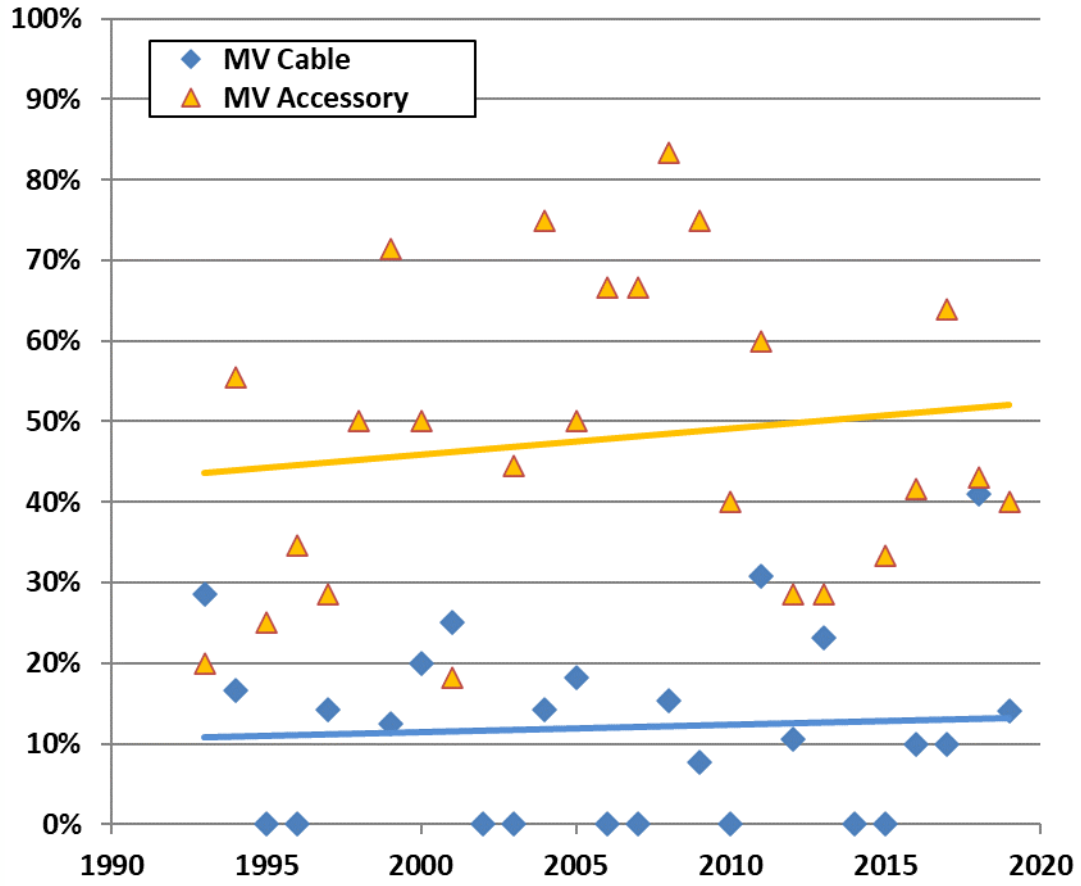
Source: KEMA Labs, large section of components tested

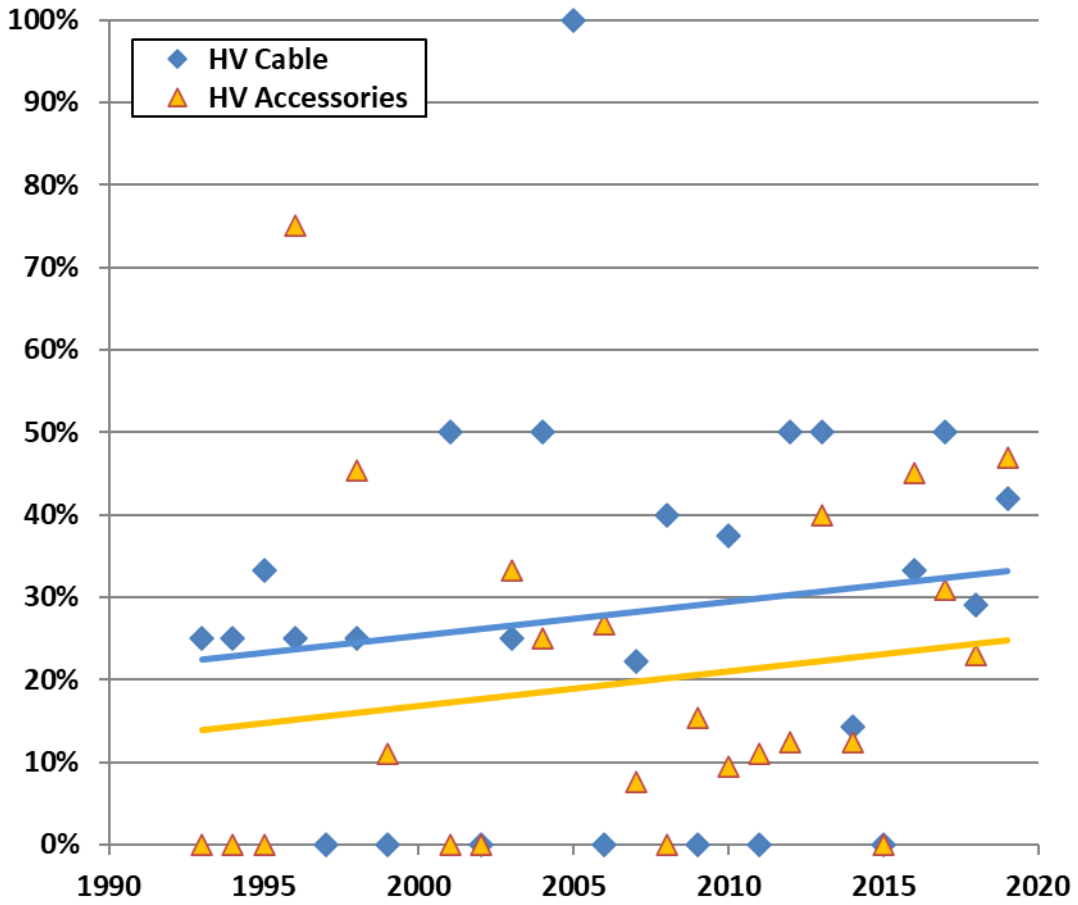
Failure statistics Type Testing AC Power Cables



Souce: KEMA Labs for time period 1993 - 2021

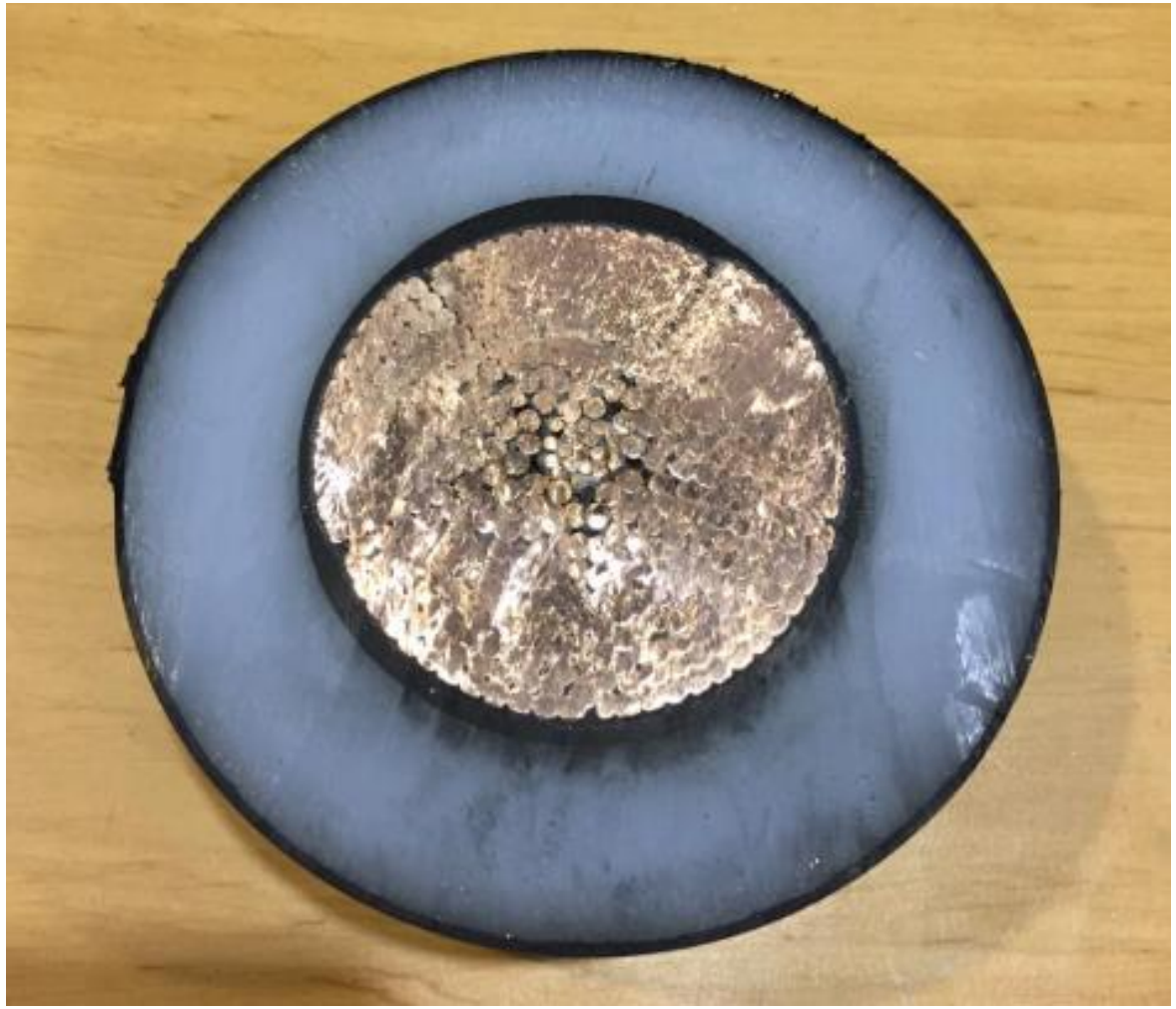
Trend of Failure Statistics AC Power Cables





Souce: KEMA Labs for time period 1993 - 2021

Samples of HV Cables submitted to KEMA Labs for type testing



HV cable and accessories observed failure mode

HV cable

- 57% failed by ET
- 43% failed by NET

Most failed NET:

- Insulation related tests (44%)
- Water penetration test (31%)
- Sheath related tests (25%)

Most failed ET:

- Tan Delta (29%)
- LI (24%)
- Heating cycles (19%)

HV joint

Most failed tests:

- Annex G (57%)
- LI (19%)
- Examination (19%)

HV GIS termination

Most failed tests:

- PD (43%)
- LI (29%)
- Examination (14%)

HV outdoor termination

Most failed tests:

- LI (53%)
- Examination (29%)
- AC (12%)

MV cable and accessories observed failure mode

MV cable

- 56% failed by ET (electrical tests)
- 44% failed by NET (non-electrical test)

Most failed NET:

- Sheath related tests (71%)
- Insulation related tests (29%)

Most failed ET:

- Rdc (44%)
- Examination (23%)
- Partial discharge (PD) (11%)

MV joint

Most failed tests:

- AC (31%)
- PD (31%)
- Heating cycles (23%)

MV indoor termination

Most failed tests:

- Humidity (35%)
- AC (20%)
- PD (20%)
- Lighting impulse (LI) (20%)

MV outdoor termination

Most failed tests:

- Salt fog (48%)
- AC (17%)
- PD (13%)

Conclusion / Recommendation

- Improvement of materials, calculation methods and production technologies are ongoing, but these do not result in a decrease of failure rate in type-testing, which, over decades, remains in the 25% range.

- The in-service failure rate of power system components is much lower. This is because type-testing aims to verify the components compliance to the standards, which cover about 90% of practical applications.

- In order to maintain the low service failure rate, type-testing and independent certification remains a key de-risking instrument to distinguish the well-designed, well-manufactured products from the inferior ones.

KEMA Labs

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