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How to prove long term performance for EHV cable system

SC B1 Insulated Cables - PS1 - Q5
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How to prove long term performance for EHV cable system ?

- Long term performance criteria of HVAC cable system has been proposed and demonstrated by PQ test since the establishment of IEC 62067 (2001).
- However, it seems not proved yet by the operational statistics (CIGRE TB815, 2021)

Table 11 Failure rates on the different types of AC land cable accessories (Unit: Faults/100units-year)

| AC ACCESSORIES | | VOLTAGE RANGE kV | | | | | |
|-----------------------------------|---|------------------------------|------------------------------|-----------------------------|----------------------------|-------------------------|---------------------|
| CABLE TYPE | COMPONENT TYPE | all voltages | 60-109kV | 110-219kV | 220-314kV | 315-499kV | 500kV and above |
| Extruded cables (EPR, PE or XLPE) | Joint | 0.0047 145905pcs/62faults | 0.0021 123230pcs/23faults | 0.0160 16624pcs/24faults | 0.0266 5449pcs/11faults | 0.113 353pcs/4faults | 0 249pcs/0faults |
| | AIS Termination Fluid filled Porcelain | 0.0107 29530pcs/28faults | 0.0018 25081pcs/4faults | 0.0111 4011pcs/4faults | 0.570 420pcs/20faults | 0 18pcs/0faults | |
| | AIS Termination Fluid filled Composite | 0.132 2741pcs/23faults | 0.0362 597pcs/1faults | 0.0307 1347pcs/3faults | 0.344 773pcs/17faults | 0.833 24pcs/2faults | |
| | AIS Termination Dry Porcelain | 0.0036 3086pcs/1faults | 0.0040 2788pcs/1faults | 0 286pcs/0faults | 0 12pcs/0faults | 0 0pcs/0faults | |
| | AIS Termination Dry Composite | 0.0880 2636pcs/13faults | 0.111 2149pcs/13faults | 0 448pcs/0faults | 0 36pcs/0faults | 0 3pcs/0faults | |
| | GIS or Transformer Termination Fluid filled | 0.0127 9412pcs/11faults | 0 6332pcs/0faults | 0.0265 1332pcs/3faults | 0.0347 1706pcs/5faults | 1.00 30pcs/3faults | 0 12pcs/0faults |
| | GIS or Transformer Termination Dry | 0.0068 34244pcs/20faults | 0.0039 29284pcs/10faults | 0.0114 4344pcs/4faults | 0.155 559pcs/6faults | 0 27pcs/0faults | 0 30pcs/0faults |

PQ tested system (220-500kV) shows much higher failure operational rate than SCOF cable system (approx. 2-10 times), and lower voltage XLPE system without PQ test shows less failure rate.

Failure mode after long time use

- Miss workmanship could be already checked by AC high voltage test at commissioning test, however, deterioration after long time use is difficult to be predicted, or not successfully recognized at early stage.
- The following is an example of Japanese report (IEEJ Trans 2007) about “Extraction mechanism” by combination of chemical and electrical deterioration.

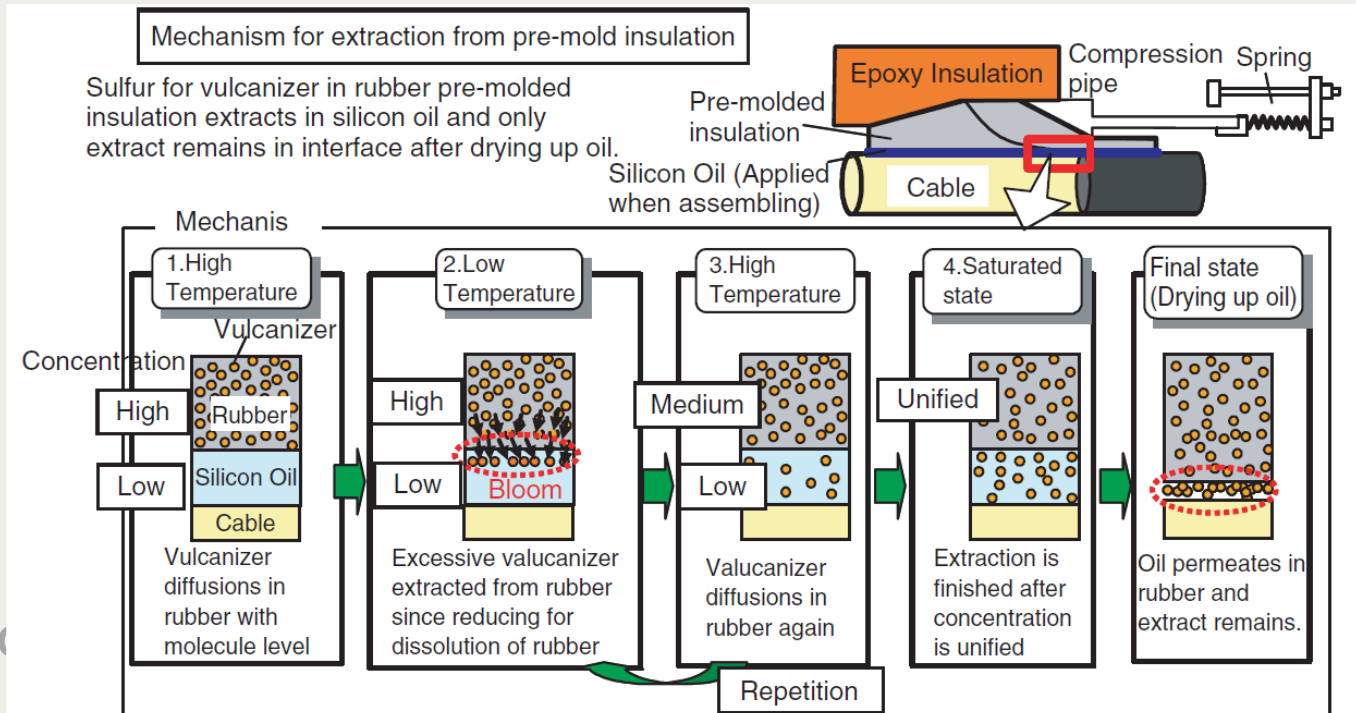


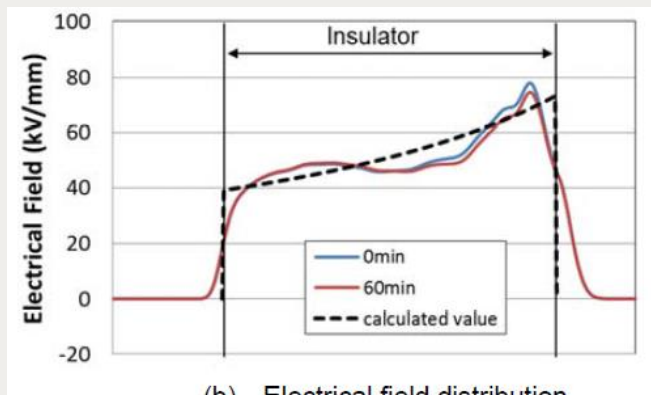
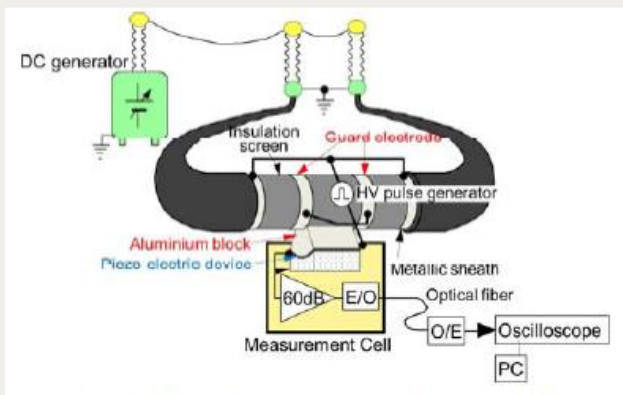
Fig. 11 Estimated mechanism for extraction



Fig. 12 Extraction of additive from rubber

Extensive performance tests after Type/PQ test for EHV DC cable system

- Case 1: Space charge measurement after 400kV PQ test
⇒ No obvious distortion of electrical stresses even at 1000kV. (Fig b below)
- Case 2: Additional 100 heating cycle after 400kV type test
⇒ More than 120 cycles and total of 120 Impulse shots were completed
- Case 3: Successful DC 525kV type test after 525kV PQ test complete
⇒ After successful completion of DC 525kV type test, breakdown test was conducted at the DC superimpose LI (+/-640kVdc +/- 1344kVp) to prove some design limit, but without no clear indication of deterioration after dissection.



(a) Space charge measurement in cable after PQ test

EHV DC cable system ($\geq 20\text{kV/mm}$) has shown no electrical deterioration so far.

More insight in chemical deterioration are necessary as we experienced in HVAC XLPE cable system.