Qualification testing of synthetic cable systems

Pierre Hondaâ

RTE (France)

HVDC cable technology

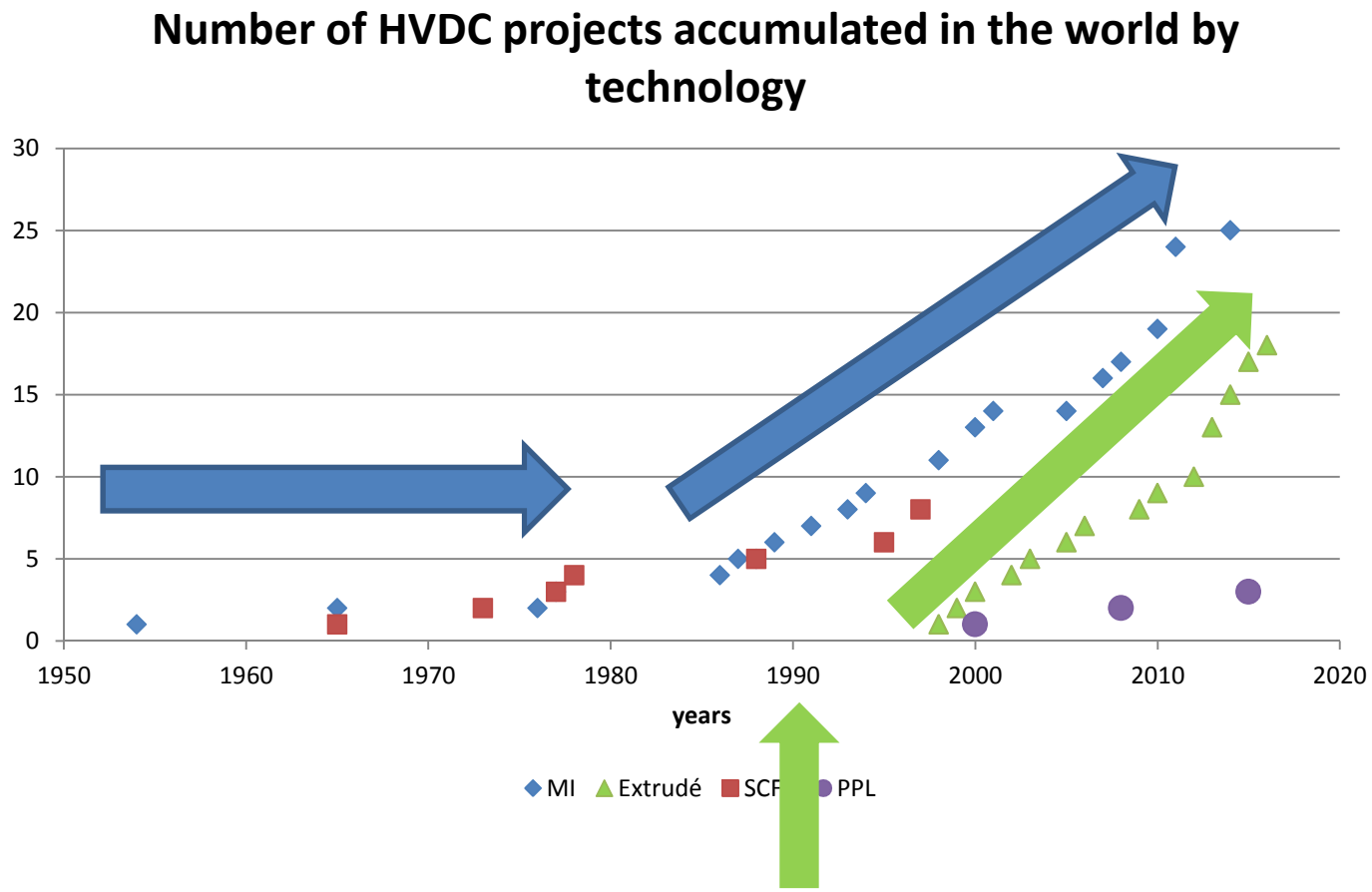
Extruded

Mass Impregnated

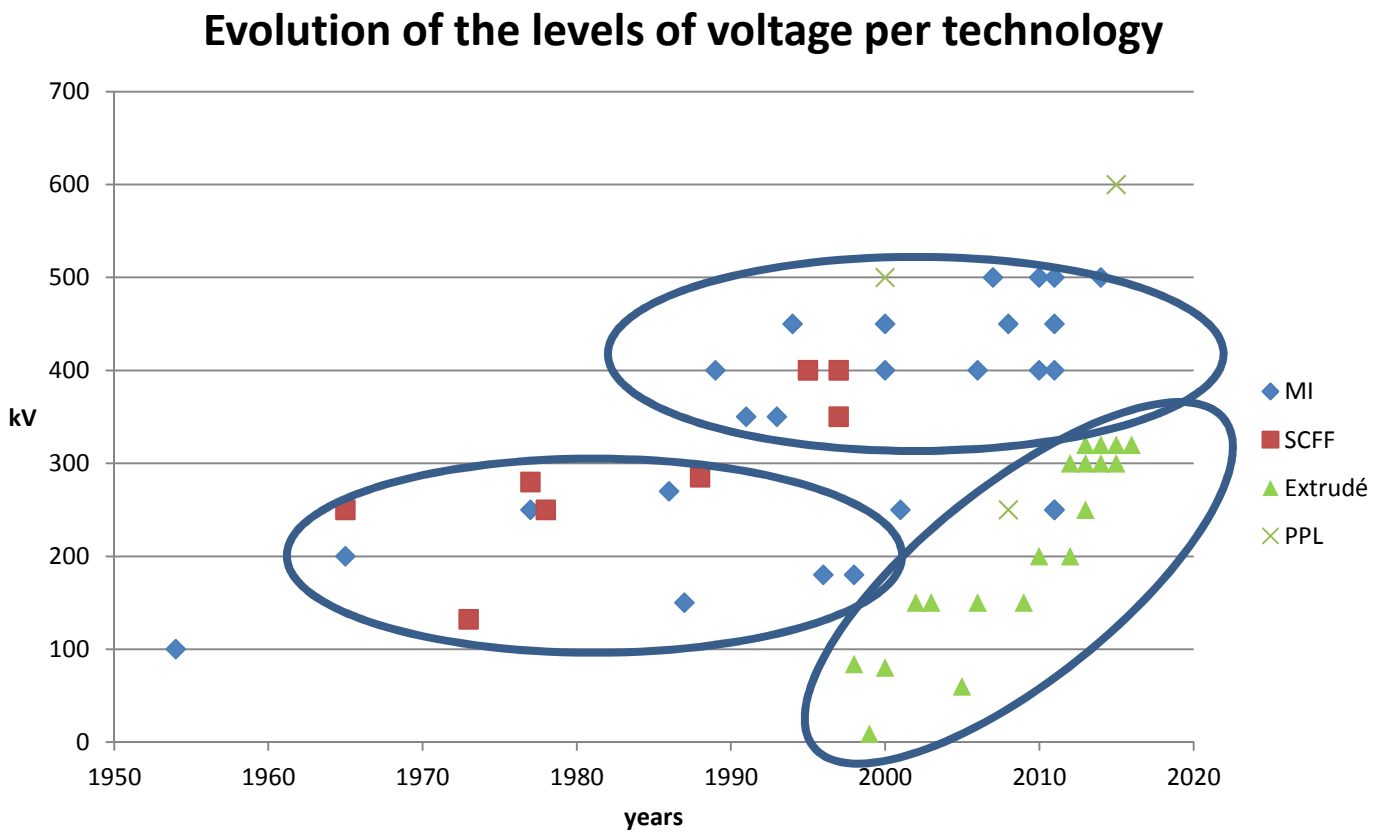
Self-Contained Fluid Filled

PPL: polypropylene/paper laminate

HVDC XLPE cable, a recent technology and feedback experience limited

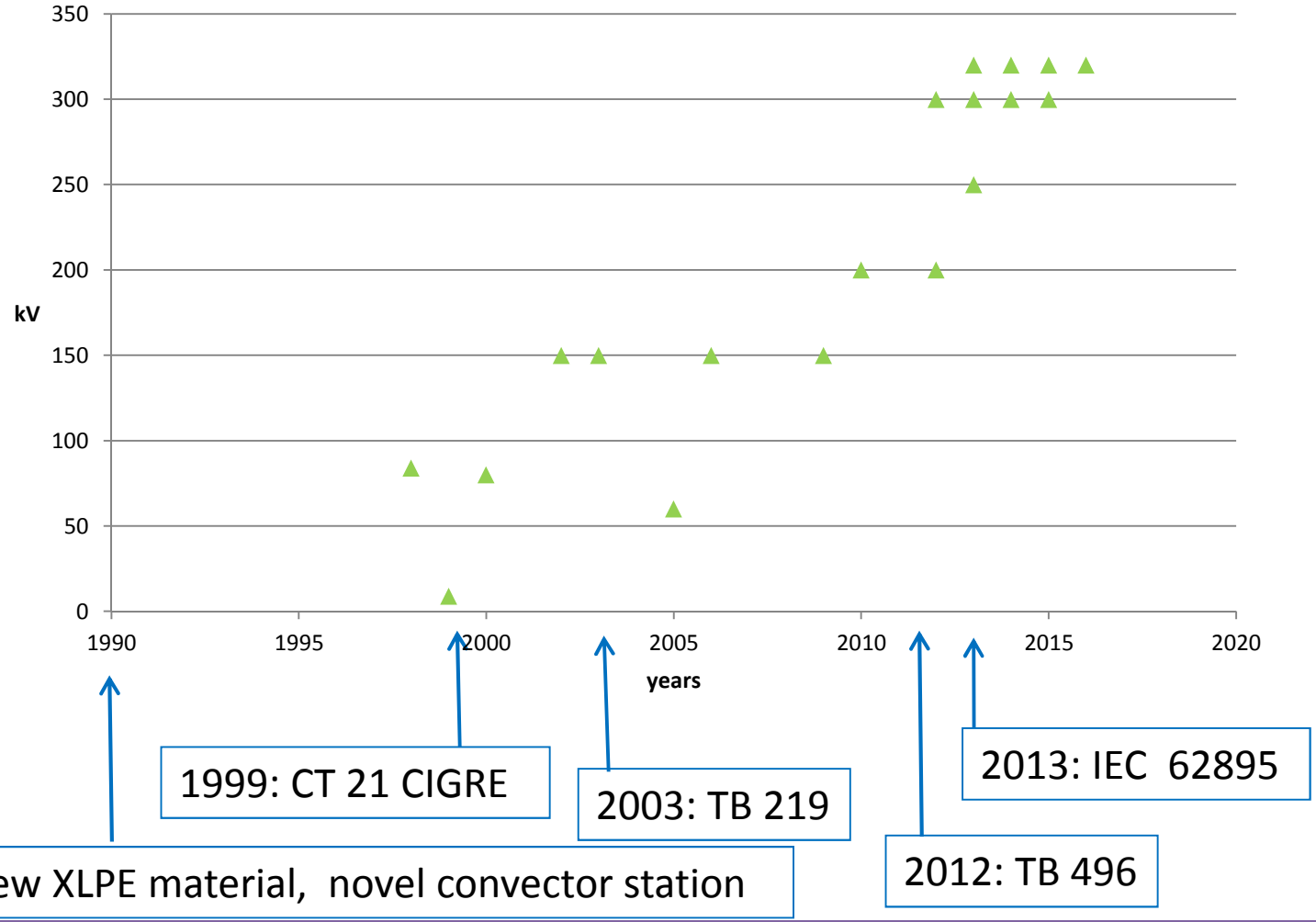


HVDC XLPE cable, a recent technology and feedback experience limited



HVDC XLPE cable, a recent technology and feedback experience limited

Evolution of the levels of voltage for XLPE technology



Problem

which functionalities are required on XLPE insulated cable and which tests are used to check them?

- Important feature of HVDC cable and compared with the AC cable
- The differents phenomenes activate during short and long-term test
- The main functionalities of a HVDC cable system and the qualification tests used to check the expected functionalities
- The qualification tests that contribute to standardisation and innovation

important feature of HVDC cable

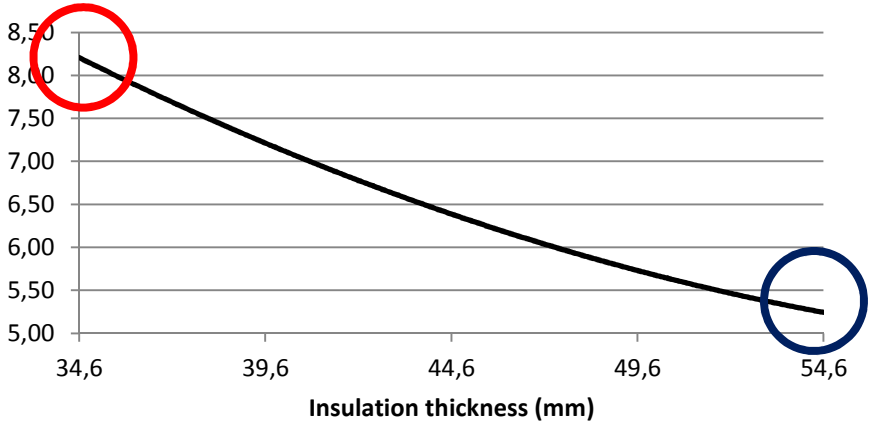
distribution of the electric field in the insulation

Cable loaded
Cable not loaded

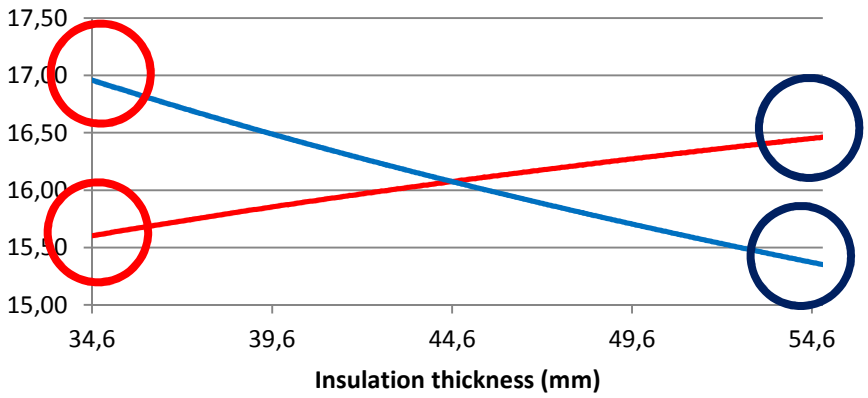
Internal Gradient **AC**

External Gradient **DC**

Electric field E(r) kV/mm



Electric field E(r) en kV/mm



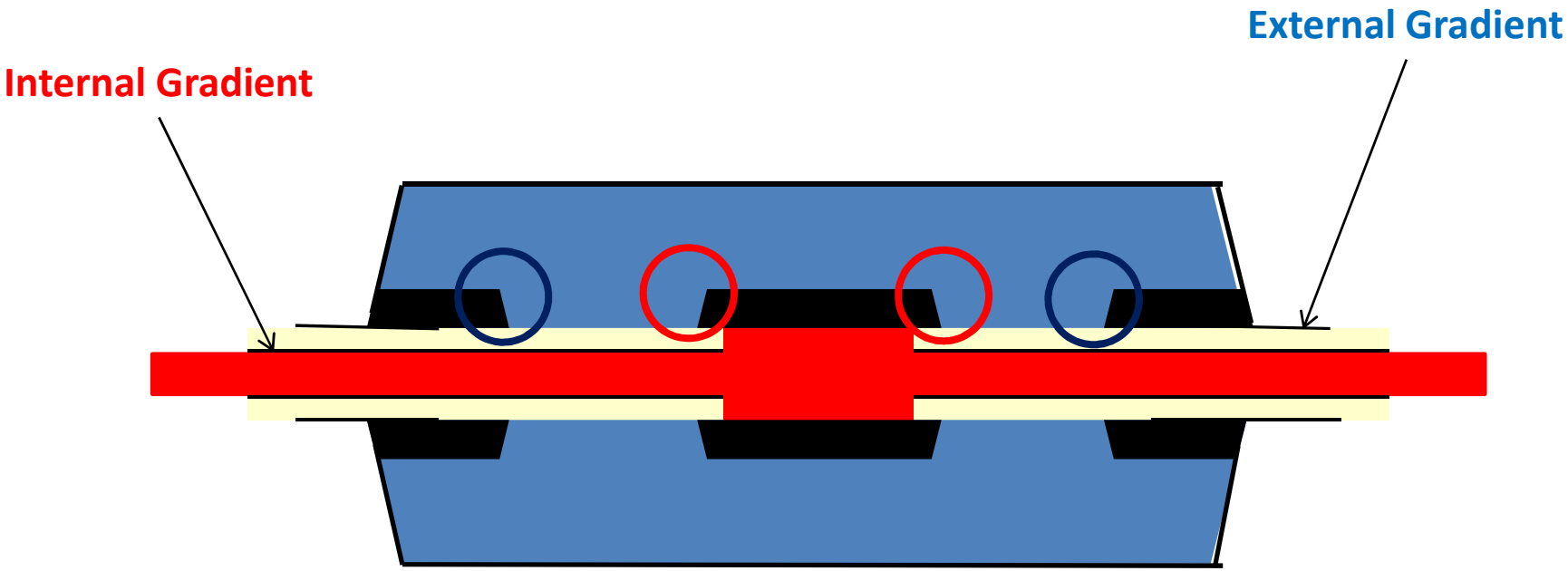
$$E(r) = \frac{V}{r \ln(r_2/r_1)}$$

$$E(r)\exp[\beta_e E(r)] = -\frac{I}{\sigma_0 \times 2\pi r}\left(\frac{r}{r_1}\right)^m \exp[-\alpha\theta(r_1)]$$

$$m = \frac{\alpha\Delta\theta}{\ln(r_2/r_1)} \qquad \sigma(r) = \sigma_0 \exp[\alpha\theta(r) + \beta_e E(r)]$$

important feature of HVDC cable

distribution of the electric field in the insulation



important feature of HVDC cable

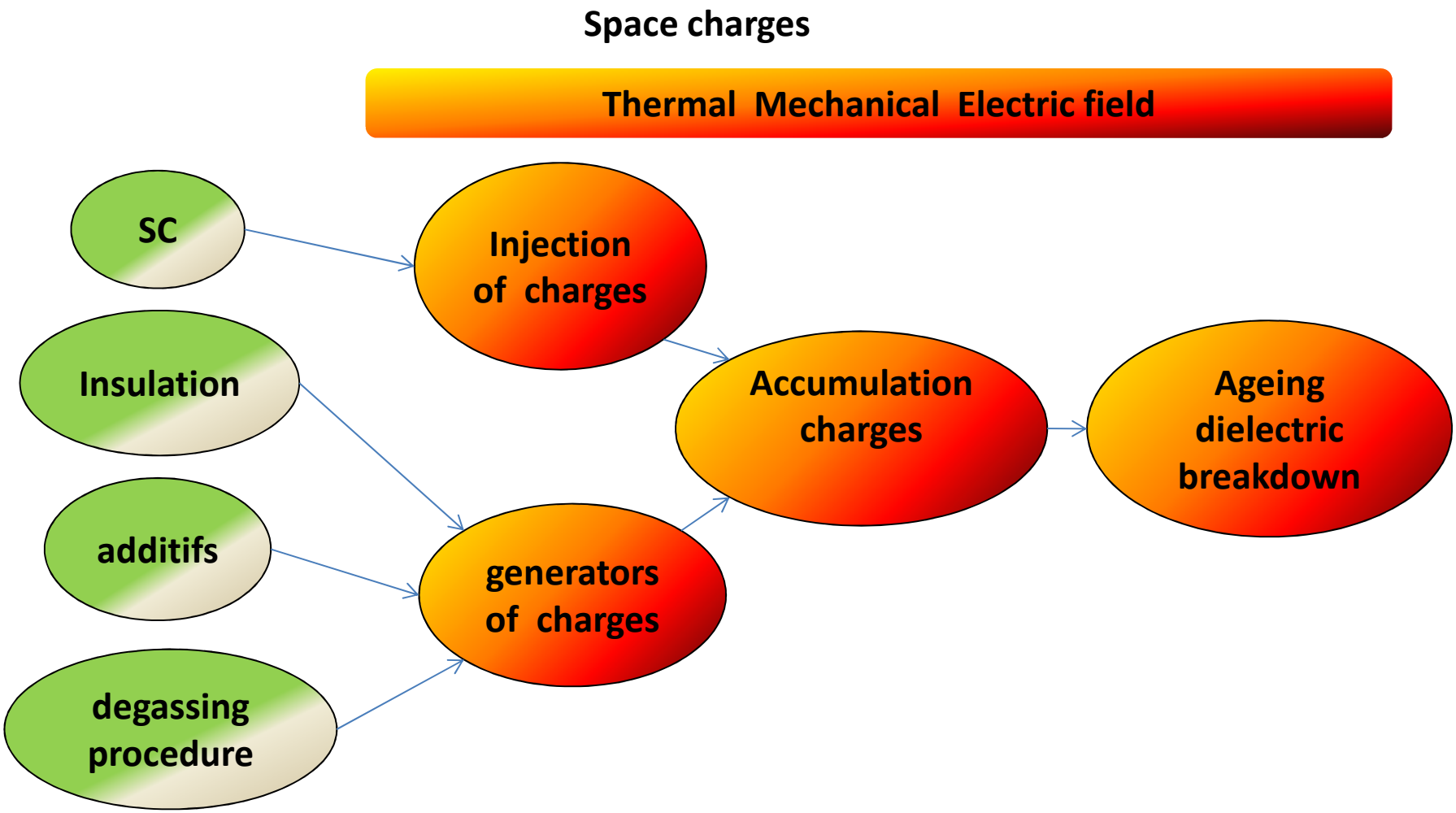
Space charges

AC 50 Hz → No displacement → No accumulation space charges

Isulation Quality high

DC Thermal, Mechanical, Electric field → displacement → Accumulation charges

important feature of HVDC cable



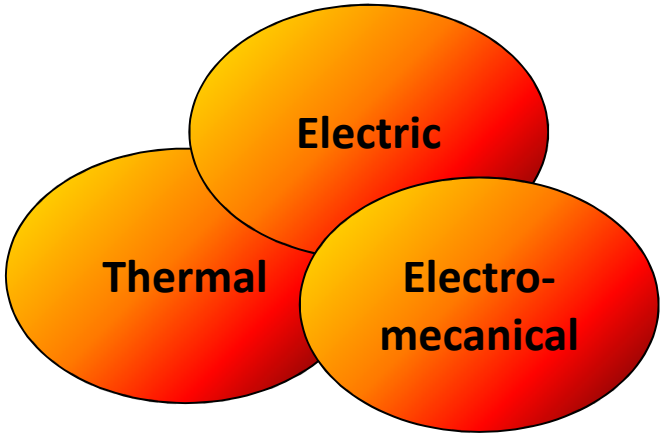
important feature of HVDC cable

The law of electric ageing which is not well-known

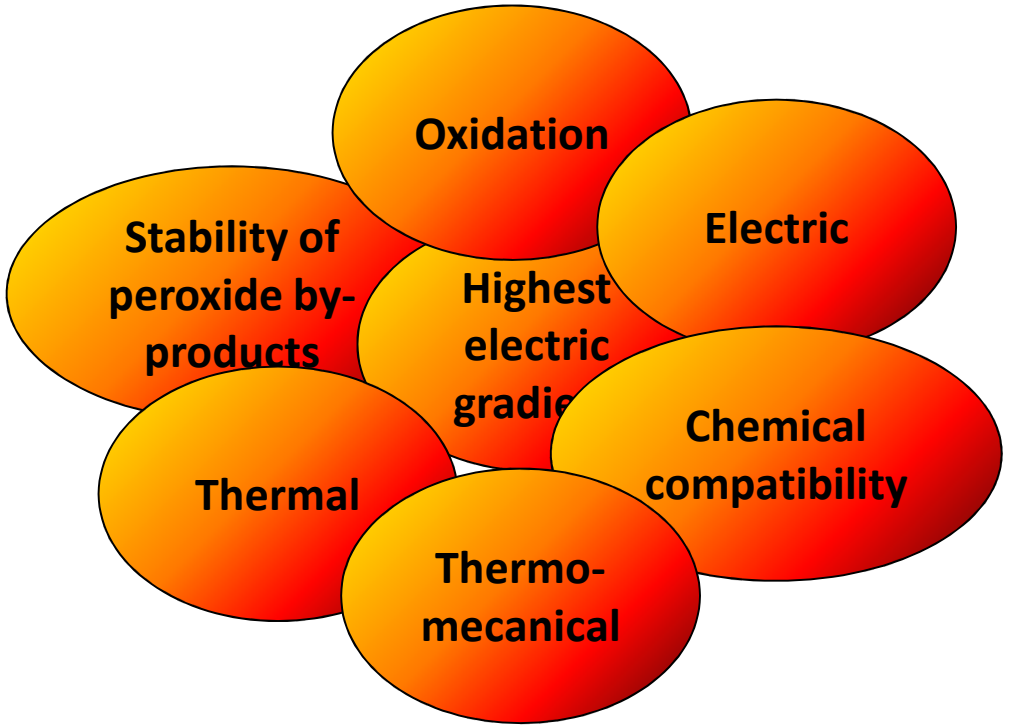
$$V^n \times t = \text{constant}$$

The different phenomena activate during short and long-term test

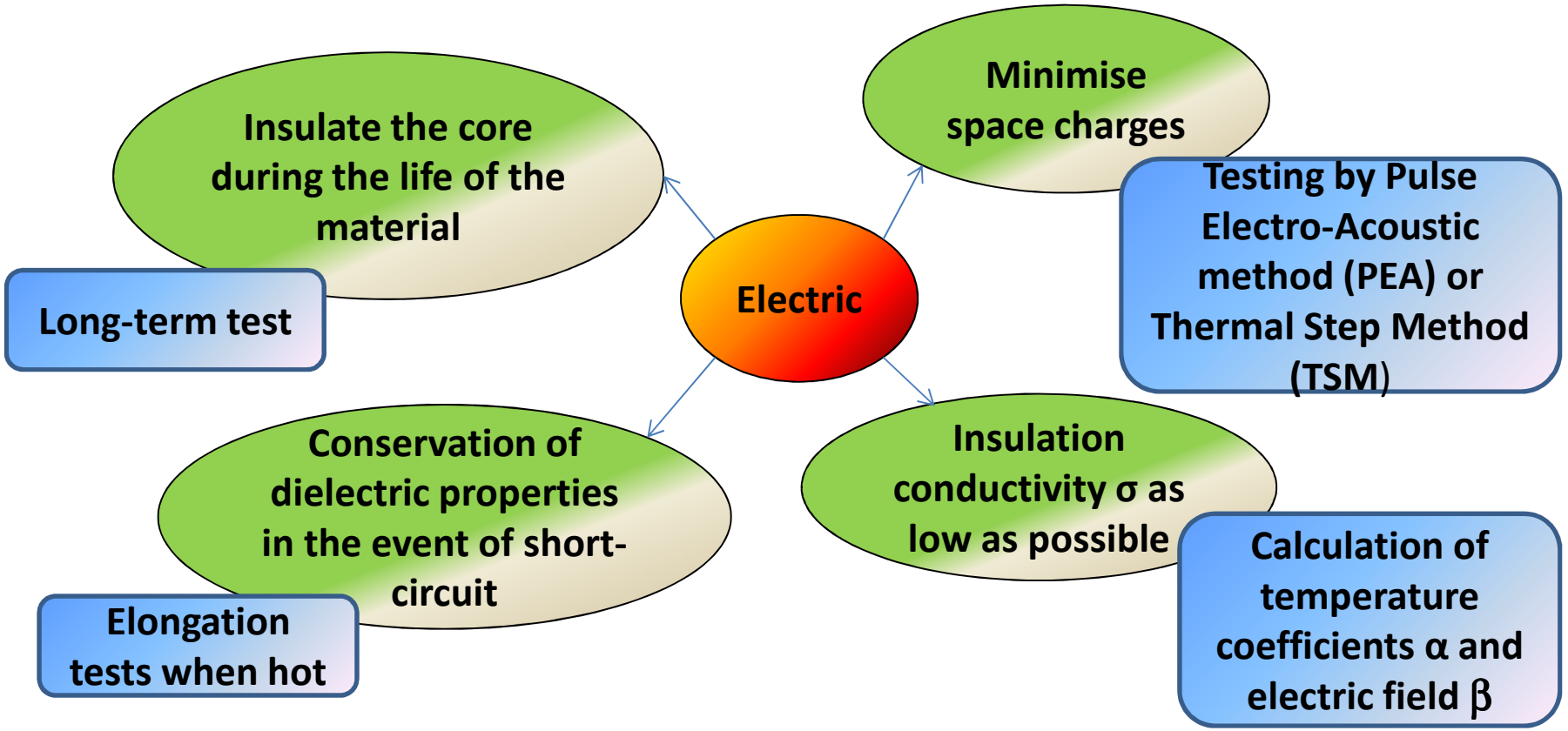
short-term test



long-term test



The main functionalities of a HVDC cable system/ Qualification tests to verify the expected functionalities



$$\rho = \rho_o \exp\left[-\left(\alpha T + \beta E\right)\right]$$

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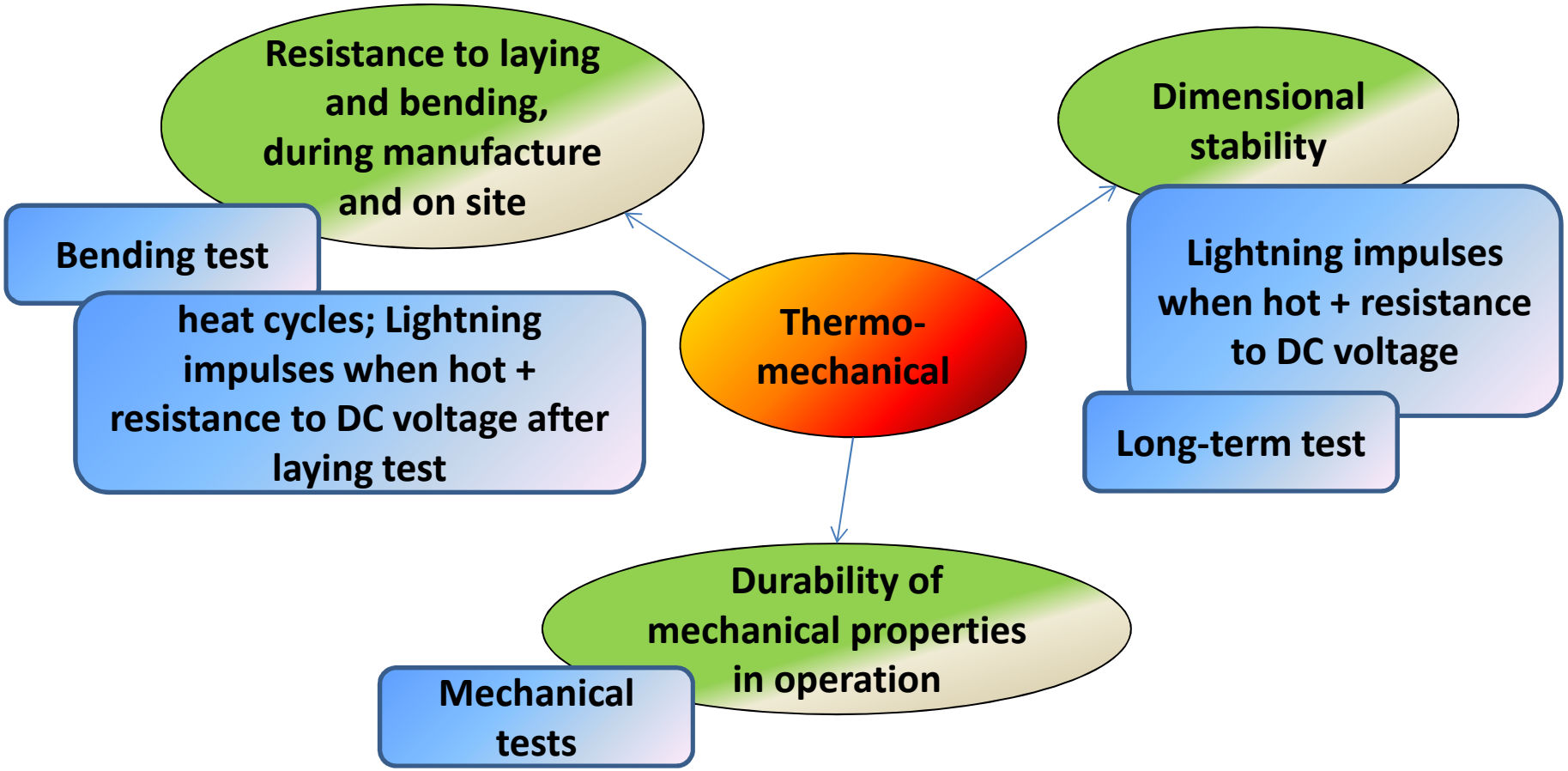

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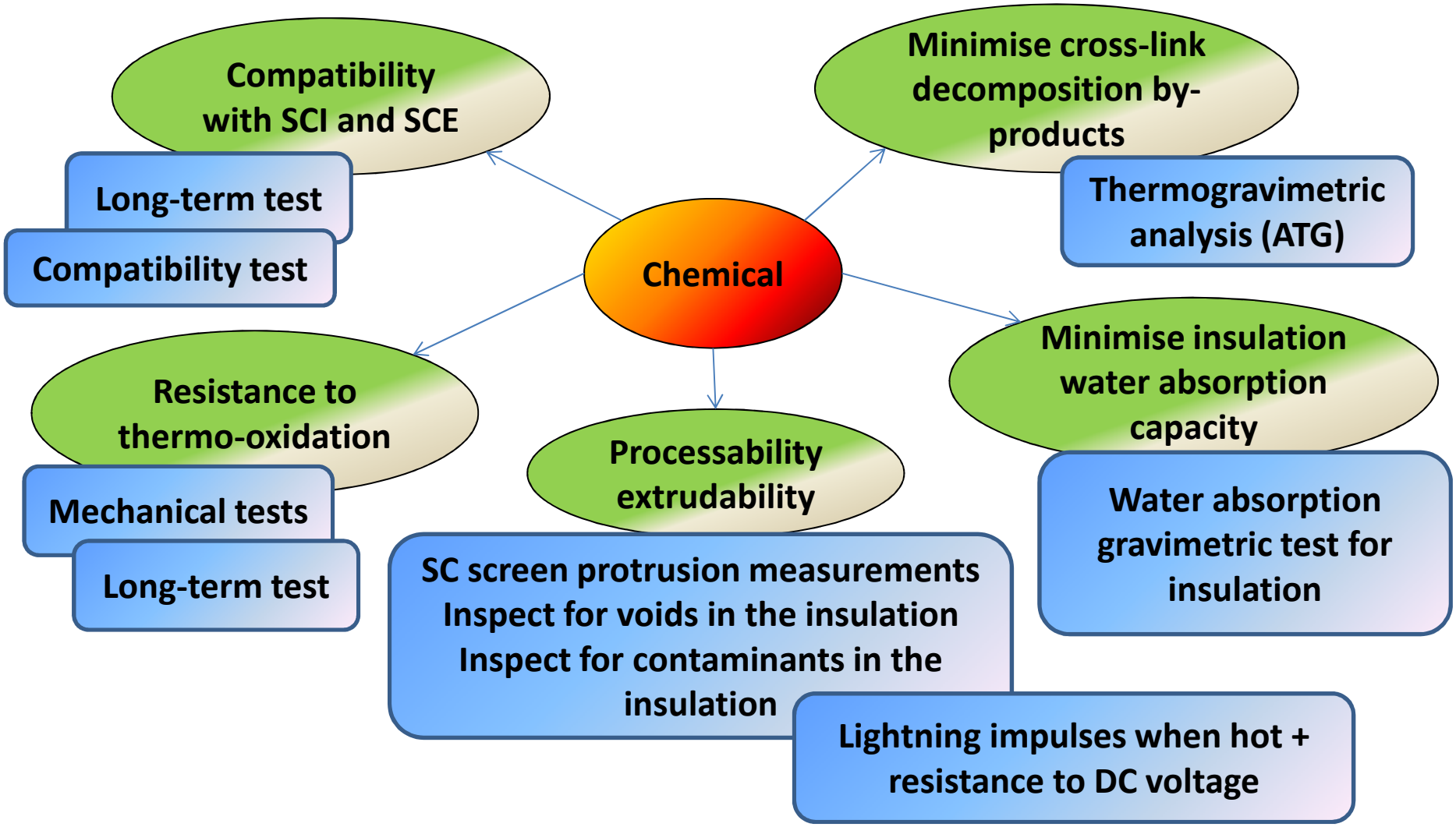

The qualification tests contribute to standardisation and innovation

Progress towards standardisation

➔ construct a quality index for HVDC cable system

➔ the test results

Promote innovation

Cable technology	Int G in kV/mm	Ext G in kV/mm
DC 320 kV	17	16.5
AC 400 kV	16	9

Conclusions

➔ More HVDC electricity networks in France and Europe

➔ More qualification tests for better understanding

➔ More laboratories for more tests

➔ More feedback for qualification and development testing to construct future HVDC standards.

All this can only be done with full cooperation between the cable-manufacturers and TSOs in international working groups for setting standards.

Thank you for your attention

Pierre Hondaâ

Réseau de transport d'électricité