Insulator radiation hardness: Definition of tests and samples

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What we need to know is at which level radiation damages can affect the lifetime of the insulation.

- First point:
  - Precise the **environment :** type of radiation, dose rate, total dose (cf. previous presentations).
    - Answers will define the scope of the study, the choice of the **appropriate reactor.**
  - **Bibliography** : what has been already studied in this area.
    - a lot of studies on the behaviour of resins after irradiation, especially connected with developments for ITER,
    - development of new resin formulations, ex : CE/epoxy blend (Hunstman, CTD), DGEBF/DETDA (RAL),.

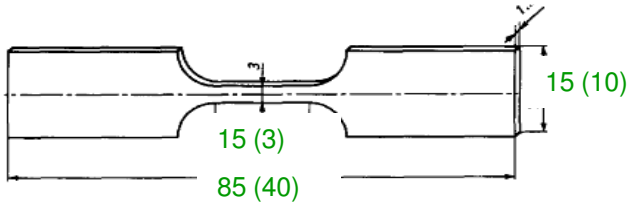
  $\Rightarrow$ not perform useless studies if test results or a solution already exit.

- What are relevant parameters to survey for the insulation?

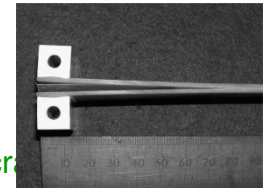
Tests

- Mechanical
  - Compressive test ➔ 200 MPa ten-stack ?

  - Ultimate Tensile Strength test in 0° and 90° directions (cf ATI ref.)
    ➔ 20 Mpa (probably not an issue, cf.biblio [2])



  - Shear stress ➔ 35 MPa
    - work of fracture (ASTM D5528)[1]
      100 x 25 x3 mm with pre-cr



    - Short Beam Shear (ASTM D2344)[1] (cf ATI ref.)
      20 x 6 x 3 mm

- Electrical
  - Electrical breakdown (BS7831)[1] ➔ > 5 kV between turns (= ? kV/mm)
    1mm thick plate 50 mm x 50 mm
- Thermal
- Gas evolution effects ?

- [1] Canfer et al., Adv. cryo. Eng. Vol 52A, pp298-305
- [2] Humer et al., J. Nucl. Mater. 212-215 (1994) 849-853

Samples

- Test protocol
  - Temperature of irradiation : room temperature, low temperature probably not necessary[2].
  - Temperature of tests:
    - At room temperature
    - At 4 K, or at 77 K : more easier and rapid[1, 2]
- Geometry of the samples
  - ➢ Adapt to the dimensions of the reactors [2]
- Number of samples : 3-5 by test.
- A priori, in a first step, one parameter for insulation : the resin
  - CE/epoxy blend (Hunstman),
  - DGEBF/DETDA (RAL).
  - CTD 101 K (FNAL)?
- If several parameters, use experimental design (Taguchi, factorial plan…)

Caution!

- Risk of activation of the samples[3]
  - Results depends on radiation spectrum, energy, interaction cross-section, chemical composition of the materials…
  - Ex: irradiation effects on insulation systems consistent or not between reactors, depending if data plotted versus fast neutron fluence or total dose;
  - Damages can be underestimated with fast neutrons [4]
- Resins processed by two different manufacturers may present different behavior[5].

- [3] CARE-Report -06-038-NED / EDMS815074.
- [4] papers from D.Evans and R.P.Reed.
- [4] Schönbacher et al., Absorbed doses and radiation damage during the 11 years of LEP operation , NIM B 217 (2004) 77–96.