SOUND VELOCITY AS A NON-DESTRUCTIVE INDICATOR FOR GAMMA-IRRADIATION INDUCED EMBRITTLEMENT IN POLYETHYLENE INSULATORS

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Nuclear power plants (NPPs) produce approximately 25 % of electricity in EU area making it the most important source of low-carbon energy. However, the European reactor fleet is growing old: Most of them are built in 1970s and 1980s. Therefore, material degradation studies have become a major topic.

There is approximately 1500 km of electric cables in a single NPP. During operation, some of these cables are exposed to high level gamma irradiation. Gamma radiation is known to brittle polymers such as polyethylene used as insulator in these cables. Since the planned lifetime for a single NPP is 60 to 80 years, a low-cost method to estimate the embittlement level non-destructively is required.

While polyethylene ages, Elongation at Break (EaB) decreases and Young's modulus increases. Since sound velocity for longitudinal wave mode in homogenous and isotropic media is a function of Young's modulus, Poisson's ratio and density (Eq. 1), it can be used as a non-destructive indicator for embrittlement.

$$v_l = \sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}} \tag{1}$$

In our study, 10 specimens of commercially available coaxial cable were exposed to gamma irradiation using two different dose rates and five different total doses. Then, the sound velocities were measured using traditional pulse-echo approach with an integrated transducer-micrometer setup developed by VTT. EaB values were measured via tensile testing by ÚJV.

The results clearly show, that sound velocity increases and EaB decreases when polyethylene is exposed to gamma irradiation. The correlation between sound velocity and EaB is linear. Based on the results, it is possible to use sound velocity as a low-cost non-destructive indicator for gamma-irradiation induced degradation of polyethylene.