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Assessment of electrical insulation of a superconducting magnet winding pack under severe loading conditions

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Electrical insulation of superconducting magnets represents one of the most critical aspects in the manufacturing and operation of these devices. In tokamaks, for instance, the use of superconducting magnets is highly recommended since superconductivity constitutes an enabling technology for fusion plasmas, nonetheless, their capability in withstanding off-normal loading conditions was never assessed. Indeed, accidents during manufacturing or severe out-of-design loadings in operations could compromise the design life of the component. In this respect, since they do not possess plastic properties, when elastic limits are exceeded, insulating materials could be irreversibly damaged. Damages could be cracks or delaminations producing different effects in terms of operational life of the magnets. Whilst a crack could give rise to electrical breakdown during fast discharge after a quench, delaminations might produce local heating due to friction that might induce superconducting quench. The present paper shows the results of the finite element models of two different winding pack mock-ups of a superconducting magnet for fusion applications subject to off-normal torsion and bending conditions. The mock-ups are supposed made of a matrix of superconducting cable in conduit conductors wrapped by 1 mm thick glass fiber resin composites. Through a detailed analysis of stress-strain properties of the insulation and a comparison with available experimental results, the authors give a threshold to the off-normal loading conditions under which the magnet could be safely operated.

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