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Electro-Mechanical Design and Experimental Validation of Post Insulators for Beam Source for ITER Diagnostic Neutral Beam

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The Beam Source (BS) for Neutral Beam Injectors consists of two parts: “ion source” and “accelerator system” . For the ITER Diagnostic Neutral Beam (DNB), the ion source is the plasma generator and consists of eight inductively coupled Radio Frequency (RF) plasma drivers. The accelerator system consists of three grids and accelerates the negative ion beam to 100 keV. The three grids: plasma grid (-100 kV), extraction grid (-90 kV) and grounded grid (ground potential) are sequentially arranged and coupled mechanically with the help of post insulators (PI).

These PIs are made of Alumina and bolted with SS304L flanges on both ends. All the grids are joined together by means of two sets, each consists of 18 number of PIs which provides not only the electric insulation between the grids but also works as a structural member as the BS is suspended vertically from an isolated frame. In this configuration, the total self-weight about seven tones acts on the PIs in cantilever fashion, and their specifications for load bearing capacity provides for this requirement. However, the mechanical behavior of alumina depends on manufacturing procedures like sintering temperature, volume of the material, shape, etc., which are not addressed by the conventional standards. So it is essential that the design has to be supported with analysis and special tests that qualify.

In the present case, an integrated Finite Element (FE) assessment in ANSYS is performed where PIs experience combined axial and transverse loading conditions. The assessment determine the most severely loaded PI and its reaction forces and moments. This data becomes inputs for the experimental tests to be carried out for validation. Prior to experimental tests, the test configuration is assessed using FEA to ensure that the test configuration under the applied load condition simulates the realistic conditions.

Additionally, the PI design need to comply with a voltage holding requirement of 140 kV in vacuum. This compliance is established in the design by FE assessment, carried out in ANSYS, for the electrical field distributions, including the stress shields and localized stress field concentrations and subsequently verified by electrical tests.

The paper presents the analysis of BS and the results from the electrical and mechanical tests that have been carried out on 4 PIs manufactured as prototypes.

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Primary author: Mr MUVVALA, VENKATA NAGARAJU (ITER-India, Institute for Plasma Research, Bhat Gandhinagar -382428, India)

Co-authors: Mr CHAKRABORTY, ARUN KUMAR (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India); Mr ROTTI, CHANDRAMOULI (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India); Mr PARMAR, DEEPAK (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India); Mr JOSHI, JAYDEEPAKUMAR (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India); Mr BANDYOPADHYAY, MAINAK (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India); Mr SHAH, SEJAL (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India)

Presenter: Mr CHAKRABORTY, ARUN KUMAR (ITER-India, Institute for Plasma Research, Bhat Gandhinagar –382428, India)

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