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Developing a benchmark example of magnetically insulated transmission line current loss

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In a high power vacuum insulated transmission line, a critical current must be reached such that magnetic insulation is obtained. Before this magnetic insulation, the threshold for vacuum field emission is reached leading to emission of electrons from the cathode. Additionally, the large conduction currents lead to Joule heating of the electrodes and subsequent sublimation of any impurities on the electrode surfaces. The combination of these processes may lead to plasma formation and loss of insulation. In this work, electron and ion flow patterns are analyzed for a 30-degree wedge of a full 31-cm convolute section used on the Z-accelerator. An electromagnetic, particle-in-cell (PIC) code is used to couple the transient wave phenomena with charged particle physics. Emission of neutral water from the electrode surface is included and allowed to interact with the charged species. Load currents are calculated with and without charged species to estimate a current loss metric. This three-dimensional example of the convolute requires cell sizes on the order of 10^{-6} m near the electrode surfaces due to anticipated plasma densities on the order of 10^{14} cm^{-3} - 10^{16} cm^{-3}. The limitations of using an explicit PIC code on modern computing hardware are examined as this example stresses computational requirements.

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