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Development of DC Ultra-High Voltage Insulation Technology for ITER NBI

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In the ITER NBI for plasma heating and current drive, a 1 MeV, 40 A deuterium negative ion (D-) beam is designed to be accelerated for 3600 s. The beam energy and the pulse duration of the D- beam are 2-5.5 times higher and 360 times longer than those in the negative-ion-based NBIs on LHD and JT-60U, respectively. Thus, to realize higher voltage and longer pulse duration, the generation, transmission and insulation of DC ultra-high voltage are critical issues for the ITER NBI. In addition, the high-current busbar, cooling water and gas pipes at -200 kV˜ -1 MV potential are simultaneously transmitted through the HV bushing from the gas-insulated transmission line in the PS to the beam source (BS) to minimize the installation space. Those are significant differences from that in existing N-NB systems. Especially, a DC 1 MV insulating transformer for feeding an electric power from the ground to 1 MV potential is one of most challenging components. For stable power transmission through the HV bushing, 1 MV vacuum insulation and a stiffness to withstand the maximum pressure difference of 0.9 MPa in a limited space are required. Japan Atomic Energy Agency (JAEA) is in charge of the procurement of these high voltage parts of the 1 MV PS and the HV bushing. As for the insulating transformer, a DC long pulse insulation structure and a composite bushing for the isolation of the high-voltage to the air have been newly developed. The mockup transformer successfully demonstrated a stable insulation of DC -1.2 MV for 3600 s. The HV bushing serves as the terminal of the HV transmission line. It is made in five 200 kV stages and a two-stage mockup has been developed, and stable voltage holding at 480 kV for 3600 s was demonstrated. These R&D results fulfill the ITER requirement, which allows the realization of the PS and HV bushing for the ITER NBI.

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Primary author: Dr TOBARI, Hiroyuki (Japan Atomic Energy Agency)

Co-authors: Mr SHIINA, Daisuke (Japan Atomic Energy Agency); Dr BOILSON, Deirdre (ITER organization); Dr DECAMPS, Hans (ITER organization); Mr YAMANAKA, Haruhiko (Japan Atomic Energy Agency); Mr ABE, Hiroyuki (Japan Atomic Energy Agency); Dr GRACEFFA, Joseph (ITER organization); Dr WATANABE, Kazuhiro (Japan Atomic Energy Agency); Mr YAMAGUCHI, Kohei (Hitachi, ltd.); Dr SVENNSON, Lennart (ITER organization); Mr KADOWAKI, Makoto (Hitachi, ltd.); Dr KURIYAMA, Masaaki (ITER organization); Mr HANADA, Masaya (Japan Atomic Energy Agency); Mr DAIRAKU, Masayuki (Japan Atomic Energy Agency); Dr KASHIWAGI, Mieko (Japan Atomic Energy Agency); Mr UMEDA, Naotaka (Japan Atomic Energy Agency); Mr SEKI, Notikatsu (Japan Atomic Energy Agency); Dr HEMSWORTH, Ronald (ITER organization); Mr TANAKA, Shigeru

(HItachi, ltd.); Mr KONDO, Tatsuo (Japan Atomic Energy Agency); Mr MAEJIMA, Tetsuya (Japan Atomic Energy Agency); Mr TERUNUMA, Yuto (Japan Atomic Energy Agency)

Presenter: Dr TOBARI, Hiroyuki (Japan Atomic Energy Agency)

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