

**MANUFACTURING DEVELOPMENT OF THE MODULAR COIL WINDINGS
FOR THE NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX)***

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A prototype coil, known as the “twisted racetrack”, was fabricated at the Princeton Plasma Physics Laboratory (PPPL) in order to develop techniques for winding the National Compact Stellarator Experiment (NCSX) production modular coils. Planning for manufacture was performed through the development of parametric solid CAD models, which were used to build a “virtual” coil assembly. Models were developed that represent all components of the assembly, including the winding form, Kapton™ insulation, copper cladding, flexible copper conductor wrapped with fiberglass cloth insulation, ground wrap, copper chill plates, chill plate tubing, assembly clamps, lead blocks, lead terminals, sprues for epoxy impregnation, and vulcanizing tape for an outer vacuum boundary. Step-by-step instructions were generated using the three-dimensional (3D) model images as a reference, and these became more valuable than drawings during the fabrication process. One aspect of manufacture that could not be represented by the model, however, was the variability of “soft” components in the assembly. The start and end of the windings are controlled by lead blocks, made of NEMA Grade G11-CR material, which have machined grooves to precisely position the conductor. Throughout the winding pack, however, the conductor position was controlled periodically by metal clamps. The flexibility of the conductor and turn insulation led to many iterations of the clamping force in order to accurately position the winding pack. The final challenge in fabrication involved the terminal connectors, which were purposely designed to fit into the compact space required for the production coils. Implementing the CAD design proved difficult because computer models did not accurately predict the behavior the insulated conductor in tight bends. Throughout the process, many lessons were learned, components modified, assembly tools developed, and procedures established and revised, which will benefit the production coil windings.

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