THERMAL ANALYSIS AND EXPERIMENTAL VERIFICATION FOR DIII–D OHMIC HEATING COIL REPAIR*

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The DIII–D ohmic heating (OH) coil solenoid consists of two parallel windings of 48 turns each cooled by water. Each winding is made up of four parallel conductors. Desired thermal capability of the coil is 80 MJ at a repetition rate of 10 minutes. One of the conductors started leaking water in July 1995. Between July 1995 and December 1997 the coil has been operated at a reduced thermal load using one winding. An experiment followed by analysis was undertaken to determine if the OH-coil could be operated at full capacity by relying on conduction heat transfer to the neighboring cooled conductors without actively cooling the leaking segment. The analysis took into consideration the transient energy equations, including the effect of conduction between neighboring conductors. The axial conduction was modeled in the conductor, but was ignored in the coolant. An experiment was performed on the undamaged coil winding to determine the thermal conductance between neighboring conductors. The experiment consisted of passing hot water through adjacent cooling channels of two conductors and cold water through the cooling channels of the remaining two conductors of the same winding. The flow rate, inlet and outlet temperatures from each circuit were measured during the transient. From the experimental data and analysis, an average thermal conductance between the conductors was determined to be about 0.1 W/cm^2-C. Using the experimentally determined value of the thermal conductance, analysis was performed on a coil winding consisting of one uncooled conductor and three cooled conductors. Results show that it is possible to operate the full OH-coil to the desired thermal load of 80 MJ per pulse without cooling the damaged conductor. The coil was instrumented to measure the outlet water temperature from the conductors before operating it at full current capacity. First, the coil was operated at reduced current level and outlet coolant temperatures were compared with analytical results. When this showed good agreement, the coil was operated at full current capacity. The comparison between analysis and measured coolant outlet temperatures was within 10 %. This gives us sufficient confidence to operate the OH-coil at full capability in the future. It should also be noted that the coil can be operated at a capacity of 180 MJ if adequate time is allowed between cycles (~30 minutes) for the coil to cool completely. Forces (I×B) within the repaired conductor limit allowable current. For short pulses (<5 s) this limits the thermal input to slightly less than 180 MJ.

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