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THREE MILE ISLAND NUCLEAR STATION - DOCKET No. 50-289

Supplemental Testimony on Fuel Densification

By

Richard Lobel

Contention 1

The facility should not be operated at levels that would cause unsafe conditions as a result of fuel densification. Adequate protection against the effects of fuel densification must be provided before the plant becomes operable. The applicant should have adequate monitoring facilities to investigate and detect any effects of fuel densification and fuel densification itself.

The staff agrees that no facility should be operated at power levels that would cause unsafe conditions as a result of fuel densification. Adequate protection is provided by conservative design, construction, and operation practices. This protection is provided so far as densification is concerned, by assuming that densification takes place immediately and by restricting the power level of the plant so that no safety limit or limiting condition of operation can be exceeded.

The staff, making use of all available information on densification, describes in reference 1 the steps to be taken in order to assure that the effects of densification are conservatively considered in the operation of TMI-1. From the analyses supplied by the applicant, technical specifications will be written in such a way that the reactor can be operated safely at

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the rated power level of 2535 MWt (100% power) with fuel densified to a conservative value.

Fuel densification can effect the reactor in four ways:

1. Densification can decrease the length of the fuel column. Some fuel pellets may hang up on the cladding and not settle with the stack. This has the effect of forming axial gaps. These gaps increase the neutron flux which causes an increase in the power output of nearby fuel rods. This effect is accounted for by calculating a probability of gap occurrence and gap size throughout the core and using this distribution as the basis for increasing the heat generation rate in a length of fuel rod used, to confirm that the fuel will not melt and that the proper heat transfer to the coolant is maintained.
2. The gap between the fuel pellet and the cladding will increase as the fuel densifies; this increases the resistance to the flow of heat from the fuel pellet to the cladding (called gap conductance). The applicant is required to use this larger gap size in thermal performance calculations. The lowered gap thermal conductance increases the thermal energy stored in the fuel. In order to calculate the size of this larger gap, the applicant was required by the staff to assume that the final density of his fuel is 96.5% of the theoretical density, and went to that value at beginning of life. Staff analysis of existing data shows that this final density is an upper bound to final densities measured after irradiation.

In addition to these assumptions, the dimensions of the fuel rod selected for calculation of gap conductance are chosen conservatively. This also has the effect of enlarging the size of the fuel pellet - cladding gap. These assumptions and selection of conservative input values assure that the heat stored in the pellet will be calculated in such a way as to obtain a reasonable upper bound.

3. The assumed densification of the fuel decreases the length of the fuel column in a fuel rod which increases the amount of heat flowing through a unit area of cladding in a given time. This higher heat flow can cause the fuel rod to operate slightly closer to the limit at which the amount of heat which can be removed from the fuel rod decreases. This limit is known as the DNB, Departure from Nucleate Boiling (heat transfer rate). This effect is accounted for by changing the maximum operating power of the rod so that the limit is not reached.

4. Due to the presence of axial gaps in the fuel rod, it is possible, due to the large external pressure on the cladding from the coolant and neutron irradiation that the cladding could slowly creep to the point of collapse. The staff has developed a computer program which conservatively predicts the time to collapse. This computer program BUCKLE was used to calculate the time to collapse for cladding similar to that used in TMI-1. Based on the results of this calculation and data available to the staff from other pressurized water reactor vendors on cladding similar to that used in TMI-1, the staff has concluded

that collapse will not occur during the first fuel cycle, i.e., between initial startup and the first fuel reload. In addition, the staff has no knowledge of the collapse of cladding in which an internal gas pressure on the order of TMI-1 is maintained.

In summary, the technical specifications will be established so that the reactor can operate at rated power with the assumption that fuel has immediately densified. Because these assumptions are included in the technical specifications, the operator has no day by day concern as to whether and to what extent densification has taken place. He does have at his disposal adequate instrumentation to monitor the power, coolant temperature and pressure and control rod positions from which he should detect abnormal or unsafe behavior in the TMI-1 reactor.

Reference 1: Supplement No. 1 to the Safety Evaluation by the Directorate of Licensing, U.S. Atomic Energy Commission in the Matter of Metropolitan Edison Company, Jersey Central Power and Light Company, Pennsylvania Electric Company, Three Mile Island Nuclear Station Unit 1, Dauphin County, Pennsylvania, Docket No. 50-289.