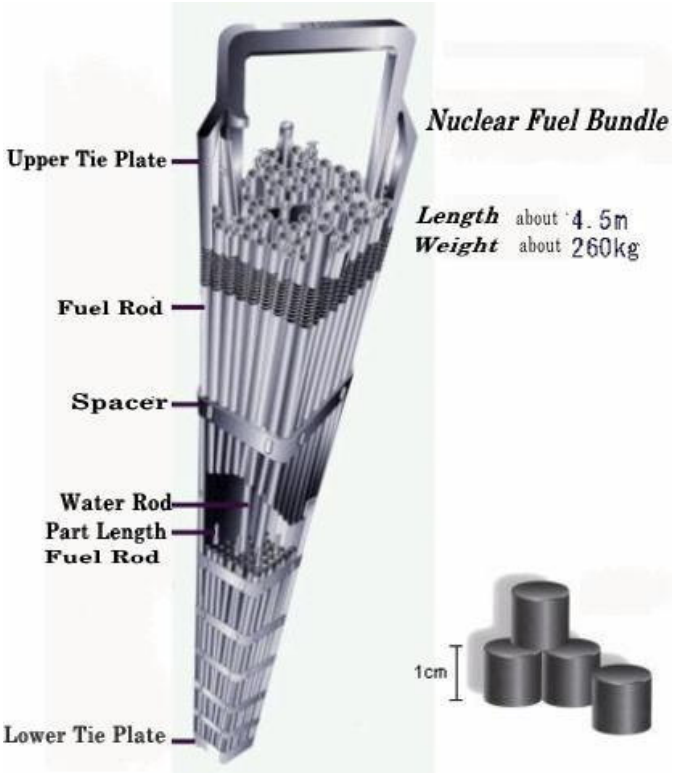
Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions
issue brief

GENERAL ELECTRIC FUEL DEFECT

Nuclear Regulatory Commission (NRC) Daily Event Report No. 41794 dated June 24, 2005, provided preliminary information about a report submitted by General Electric (GE) to the NRC per 10 CFR Part 21 about a fuel defect. GE discovered the defect during an internal review of testing performed for the GE14 fuel bundles. Further inquiry revealed the problem also affected the GE12 fuel bundles equipped with Zircaloy spacers. The nuclear plants with the defective fuel bundles are Browns Ferry Units 2&3, Brunswick Units 1&2, Clinton, Cooper, Duane Arnold, Fermi Unit 2, Hope Creek, Monticello, Nine Mile Point Unit 2, Peach Bottom Units 2&3, Perry, and Quad Cities Unit 2.

A nuclear fuel bundle consists of uranium dioxide (UO_2) fuel pellets stacked inside long, cylindrical fuel rods. The fuel rods are held in place by tie plates at either end and by several spacers along their length. A metal handle connected to the upper tie plate allows workers to remotely grip and move the fuel bundle into and out of the reactor core.



GE found deformed springs in the Zircaloy spacers used in GE14 and GE12 fuel bundles. It is possible that the springs were deformed during tests of the fuel bundles under simulated accident conditions. As a result of the deformed springs, the location of fuels rods – particularly the key corner fuel rods – might not be where they were assumed to be during safety analyses. GE reported the situation to the NRC because there is a potential for the fuel defect to reduce or even eliminate safety margin should an accident occur.

Boiling water reactors (BWRs) have three thermal limits during reactor operation to protect their nuclear fuel from damage: (a) Linear Heat Generation Rate (LHGR), (b) Average Planar Linear Heat Generation Rate (APLHGR), and (c) Critical Power Ratio (CPR). The chart on the next page outlines the thermal limits and the fuel damage they are intended to prevent.

The fuel defect reported by GE applies only to the CPR thermal limit. The CPR thermal limit is intended to prevent fuel damage caused by insufficient cooling that can occur when nucleate boiling stops. The heat produced from atoms splitting is conducted through the fuel pellets and through the fuel rod cladding where it causes steam bubbles to form in the water wetting the cladding. This is called nucleate boiling. If the fuel bundle power gets too high, the fuel rod cladding gets too hot for water to wet it. Instead, a thin layer of steam surrounds the fuel rod cladding. This is called film boiling. The steam "coat" impedes the transfer of heat out of the fuel rod. With less heat leaving the fuel rod, the fuel pellet temperature rises to the point where damage can occur. The safety studies performed by GE assumed a certain geometry of fuel rods within fuel bundles to calculate the power output and the rate heat from that power gets

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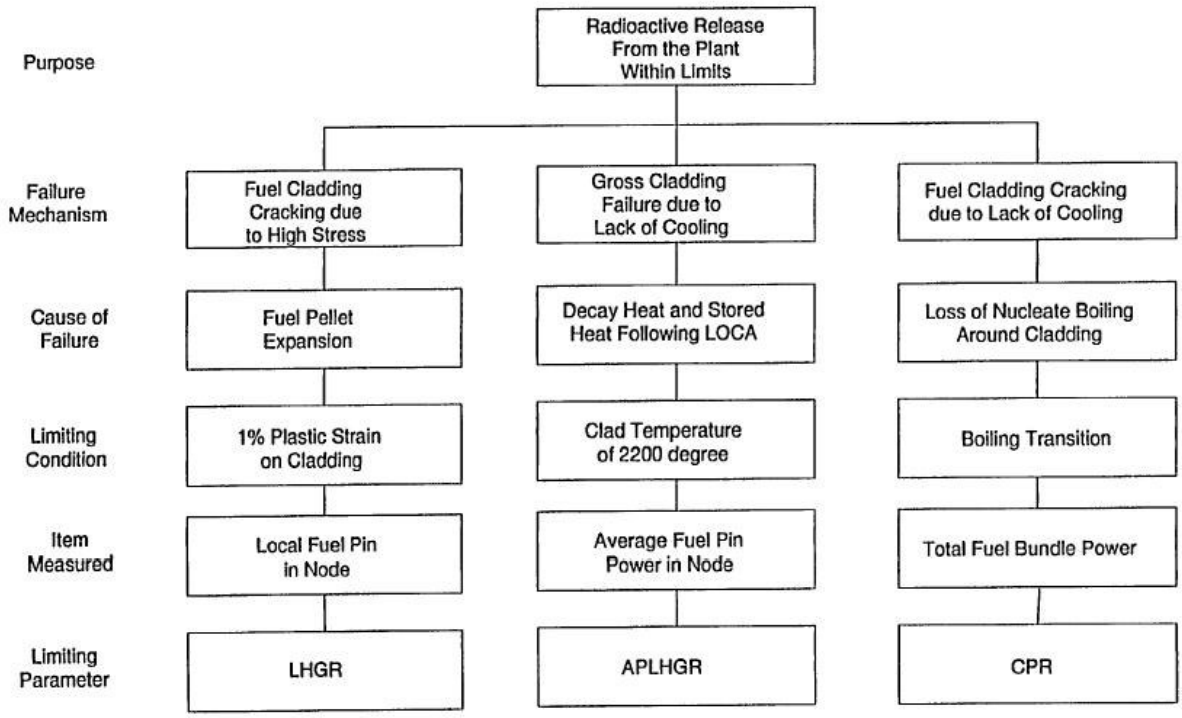
transferred to the water. The fuel defect meant that the power output could be higher than analyzed and the associated safety margin less than previously thought.

The nuclear reactors with the defective GE14 and GE12 fuel are unlikely to experience any immediate problem. The CPR thermal limit does provide protection during routine operation, but the least margin to the CPR thermal limits occurs during transients and accidents. As implied by the prior discussion, the CPR thermal limit depends on the power output of a fuel bundle and the flow rate of water passed it. The safety studies postulate various events that can increase fuel bundle output and/or decrease water flow rate to verify that nucleate boiling is not interrupted long enough to cause fuel damage.

GE's Part 21 report indicates the Rod Withdrawal Error (RWE) event is one of the analyses affected by the fuel defect. The RWE analysis assumes the operator inadvertently withdraws the control rod that exposes the highest power fuel bundle to even greater power levels. The water flow rate stays constant, but the fuel bundle power significantly to challenge the CPR thermal limit. During the design of the reactor core for an upcoming operating cycle (i.e., figuring out which fuel bundle goes where inside the reactor core), the RWE analysis prevents too many fresh fuel bundles from being placed side by side.

The GE report indicates that additional plant-specific analyses will be completed by September 20, 2005, to determine if CPR thermal limit penalties need to be imposed. If so, the penalties will essentially reduce the maximum power output of fuel bundles during routine operation to compensate for the potentially higher power output of the fuel bundles (caused by the fuel rods not being where they should be) during transients and accidents. If applied, the penalties will restore the safety margin that should have been there all along.



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