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BWR FUEL FAILURE EXPERIENCE

An analysis of the recent General Electric (GE) fuel failure experience in Dresden 3 by RO indicated a strong dependence on local power.¹ During a fuel QA inspection at Commonwealth Edison by L. Tripp and D. Pomeroy on September 27-29, 1973, additional information on these fuel failures was obtained which indicates that operating BWRs may have a generic fuel performance problem. This additional information is discussed below.

Originally, Dresden 3 was scheduled for a shutdown for a poison curtain removal at a burnup of ~7,500-8,500 MWD/MTU (fall of 1973) with the first refueling scheduled at a burnup of 12,700 MWD/MTU (fall of 1974). As a result of fuel failures and offgas limitations, Dresden 3 was refueled in the spring of 1973 at a core burnup of ~6000 MWD/MTU. Prior to this refueling, the reactor was derated to stay within the technical specification limit on stack release rates.² At the spring refueling, all of the assemblies were sipped outside the core with 103 of the 724 assemblies identified as leakers. Approximately one-half of the leaking assemblies were replaced with new fuel and the remaining assemblies were reconstituted.

Commonwealth Edison with GE has identified many of the observed Dresden 3 fuel failures as power related. That is, these failures appear to be caused by local fuel-clad interaction due to control rod movement and resultant changes in local fuel rod linear heat rating (kw/ft). The axial location of failure has been correlated with the axial location where movement of the control rod results in the largest step increase in linear power rating. Calculations have shown that control rod motion of as little as one step (six inches) could increase the local linear heat ratings by as much as 30 to 40%.

According to Commonwealth Edison representatives, General Electric was "shocked" by the failures observed in Dresden 3. They indicated that GE was "backing away" from their previous arguments that such failures were largely due to cladding ductility variability resulting in a small, but statistically significant, number of fuel rods in which local strains exceeded the failure capability of the irradiated cladding.

¹September 12, 1973 memorandum, Tripp to Reinmuth.

²Based on the 105,000 μ Ci/sec 48 hour (avg) limit.

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Commonwealth Edison also suggested that fuel failures of this type may have occurred in other BWRs such as Nine Mile Point and Oyster Creek which also had a substantial number of failures. In fact, they suggested that such failures may have been occurring for some time in many BWRs but were obscured by moisture related failures (internal hydriding). As a result of the observation of failures at Dresden 3 (and perhaps other plants), GE has made dramatic increases in the projected number of fuel failures and offgas release rates in Commonwealth Edison BWRs. In addition, GE appears to have modified Wilmington fabrication schedules to fabricate as many 8x8 fuel assemblies as quickly as possible for use as reload fuel. Finally, GE is recommending to utilities that their BWRs be base loaded and/or to make all power changes slowly including extensive utilization of flow control. In addition, GE is recommending a "pre-conditioning" period in which the power is increased at 1/2% per hour and all nodes are brought to as high a power level as they would see in subsequent operation. After "pre-conditioning", the reactor power could then be changed at the desired rate. Despite these recommendations Commonwealth has still found it necessary to control the rate of power change to avoid increased offgas release rates. The "pre-conditioning" periods have to be repeated every 2 to 3 months. General Electric is said to be developing analysis methods to predict future failure locations as well as incipient failures. This model does not yet appear ready for application. Commonwealth Edison representatives said that GE needs one more refueling outage at Dresden 3 to obtain additional data with which to normalize this model.

As a result of increased fuel failures resulting from the above mechanism, Commonwealth Edison has revised the refueling schedules for their operating BWRs. This is the result of the assumption that offgas release rates will be much higher, that additional and earlier shutdowns will be needed to replace failed fuel, and that more failed fuel will have to be replaced than originally planned. Despite revised refueling plans, possible deratings are expected to prevent stack release rates from exceeding technical specifications limits. Specific revised refueling plans by plant are listed below:

Dresden 1 - The Dresden 1 core consists of two reload batches of GE and three reload batches of GUNFC supplied fuel. At the present time, Dresden 1 is running at low power (~30%) with an extremely high offgas release rate considering the power level (~40,000 μ Ci/sec). A planned refueling outage is to start on October 7, 1973. At that time, they plan to do out-of-core sipping (this will be the first out-of-core sipping performed at Dresden 1). At this refueling, Commonwealth expects to find 60-70 failed assemblies out of 464 total. Only 50 new fuel assemblies have been ordered. GUNFC will be doing the sipping

(with new equipment) and wants to do a reconstitution, if necessary. Commonwealth has reserved the right to make the decision on the acceptability of reconstituted fuel assemblies until after the reconstitution is made.

Dresden 2 - The next refueling of Dresden 2 is presently scheduled for the fall of 1974. At that time, the maximum projected offgas at full power is $\sim 200,000^* \mu\text{Ci}/\text{sec}$. This refueling is to be with 124-136 new 8x8 assemblies.

Dresden 3 - Dresden 3 is currently close to activity limits as the result of failed fuel. The next refueling shutdown is planned for January 15, 1974. At that time, Commonwealth will have forty-four 8x8 assemblies and sixty 7x7 assemblies available.

Quad Cities 1 - Quad Cities 1 has been limited in power level by activity levels due to failed fuel since August 1, 1973. The first refueling outage is scheduled for March 15, 1974 with $\sim 88-92$ new 8x8 assemblies. At that time, the maximum projected offgas at full power is $\sim 250,000^* \mu\text{Ci}/\text{sec}$. Commonwealth is planning to operate Quad Cities in a derated mode until this refueling.

Quad Cities 2 - General Electric has always focused on Quad Cities 2 as the first GE reactor in which hydriding type fuel failures were expected to be minimal. Now, primarily as a result of fuel failures by the interaction mechanism, GE is also expecting significant fuel failures in Quad Cities 2. (In fact, the offgas increased by approximately a factor of three on September 22, 1973). The first refueling outage for Quad Cities 2 is presently scheduled for the fall of 1974. At that time, the maximum projected offgas at full power is $\sim 120,000^* \mu\text{Ci}/\text{sec}$. Quad Cities 2 is to be refueled with 72-104 new 8x8 assemblies.

At the conclusion of our inspection, Pomeroy briefly explored with Commonwealth Edison representatives the desirability of reporting Dresden 3 fuel failure experience and the results of their subsequent analyses. He pointed out that, if this was considered as an unusual occurrence or as a significant deviation from expected performance, Dresden 3 technical specifications would require

*We believe that these projected numbers are the sum of the six principal nuclides adjusted for a nominal 30 minute decay in accordance with GE practice.

reporting. Whether or not Commonwealth considered this experience as a reportable item, they were encouraged to issue a report on the Dresden 3 experience because of its significance to the industry.

Recommendations

In summary, this recent GE fuel failure experience has shown the power related interaction type fuel failures are more numerous and significant than previously suspected. It is recommended that:

1. RO Region III obtain a commitment from Commonwealth Edison to report on Dresden 3 results including the impact of these results on projected fuel failure experience, offgas releases, refueling, and mode of operation of Dresden 1, 2 and 3 and Quad Cities 1 and 2. [In preliminary discussions (Silver-Pomeroy-Oct. 1), DL agrees that a report should be submitted and recommends that RO pursue this with the licensee.]
2. Tripp and Pomeroy meet with General Electric at the earliest possible date to pursue the generic implications of the Dresden 3 (and other recent) GE fuel failure experience. GE should be asked to review BWR operating experience pertaining to the interaction failure mechanism as well as applicable test experience and post-irradiation examinations. Analytical models under development by GE should be reviewed as well as proposed operational modes to preclude and/or minimize fuel failures of this type.
3. The current reconstitution at Vermont Yankee (scheduled to have started September 28), Dresden 1 and 3 refuelings scheduled within the next few months, and other pertinent refuelings and failure experience in BWRs be closely monitored and analyzed by RO personnel to assess the magnitude of this apparent generic GE fuel performance problem.

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