72-17

Oregon

DEPARTMENT OF ENERGY

April 29, 1998

D.G. Reed
Spent Fuel Project Office, NMSS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: OOE's Review of PGE's Basis for Spent Fuel Cladding Temperature Limits

Dear Mr. Reed,

In its most recent revision of the Trojan ISFSI SAR, Portland General Electric (PGE) determined that administrative time limits for the ISFSI vacuum drying were not needed. Their calculations indicate that maximum fuel cladding temperature in a transfer cask under vacuum conditions will not reach the short-term temperature limit of 1058 °F. This limit is based on guidance in NUREG-1536, which in turn is based upon fuel rod testing data reported in Pacific Northwest Laboratory's PNL-4835 report. OOE has reviewed these and other supporting documents. In addition, on Thursday, April 16, 1998, we attended a meeting with representatives of both PNL and PGE to discuss these issues. As a result of this meeting and our document reviews, we have identified concerns that may require NRC resolution. These involve the basis for the short-term fuel cladding temperature limit of 570 °C (1058 °F) and the application of NUREG-1536. We have also listed additional, related issues of interest that PGE is currently reviewing. The attached paper summarizes these concerns.

We would appreciate discussing these concerns with you and other members of your staff, as may be appropriate, prior to making our recommendations to the Energy Facility Siting Council. Please feel free to contact me at (503) 556-0005 or our technical consultant, Jim Woessner, regarding these issues.

Sincerely,

Adam Bless

Adam Bless
Oregon Office of Energy

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Attachment: OOE Review of PGE Basis for Spent Fuel Caldding Temperature Limits

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Governor

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OOE Review of PGE Basis for Spent Fuel Cladding Temperature Limits

Background

In its most recent revision of the Trojan ISFSI SAR, PGE determined that administrative time limits for the ISFSI vacuum drying were not needed. Their calculations indicate that maximum fuel cladding temperature in a transfer cask under vacuum conditions will not reach the short-term temperature limit of 1058 °F. This limit is based on guidance in NUREG-1536, Section 4.V.1, which states:

"For short term-accident conditions, the staff accepts zircalloy fuel cladding temperature generally maintained below 570 °C (1058 °F). The short-term accident temperature of 570 °C for zircalloy-clad fuel is currently accepted as a suitable criterion for fuel transfer operations. However, this temperature limit may be lowered for fuel with hoop stresses exceeding the rods that were high temperature tested (e.g. greater than 28,000 MWD/MTU), as a result of increased internal rod pressure form fission gas buildup release into the gap and/or different helium loadings. The applicant should verify that these cladding temperature limits are appropriate for all fuel types proposed for storage, and that the fuel cladding temperatures will remain below the limit for facility operations (e.g. fuel transfer) and the worst case credible accident."

Although it is not specifically stated, we assume that the NUREG-1536 guidance for a short-term fuel cladding temperature limit is based upon data reported in Pacific Northwest Laboratory's PNL-4835 report. OOE has reviewed these and other supporting documents, including PNL-6189 and PNL-6364. In addition, on Thursday, April 16, 1998, OOE representatives attended a meeting with representatives from both PNL and PGE to discuss these issues. As a result of this meeting and our document reviews, we have identified concerns that may require NRC resolution.

Our key issues involve the basis for the short-term fuel cladding temperature limit of 570 °C (1058 °F) and the long term temperature limits for older fuel. OOE understands that the projected maximum fuel temperature for Trojan fuel under vacuum drying conditions is 881°F, well below 1058°F. We understand that this tempearture in turn is based on a 26 kW cask, while the actual hottest cask will have a heat source of about 18 kW. However, we want to discuss these issue in order to clarify the intent of the NUREG.

Summary of Issues

1. Hoop stresses exceeding the rods that were tested at 570 °C (1058 °F)

In describing the 1058 °F short-term temperature limit, NUREG-1536, Section 4.V.1, states that "this temperature limit may be lowered for fuel with hoop stresses exceeding the rods that were high temperature tested...." PGE has inferred from the description of characteristics of rods tested accompanying Table 5, pages 20, 22, and 23, that the maximum hoop stress for these rods with 28,000

MWD/MTU burnup was 140 MPa. Based on plant specific fuel information from Westinghouse, PGE demonstrated by analysis that their worst case rods had stresses below 140 MPa, and, therefore, concluded that they could use the short-term temperature limit of 570 °C (1058 °F) for cask drying operations.

PNL-4835 states, however, only that the maximum rod hoop stress for all the rods tested was "to 140 MPa." It does not state specifically that this maximum hoop stress applied to the 6 rods that were tested at 570 °C (1058 °F). We asked PNL what hoop stresses applied to the rods tested at 570 °C (1058 °F). They answered with actual test data, as reported in an April 1982 article in Nuclear Technology by Robert Einziger, et al., entitled, High Temperature Postirradiation Materials Performance of Spent Pressurized Water Reactor Fuel Rods Under Dry Storage Conditions. This article reported that the initial stress at the test temperature varied between 25.2 and 75.7 MPa.

We concluded, therefore, that the peak rods at Trojan, which have a calculated stress in excess of 100 MPa, would be subject to a lower short-term temperature limit, as prescribed in NUREG-1536. Our question is, what is the NRC's opinion regarding the hoop stresses on the rods that were high temperature tested? Does the NRC consider a short-term limit of 1058 °F appropriate for fuel rods with hoop stresses greater than 100 MPa and burnup greater than 28,000 MWD/MTU?

2. Methodology for determining short term limit

Assuming that a short term temperature limit less than 1058 °F applies to Trojan fuel, we are not aware of any methodology described in the NUREG, or other regulatory guidance, for determining the value of a lower temperature limit. We note that the NUREG refers to LLNL report UCID-21181. However, we reviewed UCID-21181 and believe that the report addresses long term effects, not the short periods of time required for vacuum drying. We request that the NRC examine this issue and determine if an approved methodology for determining a lower short-term temperature limit is available or recommended.

A further concern is the fact that "short-term" is not defined. Vacuum drying operations at ANO and Palisades have taken more than 30 hours. However, all references to vacuum drying in the PNL documents referenced in the NUREG describe vacuum drying as taking about 2-5 hours. Since vacuum drying is the time when short-term temperature limits might apply, we would ask the NRC to clarify the definition of "short-term".

3. Hydride reorientation in zircaloy cladding

At the April 16 meeting, we reviewed the various mechanisms for clad degradation described in PNL-6364. Because of the relatively high internal rod stress (>100 MPa) calculated for the peak Trojan rods, PNL representatives stated that hydride reorientation was a potential concern. This mechanism occurs with the reorientation of hydrides in the zircaloy cladding from circumferential to radial, which reduces zircaloy's resistance to brittle fracture.

This mechanism had not previously been considered significant because PNL concluded that fuel rods stresses were unlikely to reach the level at which hydride reorientation becomes a significant failure mechanism. However, using the methods described in Section 4.0 of PNL-6189 for fuel at Trojan, we calculated a hoop stress greater than 100 MPa, which is above the threshold for hydride reorientation to occur. PGE has confirmed these hoop stresses for Trojan fuel.

PNL also stated that this failure mechanism is highly dependent on oxide levels. PGE states that the oxide levels on the Trojan fuel are low, which should reduce or eliminate hydride reorientation as a concern. However, the evidence for the measured amount of zircaloy oxide comes from a 1983 Sandia study of Trojan fuel. PGE representatives said that primary coolant chemistry improved after that study and that oxide levels should be even lower. PGE representatives stated that they willinvestigate this issue to provide better assurance of oxide levels and to evaluate the potential for hydride reorientation. We ask if NRC has considered hydride reorientation as a significant fuel degradation mechanism for fuel with high internal stress, and if not, why not?

4. Long-term temperature limits for older fuel

PGE determined the long-term temperature limit (705 °F) for what is currently considered the most limiting Trojan fuel based on hoop stress, but they have not addressed the issue of temperature limits for older fuel in accordance with PNL-6189 and the Commercial Spent Fuel Management (CSFM) curves, Figure 3.9 of PNL-6189.

Several Trojan casks are currently designed to mix older and younger fuel. One cask mixes 20 year old fuel with 6 year old fuel. We performed a calculation on a sample fuel assembly in this cask, and determined a temperature limit on the CSFM curve 15 year curve as 640.4 °F. Since the CSFM curves don't address fuel older than 15 years, we could not determine the appropriate limit, which raised the question of how to evaluate the impact of older fuel on the long-term temperature limit with the CSFM model. At the meeting on April 16, PNL representatives stated that they would create an additional curve to cover this situation.

PNL representatives presented two approaches to resolving this issue. One was the conservative method described in PNL-6189, which simply says that the most restrictive assembly in terms of the CSFM curve parameters (e.g. the older assembly) sets the initial temperature limit. The other method is to perform an analysis for each basket based on the expected temperature at the location of each assembly. PGE is investigating the different approaches to resolving this issue.

We understand that, in general, the long term temperature limits described by the CSFM curves will decrease for older fuel. We also understand that this may not be a problem because the actual temperature of older fuel will also decrease due to the smaller heat source. We believe it is plausible that the actual temperature will decrease faster than the CSFM temperature limit, so that the limiting fuel assembly will be the one with the shortest cooling time. However, we have seen no calculation to verify this. Has the NRC has seen such a calculation, or is such a calculation needed? If none is needed, why not?

5. PNL Testing versus the TranStor™ System

PNL-6189, Section 3.2.3, states that "The CSFM generic limit curves for 5-, 10- and 15-yr-old fuel are based on the temperature decay histories of the respective CSFM model casks, as described in Section 3.1.2. These casks represent maximally-loaded, helium-backfilled metal casks containing PWR fuel." PNL-6364, p. 4.6, adds that "Dry storage casks impose their own heat transfer characteristics on the natural cooling rate of the fuel. Due to the declining temperature history used in the CSFM IDS model, the generic temperature limit curves are conservative for a variety of dry storage cask designs...." We asked PNL if there had been a determination as to the applicability of the PNL tests and the CSFM model studies to the TranStor™ system, since both SNC's VSC and TranStor™ systems were developed after the PNL reports. They were unaware of any such determination.

We have seen no calculations or other determinations that the temperature history characteristics of fuel stored in SNC VSC casks are consistent with the temperature history used in developing the curves in PNL 6189. Is the NRC aware of any? Is such a determination needed?