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November 13, 1979

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Richard P. Denise, Acting Assistant Director for Reactor Safety

Reference: Letter, R. P. Denise to Dr. G. G. Sherwood, on PCI Program Status, dated August 2, 1979

Gentlemen:

In the referenced letter General Electric was made aware of the NRC's most recent plans in the area of pellet/cladding interaction. GE has reviewed the copy of the PROFIT model provided by the NRC at the Portland meeting in May of this year. The details of our review of the PROFIT model are contained in Attachment 1 to this letter. A summary of our comments is as follows:

1. The principal impact of a PCI failure is basically an economic loss to the licensee rather than a potentially significant safety issue. The inherent BWR design provides defense against an adverse impact upon the public health and safety for a PCI failure. The need on the part of the licensee to reduce power upon determination of high off-gas is the major impact of PCI failures.

2. The data base apparently used to develop PROFIT is not representative of current GE product line design. Prior to considering the use of PROFIT for PCI review in the licensing arena, (i.e., in the SRPs) the PROFIT data base must be significantly upgraded. Examples of a deficient data base are provided in the attached material.

3. Prior to considering a formal PCI licensing review, the NRC needs to complete its review of the GE topical report NEDO-23785 (GESTR - A Model for the Predictions of GE BWR Fuel Rod Thermal-Mechanical Performance). This document contains a description of the most recent efforts on the part of GE to improve fuel rod resistance to PCI via mechanical design.

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4. The PROFIT model appears to lack parameters which have been proven to be major contributors to PCI events. Examples are "time at elevated power," "rate of power increase," "power overshoot," etc.

In summary, General Electric is concerned that efforts regarding premature implementation of an unproven empirical PCI model that is unable to predict observed current product line reactor fuel performance data into the licensing process will detract from ongoing review and approval of GE's rod behavior code (GESTR). Furthermore, review of admittedly sparse information on the PROFIT model and its data base has raised numerous questions and concerns which require resolution prior to considering PROFIT implementation or development of an alternate to PROFIT as suggested in Reference 1.

Questions on our comments should be directed to Noel Shirley of my Staff on (408) 925-1192.

Sincerely,

Glenn Sherwood

Glenn G. Sherwood, Manager
Safety and Licensing Operation

GGS:cas:at/92H

Attachment

cc: L. S. Gifford

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ATTACHMENT 1

GE REVIEW OF THE NRC PROFIT MODEL

In Reference 1, General Electric was advised of USNRC accomplishments and future plans with regard to the pellet-cladding interaction (PCI) phenomena. It is the purpose of this letter to provide General Electric comments and discussion relative to the PCI efforts and to Reference 1 in particular.

It was indicated in Reference 1 that the PROFIT model will soon be ready to provide conservative estimates for licensing-type PCI analyses. Based on the information currently available documenting the PROFIT model, its calibration and qualification[2], this targeted implementation appears to be unjustified and premature.

General Electric has addressed the PCI phenomena through an aggressive program including research and testing to understand the mechanisms involved, and a disciplined program of design changes and plant operating recommendations to ameliorate the effects of PCI. A major conclusion resulting from GE's work is that, while PCI-induced fuel failures represent a commercially undesirable fuel reliability problem, PCI is not considered a safety concern. This perspective of PCI is supported by the inherent BWR design which provides capability to operate with fuel cladding perforations. Furthermore, all field experience to date for steady state operation and abnormal operational transients confirms that BWRs do indeed operate within radiological release limits.

As the NRC Staff is aware, one of the facets of GE's concerns regarding PCI has led to the development of a more sophisticated fuel rod behavior model, GESTR[3]. GESTR provides improved capability of predicting cladding local strain which GE believes is an important ingredient in addressing the effects of differential thermal expansion which is a recognized driving force for PCI. It is recognized that GESTR does not address all the elements of the PCI phenomena which is an ongoing developing technology. However, it is GE's belief that GESTR represents a requisite first step which will be built upon as more data become available to ultimately model all the aspects of PCI. Consequently it is considered reasonable and logical that GESTR receive expeditious review. It is GE's concern that the Staff efforts on an empirically-based correlation is diverting review and approval of a qualified model which is both a building block to future model improvements and is ready for immediate implementation as a vastly improved design tool.

As a result of the GE review of PROFIT[2], a number of concerns regarding the proposed NRC action concerning near-term introductions have been identified and are presented in the following paragraphs.

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It is not clear from the information provided that all the failures noted in the data base were definitely attributable to PCI. In the May 3, 1979 meeting in Portland, Oregon, additional detail of some of the data was presented. It was indicated at that time that some of the data were the result of sipping examinations with no characterization of the failure mechanism. This could bias the resulting correlation by placing undue emphasis on non-PCI failures and is hence unacceptable for the generation of a PCI transient failure probability model. Clear definition of PCI failure data should be made and the PROFIT preliminary analytical functions should be rederived based only on verified PCI failure data.

It is also evident from Table 1.1 that the data are primarily based on older fuel designs (at least in GE's case). All GE field experience has shown that the older 7x7 fuel design does not behave as well as the improved 7x7 or 8x8 designs even with the application of operating recommendations due to the distribution of original hydride content/damage. Therefore, basing the PROFIT model on that data and applying the model to current GE product line fuel is not appropriate. The data base should include applicable data or some means should be devised so that current more PCI-resistant fuel designs are not unduly penalized. This weakness is briefly acknowledged in the section on the general characteristics of the data sets[2]. It is noted that the failure fraction of data sets 1-4 appears to be generally greater than reported by the industry. This is particularly true relative to the most recent GE fuel experience, in which failure data from all known mechanisms being as much as orders of magnitude below the fractions quoted for the data sets. In this regard, it was also clear that successful operation of the same fuel design (other than that in the individual data sets) was not factored into analytical functions. Since it is desirable to define a probability of a failure, it would be appropriate to consider successful fuel operation under similar operating circumstances. Consequently, any additional data which support the successful operation of the fuel design of data sets 1-4 under similar operational circumstances (power, power increases, exposure, hold time, etc.) should be added to the data base and the preliminary analytical functions should be rederived.

It was pointed out in Reference 2 that of the four data sets employed in the PROFIT generation, some of the data are considered to be the result of atypical power plant operation. It is not clear what is meant by this statement, however, if any of the data resulted from conditions significantly outside the realm of those expected for abnormal operational occurrences (i.e., excessively long hold times, overpowers well above automatic shutdown limits, etc.), that information should receive only secondary consideration. If the author's statement meant that data were taken from abnormal occurrences (which represent atypical operation relative to steady-state) that data should, of course, be employed. In any event, this area should be clarified in future reports on the model.

The Reference 2 report recognizes a number of operating parameters which may be required to fully define the PCI fuel failure phenomenon and which, almost unanimously, are not provided directly with the data sets. These parameters include: impact of nonequilibrium Xe-135 affecting power overshoot, a time to fail parameter, rate of power increase, and post transient power. As NRC personnel are aware, General Electric has recognized the complexity of the PCI mechanism and has documented in past correspondence to the NRC that the mechanism appears to be made up of thermo-mechanical as well as thermo-chemical components[4-9]. Based on experimental data and field experience, GE and others have concluded that important parameters in determining fuel rod failure susceptibility and the relative importance of mechanical localized strains and environmental effects on fuel clad performance are strongly dependent on magnitude of power increase, rate of power increase, power after the increase, and hold time at increased power level and exposure. Thus, any data set not containing all these paramters is deficient. GE considers the influence of hold time of particular importance in addressing overpower transients and the PCI mechanism. This position has been documented elsewhere[7-9] and is reiterated herein. This fact has also been recognized in other government sponsored (Naval Reactor) programs almost over 2 decades. Data from GE operating BWRs have yielded no evidence that full core short duration abnormal operational transients (AOTs) result in PCI fuel failure[9]. It is believed that the reason AOTs have not and are not expected to result in any significant number of PCI failures can be traced to a hold time requirement. Available data from experimental and commercial reactors indicate that fuel failures due to PCI are likely to occur after a rapid power increase only if the fuel remains at the higher power for a relatively long period of time. Most of the defined BWR AOTs, however, are of a very short duration (seconds) and therefore do not fulfill the hold time condition which is associated with PCI induced fuel failures. Data on the hold time requirements, including proprietary results of General Electric testing were previously documented in References 4-9. More recent test reactor data[10] continue to support the GE hold time data base. It is suggested in a recent NRC Staff response to the GE position on ATWS-induced PCI failure[11], that consideration of hold time lacks conclusive support despite all the evidence by GE, AECL and other U.S. Government sponsored (Naval Reactor) programs indicating that hold time is a primary variable. All the data previously cited indicates it plays a vital role and should be a primary variable in the failure probability relationships. Such a variable is, in fact, incorporated into the GE issued PCI-OGRAMS. It should be noted that perhaps the lack of a definite hold time input in the PROFIT failure probability relationships explains the model's current inability to predict BWR field data. Comparing the GE reactor data described in Reference 4 with the probability of failure relationships indicates a significant inability to predict real results with the PROFIT model. PROFIT would indicate a significant quantity of failed fuel for the operating transients identified in Reference 4 (73 transient events at 6 reactors covering 17 reactor years of operation), when in actuality there was no indication of significant failure. In only one case, a rod withdrawal error, was there any evidence of fuel failure, and that was a highly local event where only four fuel bundles experienced rod failures following the error.

Although the operating reactor data used in PROFIT did not include all of the parameters thought to influence PCI, there are various test reactor data in the literature (such as the Studsvik ramp data[10]) which could be included directly or considered in some manner to better define such analytical functions as probability of failure and hold time and/or time to failure. This is especially true in view of the disclaimers made in Reference 1 considering the high uncertainty in the time to failure correlation and the cautions identified regarding its use. It is suggested that the PROFIT model be recalibrated making use of well-defined test reactor ramp data, then qualified by checking independent data sets, such as, for example, some of the EG&G Power Coolant Mismatch data[12,13] which include well-characterized power ramps and trajectories.

In Reference 2 in the section regarding corroboration of the COSH function in PROFIT, it was noted that a number of transient power increase simulations were analyzed with the GAPCON-THERMAL-3 fuel rod performance code. All the details of these analyses, including fuel design and operational parameters employed in the evaluations, should be presented so that verification calculations using other fuel rod performance models can be performed to assess the results shown in Figures 3.2, 3.3 and 3.5 of Reference 2. It is also requested that an independent verification of the GAPCON-THERMAL-3 analysis be performed with another transient code (such as FRAP-T4[14]).

As a result of feedback from the May 3 Portland meeting, another GE concern regarding the PROFIT model data base has been defined. It is not clear to GE, either from the Portland presentations or the information in Reference 2 how the GE-supplied data has been employed in the PROFIT development. It is recognized that much of the data resulting in the correlation is proprietary information from individual vendors, however, from the lack of detail presented in Reference 2, there is no assurance that the data has been interpreted correctly or is applicable. This lack of verifiable data base could in fact result in significant error in the ultimate PROFIT analytical functions. One means to provide a verification check in line with the 10CFR50 Appendix B Section III requirements is to involve the detailed review by each data supplier of his data set and how the data was employed. The data supplier would certify that his data meets the requirements of 10CFR50 Appendix B Section III for verification by means of test programs, and also identify limits of applicability. This would ensure the independent verification and applicability of the data by those most qualified (the data suppliers) and would lend some credibility to any model derived from these data. The imposition of a model whose qualification data is unavailable to GE for detailed applicability review is unacceptable to GE, especially when it is believed that some or all of the data used may not meet the verification requirements of 10CFR50 Appendix B Section III.

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REFERENCES

1. Denise, R. P. (USNRC) letter to Dr. G. G. Sherwood (GE) regarding PCI Program Status, August 2, 1979.

2. Pankaskie, P. J. and Wood, J. C., Draft Report on a Joint Program by Batelle Pacific Northwest Laboratories and Atomic Energy of Canada, Ltd., March 1979.

3. Johansson, E. B.., Potts, G. A. and Rand, R. A., GESTR - A Model for the Prediction of GE BWR Fuel Rod Thermal/Mechanical Performance, NEDE-23785-P, April 1978.

4. Stuart, I. F., letter to Victor Stello, Jr., General Electric Response to Nuclear Regulatory Commission Questions on Pellet Clad Interaction, December 12, 1975.

5. Ross, G. C. letter to Ross, D. F., Pellet Clad Interaction (PCI), April 1, 1976.

6. Engel, R. E. letter to Check, P. S., Response to Supplemental NRC Qustions on PCI, June 24, 1976.

7. Sherwood, G. G. letter to Victor Stello, Jr., Information Concerning Feedwater Nozzles and Pellet Clad Interaction, November 10, 1976.

8. Sherwood, G. G. letter to Ross, D. F., Fuel Damage Limits Meeting (GE Proprietary Session), June 27, 1977.

9. Sherwood, G. G. letter to Ross, D. F., General Electric BWR Fuel Damage Limits and Criteria Report, November 7, 1977.

10. Thomas, G. R., The Studsvik Inter Ramp Project An International Power Ramp Experimental Program, October 1978. An invited paper for presentation at the meeting on Ramping and Load-Following Behavior of Reactor Fuel, at Petten, Netherlands (November 30-December 1, 1978).

11. Meyer, R. O. Memorandum for A. Thadani, Reactor Fuels Response to GE Position on ATWS-Induced PCI Failure, August 9, 1979.

12. MacDonald, P. E., et. al., Response of Unirradiated and Irradiated PWR Fuel Rods Tested Under Power Cooling-Mismatch Conditions, TREE-NUREG-1196, January 1978.

13. Van Houten, R., Fuel Rod Failure as a Consequence of Departure from Nucleate Boiling or Dryout, NUREG-0562, June 1979.

14. Bohn, M. P., et. al., FRAP-T4 - A Computer Code for the Transient Analysis of Oxide Fuel Rods, CDAP-TR-78-027, July 1978.