Maine Yankee

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June 18, 1998
MN-98-045 GAZ-98-037

UNITED STATES NUCLEAR REGULATORY COMMISSION
Attention: Document Control Desk
Washington, DC 20555

Reference: (a) License No. DPR-36 (Docket No. 50-309)
(b) Letter: M. J. Meisner to USNRC; Request for Exemption From the Financial Protection Requirement Limits of 10CFR50.54(w) and 10CFR140.11; MN-98-01, dated January 20, 1998. See also, Letter: M.J. Meisner to USNRC; Defueled Emergency Plan and 10CFR50.54(q) - Exemption Request; MN-97-119, dated November 19, 1997.
(c) Letter: USNRC to M. J. Meisner; Request for Additional Information For Exemption From Financial Protection Requirement Limits (TAC Nos. MA0659 and MA0660; dated April 9, 1998
(d) Letter: M. J. Meisner to USNRC; Response to NRC Request of Additional Information For Exemption From Financial Protection Requirement Limits; MN-98-27, April 13, 1998

Subject: Response to NRC Request for Additional Information on Maine Yankee's Spent Fuel Heatup Analysis; (TAC Nos. MA0659 and MA0660)

Gentlemen:

In Reference (b), Maine Yankee submitted requests for exemptions from the Emergency Plan and Financial Protection requirement limits of 10CFR50.54 and 10CFR140.11. In Reference (d), Maine Yankee responded to an NRC request (Reference c) for additional information that the NRC believed was necessary to assist in reviewing the licensing requests. On June 9, 1998, Maine Yankee met with the NRC to discuss Maine Yankee's spent fuel heat-up analysis. In these discussions, Maine Yankee provided answers to specific NRC questions. The purpose of this letter is to document these answers.

The Maine Yankee answers are provided as a series of Attachments to this letter. Please note that Attachments A and B contain proprietary information and, therefore, Maine Yankee requests that this information be maintained proprietary and withheld from public disclosure. Attachment C contains the non-proprietary information requested as discussed with the NRC on June 9, 1998.

We believe that this response should provide sufficient information to complete the NRC review of the beyond design basis spent fuel heatup analysis, and understand that approvals for both the emergency planning and financial protection exemptions should be forthcoming in early July, 1998.

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APO1 1/1

The designated point of contact for this information is Mr. Robert P. Jordan; Manager, Analysis, (207- 882-5688). If you have any questions, please contact us.

Very truly yours,

for George A. Zinke
Director, Nuclear Safety & Regulatory Affairs

Attachments

c: Mr. H. J. Miller
Mr. M. K. Webb
Mr. M. Masnik
Mr. R. Bellamy
Mr. P. J. Dostie
Mr. U. Vanags

AFFIDAVIT PURSUANT TO 10CFR2.790

SCIENTECH, Inc.)
Generation Services Division)
State of New Mexico)
Bernalillo County) SS:

I, Robert J. Dallman, depose and say that I am the Technical Director of SCIENTECH, Inc., duly authorized to make this affidavit and have reviewed or caused to have reviewed the information which is identified as proprietary. I am submitting this affidavit in accordance with the provisions of 10CFR2.790 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is the response contained in the proprietary enclosure to Maine Yankee letter (MN-98-45), Maine Yankee Atomic Power Company to U.S. Nuclear Regulatory Commission.

Pursuant to the provisions of Paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure included in the referenced document should be withheld.

1. The material contained in this transmittal was obtained at considerable expense to SCIENTECH, Inc. and Maine Yankee Atomic Power Company and the release of which would seriously affect our competitive position.

2. The material contained in this transmittal is of the type customarily held in confidence and not customarily disclosed to the public.

3. This information is being transmitted to the Commission in confidence under the provisions of 10CFR2.790 with the understanding that it is to be received in confidence by the Commission.

4. This information is for Commission internal use only and should not be released to persons or organizations outside the Directorate of Regulation and the ACRS without prior approval of SCIENTECH, Inc. Should it become necessary to release this information to such persons as part of the review procedure, please contact SCIENTECH, Incorporated.

Further deponent sayeth not.

Sworn to before me this
17th day of June, 1998

OFFICIAL SEAL
STEPHEN LLOYD IRISH
NOTARY PUBLIC
STATE OF NEW MEXICO

Stephen Lloyd Irish

Notary Public
Stephen L. Irish, Notary Public
State of New Mexico
County of Bernalillo
My Commission Expires May 3, 1999

RJ Dallman

Robert J. Dallman
Technical Director

Attachment C

NRC Request

The information submitted by MY does not contain sufficient information about the adequacy of TRAC for the analysis. Provide information that demonstrates the models contained in TRAC (including heat transfer and wall drag correlations) are adequate for the geometry and conditions being analyzed. Include any information about code assessment applicable to the conditions MY is using the code for.

Maine Yankee Response:

The calculation of heat transfer is essentially dependent on the calculation of the heat transfer coefficient (h). Heat transfer coefficients for air under natural circulation conditions range from 1.0 to 10.0 BTU/(hr•°F•ft^2) (Reference 1). Section 4.2.1.5 of Reference 2 describes the convective heat transfer to a single-phase vapor with the necessary correlations. Specifically, Section 4.2.1.5.7 of Reference 2 states that '*All of the correlations used in heat-transfer regime 6 (single-phase vapor) are well known and have been applied to a wide variety of fluids and geometries.*' In our TRAC calculations, the code-calculated values for heat transfer coefficient vary from 0.6 to 1.0 BTU/(hr•°F•ft^2). Given q = h • A • ΔT, a lower heat transfer coefficient results in a larger ΔT (higher $T_{surface}$). Therefore, the low values of h calculated by TRAC are considered conservative.

As an example, using 100 °F inlet air, and performing a simple heat balance, results in the following:
- Heat transfer coefficient = 1 BTU/(hr•F•ft^2) (low value from Reference 1)
- Height of rod = 11.39 ft
- Circumference of rod = 0.11519 ft
- Total area of rod = 1.312 ft^2
- Total area of all rods = 220.44 ft^2
- Heat = 2500 kW = 8530 BTU/hr
- ΔT = q / (h • A) = 8530 / (1 • 220.44) = 39 °F

So, the resulting average surface temperature = 100 °F + 39 °F = 139 °F

Compare this to the TRAC calculated average surface temperature of 278 °F. TRAC calculated a value which is 139 °F higher than the simple hand calculation. TRAC used a lower heat transfer coefficient, thus resulting in a larger ΔT. Since TRAC used a different h at each node, a single composite heat transfer coefficient was not available. The hand calculation used the low (conservative) value from Reference 1 and resulted in a lower calculated temperature. This comparison indicates that TRAC is conservative.

Another correlation used in the tRAC analysis is the wall drag correlation. The Maine Yankee application has very low single phase flows (~2 ft/sec) with air as the working fluid, so the pressure drop across the fuel assembly is negligible. For the case with 100 °F inlet air, the ΔP across the fuel assembly was calculated by TRAC to be 0.0057 psid. This is so small, that it would not be measured accurately. The wall friction will contributes to the total ΔP, but the contribution will be insignificant. Assessment of an instance where the wall surface roughness was 100 times the original value did not make a noticeable difference in these conclusions.

ATTACHMENT C (continued)

The TRAC code has been assessed for a wide range of conditions for single phase and two-phase flow conditions. Because situations in the analysis of nuclear reactors occur where the effects of noncondensable gas must be considered, TRAC does have the capability to model a single noncondensable gas field (Ref. 2). For the Maine Yankee analysis, the model involves a fuel assembly being cooled by natural convection of air. A review of the TRAC developmental assessment manual (Ref. 3) and the description of the test problems in the TRAC standard test matrix document (Ref. 4) yield three assessment cases that are applicable to the Maine Yankee analysis.

The first assessment involves the interaction of air-water mixtures to assess the code for countercurrent flow limitations (Section 4.1 of Ref. 3). This will test the code's ability to correctly model the interfacial heat and mass transfer where the effects of noncondensables are important. The assessment shows that the TRAC results are in very good agreement with the experimental data. Thus, TRAC is adequate to analyze situations of air (or noncondensable gas) water mixtures.

A second code assessment case (TFPIPE2) was performed where there is a comparison of heat lost to air through convection. While this problem is not exactly the same as the Maine Yankee application, it demonstrates that the concept of convective heat transfer to an air medium has been examined.

The final applicable assessment demonstrates the effectiveness of TRAC to model a single fuel assembly. The assessment case involves a reflood test using the Lehigh University rod bundle test facility (Section 4.4 of Ref. 3). The test section consisted of a heat shroud containing a 3x3 rod bundle assembly. Thus, the basic geometry of the test problem is directly applicable to the Maine Yankee analysis. For this case, the TRAC nodalization of the vertical heated section is the same. The assessment case and the Maine Yankee analysis both use eleven vertical volumes and one heat structure to model the heated rods/fuel pins. Therefore the model used in the Maine Yankee analysis is proper and consistent with current user practices.

In summation, while TRAC has not been directly assessed for the simplified case of spent fuel assembly cooling by natural convection of air, the sited assessment cases show that TRAC has been adequately assessed for the phenomena and geometry of concern. These areas of concern of importance to the Maine Yankee analysis includes geometric model (single fuel assembly) and heat transfer conditions (air-water mixtures, natural convection of air).

The Maine Yankee application is a very simple problem since it contains only an ideal gas (single phase flow). The ability to solve the mass, energy, and momentum equations is dependent on knowing the correct properties of the fluid in question. Since the fluid is air, the properties are well established and known. Additionally, TRAC has been demonstrated to correctly solve the governing equations. Section 9 of the TRAC theory manual (Reference 2) discusses the calculation of the properties of air. Figure 9-16 shows that the TRAC calculated density of air matches almost exactly with experiential data. Figure 9-31 shows that the TRAC calculated thermal conductivity of air matches extremely well to experimental data. Other properties are also in good agreement with experimental data.

For a listing of references, please see the following response.

ATTACHMENT C (continued)

NRC Request:

The information submitted by MY does not contain sufficient information about the adequacy of the modeling approach used in the analysis. Provide information showing that the additive form loss coefficients used in the analysis are appropriate for the geometry and flow conditions present in the analysis. Also provide information showing the single hot channel modeling results are conservative compared to an approach that would include parallel flow paths through lower powered bundles.

Maine Yankee Response:

The K factor (form loss) is determined by the geometry of the problem, and not the flow conditions. In a fuel bundle, there are spacer grids which have associated losses. During natural circulation flow, the fluid (whether it is air or water) passes through numerous spacer grids. These spacer grids have a contraction (from the bundles full flow area to the spacer flow area), followed by an expansion (from spacer flow area to full channel flow area). If the spacer area were identical to the full bundle flow area, the K factors would be zero. As the spacer area is decreased, the K factor for the contraction approaches 0.5, and the K factor for the expansion approaches 1.0. The larger K factor results in slowing down the flow through the fuel bundle, which keeps more heat in the rods. Therefore, a conservative value of K = 1.5 was used at each of the ten TRAC cell interfaces. This results in a total K=15 for the fuel assembly. This value is larger than typically used in other analyses of PWR fuel assemblies.

The traditional approach to modeling loss of water in spent fuel pools is embodied in the approach modeled by the SFUEL code (Ref. 5). That approach arranges fuel assemblies typically into 6 groups according to their decay heat values and location in the pool. SFUEL results show that the group with the highest decay heat (all other parameters being similar) will have the highest peak clad temperature. In the SFUEL modeling, approximately 19% of the fuel assemblies would be grouped into the highest decay heat group. Thus, the decay heats of those assemblies would be averaged. That causes the average decay heat to be less than the highest value. The approach used in the Maine Yankee analysis modeled a single assembly with the highest decay heat of all the assemblies. This ensures that the actual peak clad temperature is calculated and is conservative compared to a grouping approach.

Modeling of the entire pool is important if the spacing and storage of fuel racks causes restrictions in the flow of air to the bottom of the assemblies. This is not an issue with the Maine Yankee pool. There are large flow areas adjacent to the fuel racks, that allow the unrestricted down flow of air to the bottom of the assemblies. Since the flow losses through the assemblies were modeled conservatively (see answer to RAI #3), the use of a single (high decay heat) assembly is conservative for this application.

REFERENCES:

1. Welty, J.R., C.E. Wicks, and R.E. Wilson, "*Fundamentals of Momentum, Heat, and Mass Transfer*", Second Edition, John Wiley & Sons, New York, pg. 232, 1976.
2. Spore, J.W. et al,"*TRAC-PF1/MOD2 Volume 1: Theory Manual*," NUREG/CR-5673, July, 1993.
3. Lin, J.C., V. Martinez, and J.W. Spore, "*TRAC-PF1/MOD2 Developmental Assessment Manual*," Draft, TRAC DAM-Ver. 5.4, August 20, 1993.
4. Steinke,R.G.,"*A Description of the Test Problems in the TRAC-P Standard Test Matrix*," LANL, May 1996.
5. Benjamin, A.S. et al., "*SPENT FUEL HEATUP FOLLOWING LOSS OF WATER DURING STORAGE*", NUREG/CR-0649, March 1979

ATTACHMENT C (continued)

NRC Request:

> TRAC and other NRC computer codes are not developed and maintained under an Appendix B QA program. Computer codes used by the industry in regulatory analyses must meet Appendix B QA standards. This means that someone has to verify that the models are correctly coded in TRAC and that code assessment must be performed to show that the code is adequate for the analysis. Please certify that the version of TRAC used in the analysis meets Appendix B QA standards.

Maine Yankee Response:

> The application of the TRAC code to the zirconium heatup transient does not fall under 10 CFR 50 Appendix B requirements. Unlike the historical generation of safety analyses such as a LOCA, the assessment of a beyond design basis event is not mentioned in the regulations, nor has the NRC established any regulatory guidance for conducting such an analysis.
>
> Nonetheless, TRAC is an industry standard code endorsed by the NRC for other more grueling and extensive applications. The Maine Yankee analysis was conducted by qualified individuals with extensive experience in TRAC applications and transient analysis. The level of quality in the code applications and engineering judgement is appropriate to a beyond design basis event and is similar to that used in a Probabilistic Risk Assessment application.

ATTACHMENT C (continued)

NRC Request:

Provide a discussion of the available margin determined by the analysis and an estimate of the calculation uncertainties.

Maine Yankee Response:

The Maine Yankee analysis of spent fuel assembly response to the instantaneous draining of the Spent Fuel Pool (SFP) is a realistically based analysis. The intent of the analysis is to determine the cooling period required to ensure that the cladding temperature of a spent fuel assembly would not exceed 565°C, if the SFP were instantaneously drained, exposing the assembly to an air environment.

In the context of this analysis, a number of simplifying conservatisms have been incorporated in the analysis. A summary of these conservatisms is as follows:

Conservatism	Impact
Maximum allowable clad temperature of 565 °C before cladding rupture due to heat addition by zirconium oxidation.	Significant. Zirconium oxidation adds less than 1% of the heat generated in the fuel rod at temperatures <760C. The margin associated with this conservatism is represented by almost 200C to the NRC limit.
Air temperature at inlet of assembly is variable, ranging from 100F to 200 °F.	Significant. Building air temperatures, through a supporting analysis, are expected to be <140F. The degree of conservative margin represented by this parameter is 235C to the NRC limit.
Storage cell periphery is modeled as an adiabatic boundary.	Significant. The lack of allowed heat transfer through the cell wall to cooler cells is not physically representational.
Evaluated response of "worst case" assembly, i.e. assembly with highest burnup and highest initial enrichment and shortest decay period.	Significant. This assembly is the worst assembly of the 1434 spent fuel assemblies in the spent fuel pool. Assemblies of this design type and decay heat represent less than 5% of the pool inventory.
Limiting power distribution applied to "worst case" assembly..	Moderate. The "worst case" assembly did not actually experience the limiting power distribution
Used test data that maximized heat SFP losses in order to maximize calculated SFP decay heat load.	Moderate.
Heat capacity of all items in the SFP are assigned the heat capacity of water in order to maximize calculated SFP decay heat load.	Small.

ATTACHMENT C (continued)

The Maine Yankee analysis of spent fuel assembly response to the instantaneous draining of the Spent Fuel Pool (SFP) is a reasonable approach to the characterization of the zirconium heatup transient. The incorporated conservatisms assure that the results, although realistically modeled, contain a significant degree of margin to any realistic or NRC specified limit as would be associated with the beyond design basis accident of this nature.