NS-NRC-89-3466

**Westinghouse Electric Corporation** **Energy Systems**

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October 23, 1989

Mr. Robert C. Jones, Chief
Reactor Systems Branch
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Attention: Document Control Desk

Subject: Use of 2700°F PCT Acceptance Limit in Non-LOCA Accidents

Dear Mr. Jones:

During the staff's review of several licensee submittals for license amendments, the NRC has questioned the Westinghouse use of 2700°F as an acceptance limit for peak clad temperature (PCT) in non-LOCA accidents, primarily the locked rotor and rod ejection events. The purpose of this letter is to re-state the bases and use of this value. Specifically, 2700°F PCT has been used in these events to demonstrate that a coolable geometry is maintained in the core. It is not currently being used as a criterion by which to evaluate fuel failure (e.g. in lieu of a DNB mechanism). Although this latter approach is defined in WCAP-11157 "Integrity of Fuel Rods During a Locked Rotor/Shaft Break Accident", this WCAP has not received NRC's approval and consequently, Westinghouse has not used it as the basis for satisfying NRC criteria for fuel failure in supporting utility submittals.

The attachment contains a detailed summary of the technical and licensing bases for the use of 2700°F PCT as an acceptance criterion for coolability in non-LOCA events as analyzed using Westinghouse methods which have been approved by the NRC.

Sincerely,

WESTINGHOUSE ELECTRIC CORPORATION

W. J. Johnson, Manager
Nuclear Safety

Attachment

0212N:WJJ-10/23/89

# WESTINGHOUSE 2700°F CLAD TEMPERATURE LIMIT FOR NON-LOCA ACCIDENTS

## I. Introduction and Purpose

A maximum clad temperature limit of 2700°F has been used by Westinghouse as one of the acceptance criteria for the RCCA Ejection and Locked Rotor accidents since the late 1960's and early 1970's. This limit is listed in the accident analysis section for these accidents in the FSAR and in other licensing documentation, which has been submitted to the NRC on virtually every Westinghouse plant. The purpose of this limit is to ensure that a coolable geometry is maintained for these short-duration (short time in DNB) non-LOCA transients. It is not used to demonstrate compliance with fuel failure limits, or for the purpose of dose evaluations. Although a lower clad temperature limit has been established for the LOCA accident, the NRC has not established any required clad temperature or oxidation limit for non-LOCA accidents. The purpose of this report is to describe the technical basis and licensing background for the non-LOCA clad temperature limit as used on Westinghouse plants or Westinghouse- performed safety analysis.

## II. Technical Basis

The clad temperature limit, along with some other accident-specific limits for the RCCA Ejection accident, were presented and discussed in WCAP-7588, Revision 1-A (Ref. 1). This WCAP received NRC review and approval on August 28, 1973 (Ref. 2). The limits presented in the WCAP were chosen by Westinghouse prior to the issuance of NRC Regulatory Guide 1.77 (Ref. 3), which contains the specific NRC limits for the accident. The limits were chosen by Westinghouse to ensure compliance with the requirement to demonstrate a coolable geometry following an accident event which results in fuel rods entering DNB. Due to the limited data available at the time (1969-1971), the limits were conservatively set at values which approximated the fuel failure threshold. These limits were chosen as a calculational convenience, and do not represent the actual safety boundary for core coolability for either the RCCA Ejection or Locked Rotor accidents.

The maximum limit on clad temperature of 2700°F was selected on the basis that, considering the short time in DNB for the RCCA Ejection or Locked Rotor accidents, the peak clad temperature and total metal-water reaction at the hot spot will be within the experimental no-failure boundary (2700°F and 17% metal-water reaction) presented to the NRC in Reference 4. Since that time, much additional experimental data has become available. A summary of this data (Ref. 5) shows that depending on the time at temperature, the fuel rod cladding will not become embrittled and fail upon quenching, even for accident temperatures higher than 2700°F. However, as stated above, the concern being addressed

by Westinghouse is continued core coolability, not fuel failure. Westinghouse continues to use the number of fuel rods in DNB to determine fuel failures for dose release calculations as currently required by the NRC for both the Locked Rotor and RCCA Ejection accidents. The use of the 2700°F limit as an indication of continued core coolability therefore remains a conservative criterion for the short-duration Locked Rotor and RCCA Ejection accidents.

## III. Licensing Background

In addition to appearing in plant-specific licensing documents which have received NRC review on nearly every Westinghouse plant, the clad temperature limit has been specifically reviewed and approved by the NRC in several generic documents. For example, the clad temperature limit is one of four limiting criteria specifically stated by Westinghouse as used for the RCCA Ejection accident in WCAP-7588, Revision 1-A (Ref. 1). In the NRC's August 28, 1973 SER for this document (Ref. 2), the NRC (AEC) stated:

> "Although this is several hundred degrees above the maximum clad temperature limitation imposed in the AEC ECCS Interim Acceptance Criteria, this is felt to be adequate in view of the relatively short time at temperature and the highly localized effect of a reactivity transient."

Similarly, in the NRC's May 22, 1981 SER on WCAP-9500 for the Optimized Fuel Assembly (Ref. 6), the NRC stated that with respect to the application of the Westinghouse clad temperature limit to undercooling events such as the Locked Rotor accident:

> "We, therefore, conclude that there is reasonable assurance that the 2700°F PCT limit for short-term events such as locked rotor is an acceptable coolability limit for the Westinghouse OFA design."

Relative to the RCCA Ejection accident, the NRC stated in the same SER that:

> "These limits are more conservative than the single 280 cal/g limit given in Regulatory Guide 1.77, and they have been previously approved in the review of WCAP-7588, and they remain acceptable."

## IV. Conclusions and Recommendations

As discussed above, the 2700°F clad temperature limit for the RCCA Ejection and Locked Rotor accidents was chosen by Westinghouse to ensure compliance with the requirement that the fuel maintain a coolable geometry following the occurance of DNB in these events. The limit was conservatively chosen to be below the approximate

failure threshold of the cladding due to embrittlement, based on experimental data. The limit has received NRC review and approval as a conservative representation of core coolability for the Locked Rotor accident, and, in conjunction with other criteria, as a conservative limit for the analysis of the RCCA Ejection accident. This limit is not believed to represent the actual core coolability limit for these accidents, and therefore can be replaced with other, less restrictive criteria if such criteria are available.

In view of the discussion above, Westinghouse intends to take the following approach with this criterion:

A. For the RCCA Ejection accident, following publication of the Regulatory Guide for this accident, it is recognized by the NRC that a cal/g limit is sufficient to ensure continued core coolability (Ref. 3). The NRC states in this document that:

> "Therefore, a calculated radial average energy density of 280 cal/g at any axial fuel location in any fuel rod as a result of a postulated rod ejection accident provides a conservative maximum limit to ensure that core damage will be minimal and that both short-term and long-term core cooling capability will not be impaired."

Although the NRC allows a fuel rod enthalpy criterion of up to 280 cal/g, Westinghouse will continue to use a more conservative peak fuel enthalpy criterion of 200 cal/g. This limit will be applied to irradiated fuel, and also used to conservatively bound unirradiated fuel. The Westinghouse criterion on the clad temperature limit will be eliminated for this accident. The limit on percent fuel melt will be retained even though it is not required by the NRC since it is used as one of the inputs to the dose release evaluation. The revised Westinghouse RCCA Ejection criteria used to ensure long term core coolability and compliance with applicable radiological release standards now become:

1. The average fuel pellet enthalpy at the hot spot shall be below 200 cal/g (360 BTU/lbm) for irradiated or unirradiated fuel.
2. Fuel melting will be limited to less than the innermost 10 percent of the fuel pellet at the hot spot, even if the average fuel pellet enthalpy at the hot spot is below the limits of Criterion 1.
3. The peak reactor coolant pressure shall be less than that which would cause stresses to exceed the faulted condition stress limits.

B. In the case of the Locked Rotor accident, the NRC has not established any specific clad temperature limit or oxidation criterion for this event. As discussed above however, the NRC has accepted the Westinghouse clad temperature limit as an acceptable coolability limit for the Locked Rotor accident (Ref. 6). Therefore, Westinghouse will continue to use this criterion rather than proposing an alternative criterion. This criterion may be replaced by an appropriate cladding embrittlement limit at a later date.

## REFERENCES


1. D. H. Risher, "An Evaluation of the Rod Ejection Accident in Westinghouse Pressurized Water Reactors Using Spatial Kinetics Methods", WCAP-7588 Revision 1-A, January, 1975. (Original issue, December, 1971).

2. NRC SER "Evaluation of WCAP-7588, Revision 1", letter from Mr. D. B. Vassallo, NRC, to Mr. Romano Salvatori, Westinghouse Nuclear Safety Department, dated August 28, 1973.

3. NRC Regulatory Guide 1.77, "Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors," May, 1974.

4. Appendix E of the March 23, 1972 Testimony of Westinghouse Electric Corporation, in the matter of the Interim Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Nuclear Power Reactors (Docket No. RM50-1).

5. R. Van Houten, "Fuel Rod Failure As a Consequence of Departure from Nucleate Boiling or Dryout", NUREG-0562, 1979.

6. NRC SER "Safety Evaluation of the Westinghouse Electric Corporation Topical Report WCAP-9500, Reference Core Report 17x17 Optimized Fuel Assembly", letter from Mr. R. L. Tedesco, NRC Division of Licensing, to Mr. T. M. Anderson, Westinghouse Nuclear Safety Department, dated May 22, 1981.