Supplemental Safety Evaluation

For The

General Electric Topical Report

Qualification Of The One-Dimensional

Core Transient Model For

Boiling Water Reactors

NEDO-24154 and NEDE-24154P

Volumes I, II and III

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The Safety Evaluation Report on the ODYN code (Reference 2) is primarily an evaluation of the calculational model with little discussion of implementation requirements. Reference 3 provides the information required to bridge the gap between evaluation and implementation. Specifically, there are eight items covered in Reference 3; these are:

1. ODYN Option B statistical adjustment factors,
2. Control rod drive scram insertion time conformance procedure for plants licensed under ODYN Option B,
3. Uncertainty in ODYN pressure calculations,
4. ODYN model temperature limits,
5. Uncertainty in subcooled boiling model,
6. Description of electronic hydraulic control model,
7. Listing of ODYN input variables,
8. Comparison of minimum critical power ratio operating limits established by REDY and ODYN.

Each of these items is discussed below.

Item 1. Statistical Adjustment Factors

Page III-6 of Reference 2 allows two statistical approaches; one is a plant-specific statistical analysis and the other is a generic analysis for plant groups (e.g. BWR/2, 3, 4, 5, 6) and transients. The second approach involves the establishment of generic ΔCPR/ICPR adjustment factors for groupings of similar-type plants which can be applied to plant-specific ΔCPR/ICPR calculation from the ODYN licensing topical report (LTR) deterministic approach. Reference 3 provides the statistical adjustment factors for the three transients which are normally limiting transients (load rejection or turbine trip without

At the completion of each surveillance test performed in compliance with the technical specification surveillance requirements, the average value of all surveillance data at the 20% insertion position generated in the cycle to date is to be tested at the 5% significance level against the distribution assumed in the ODYN analyses. The surveillance information which each plant using this procedure will have to retain throughout the fuel cycle is the number of active control rods measured for each surveillance test (the first test is at the BOC and is denoted N_1; the ith test is denoted N_i) and the average scram time to the 20% insertion position for the active rods measured in test i (τ_i). The equation used to calculate the overall average of all the scram data generated to date in the cycle is:

$$\tau_{ave} = \frac{\sum_{i=1}^{n} N_i \tau_i}{\sum_{i=1}^{n} N_i} \qquad (2\text{-}1)$$

where

n = number of surveillance tests performed to date in the cycle;

$\sum_{i=1}^{n} N_i$ = total number of active rods measured to date in the cycle; and

$\sum_{i=1}^{n} N_i \tau_i$ = sum of the scram times to the 20% insertion position of all active rods measured to date in the cycle to comply with the Technical Specification surveillance requirements.

Note that Equation 2-3, which establishes the maximum allowable scram insertion time for operation under Option B, may also be expressed in the following manner:

$$\tau_B = \mu + A\sigma \qquad (2\text{-}5)$$

where

$$A = 1.65 \left(\frac{N_1}{\sum_{i=1}^{n} N_i} \right)^{1/2} \qquad (2\text{-}6)$$

The relationship between the coefficient, A, and the amount of surveillance data generated during the cycle is illustrated in Figure 2-1. As more data become available through the performance of in-cycle surveillance tests, the coefficient decreases, as does the acceptance criterion, τ_B. Thus, the scram speed criterion is being tightened as the cycle progresses, based on the assumption that, as more scram data become available during the cycle, the uncertainty in the mean value calculation should decrease.

We find the scram insertion time conformance procedure to be acceptable.

Item 3. Uncertainty in ODYN Pressure Calculations

Page III-7 of Reference 2 states that if GE can demonstrate that the uncertainty in calculated pressure is small (e.g. by a factor of 10 or more) relative to the bias in determining ASME vessel overpressure limit, no addition of uncertainty to the calculation's of pressure is needed. A sensitivity study varying ODYN input parameters over the range of Table 1 of Reference 2 shows the RMS uncertainty in the peak vessel pressure to be 11 psi. GE estimates the bias in the ASME code to account for the material uncertainty to be approximately 310 psi. Therefore, there is no need to account for pressure uncertainty in

Item 6. Description of Electronic Hydraulic Control Model

An early draft of Reference 2 stated "Wherein electronic hydraulic controls are used in the design, the model used in selection of initial control setting shall be submitted for staff review." This statement was made because Reference 1 provided information only for the mechanical hydraulic control. GE claims that there is no functional difference between the two types of control. However, they provided a description of the model in Reference 3. We agree with the GE claim that there is no functional difference between the two types of control.

Item 7. Listing of ODYN Input Variables

Page III-10 of Reference 2 states "Listing of important input variables such as listed in Table IV and initial plant parameters including but not limited to control system characteristics as depicted in Figures 4-13 through 4-16 of NEDO-24154, vol. 1, but with numerical values provided should be provided with each submittal. The initial control system characteristics, including the model used in the selection of initial settings, shall be defined and substantiated in terms of the design basis for each control system of the plant." Item 7 of Reference 3 lists typical values of these initial parameters which may be included by reference into individual plant submittals provided the values are appropriate to the individual submittals.

Item 8. Comparison of MCPR Operating Limits Established by REDY and ODYN

The Staff requested GE to provide a comparison of CPR operating limits based on REDY and ODYN prediction. The purpose of such a comparison was to

The events for which ODYN has been qualified and approved are listed in Reference 1, Volume 3, and include the following: (1) feedwater controller failure-maximum demand; (2) pressure regulator failure-closed direction; (3) generator load rejection with and without bypass operation; (4) main steamline isolation valve closure (trip scram and flux scram); (5) loss of condenser vacuum; (6) turbine trip with and without bypass; and (7) loss of auxiliary power - all grid connections. GE proposes that only the following three events be reported for reload submittals or safety analysis report revisions: generator load rejection/turbine trip without bypass (whichever is limiting), feedwater controller failure-maximum demand, and main steamline isolation valve closure-flux scram (to satisfy ASME code pressure requirements). These are the same pressurization events presently included in reload submittals, and reflect the consistency in the ODYN and REDY results. The events not included in the submittal are much less severe, for the reasons discussed below.

1) Turbine/Generator Trips With Bypass

These events are considerably less severe than the transients in which the bypass system is assumed to fail. Typical turbine bypass capacities range from 25-40% of rated steamflow. This bypass capacity results in a considerably milder thermal and overpressurization event.

2) Pressure Regulator Failure - Closed Direction

The standard event evaluated in SAR analysis is one in which the controlling pressure regulator is assumed to fail in the closed direction. Under these failure conditions, the backup regulator takes over control of the turbine admission valves, preventing any serious transient. The disturbance is mild and similar to a pressure set point change with no significant reductions of fuel thermal margins occurring. As shown in the SARs, this event is considerably less severe than the generator and turbine trips without bypass.

The staff agrees with the GE assessment of the relative severity of the transients listed. Therefore, the following events should be reanalyzed with ODYN for plants which have analyses of record using REDY:

1) generator load rejection/turbine trip without bypass
2) feedwater controller failure maximum demand
3) main steam line isolation valve closure-flux scram.

If for a particular plant another event should be more limiting than those just listed, then the other event should also be reanalyzed with ODYN. For the new plants with transient analyses supplied by GE, all of the events listed in Table 3 of Reference 1 should be analyzed with ODYN.

Table 1

SUMMARY OF GENERIC STATISTICAL ADJUSTMENT FACTORS (ΔCPR/ICPR)

Plant Groupings	LR/TTWOBP*	FWCF	PRDF
BWR 2/3 - EOC	+0.006	-0.016	—
BWR 4/5 w/o RPT - EOC	-0.039	-0.009	—
BWR 4/5 w/o RPT - MOC	-0.111	-0.009	—
BWR 4/5 w/RPT - EOC	-0.024	+0.016	—
BWR 4/5 w/RPT - MOC	-0.001	+0.026	—
BWR 6 - EOC	-0.021	+0.003	+0.017

*With the exception of FWCF or PRDF events, this set of adjustment factors will be applied to all pressurization events analyzed with the ODYN code to establish the CPR operating limit, since they typically involve generator or turbine trips.

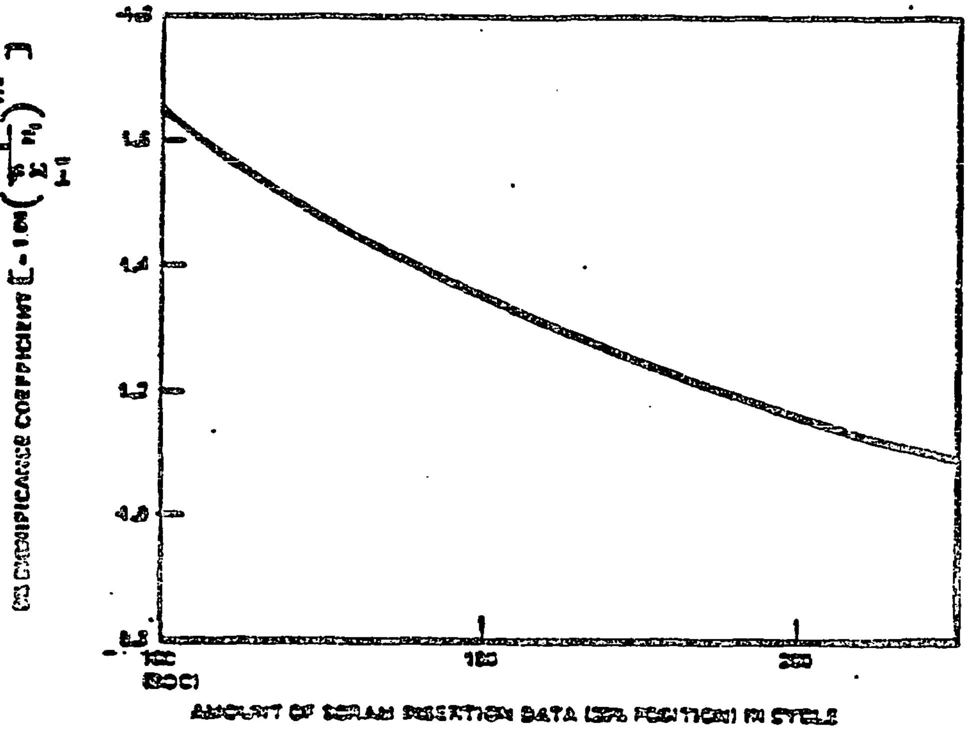

Figure 2-1. 5% Significance Coefficient (A) vs. Surveillance Data in Cycle

adjustment factor (AF) to the ratio of the calculated values of ΔCPR and ICPR $(\Delta CPR/ICPR)_c$:

$$\left(\frac{\Delta CPR}{ICPR}\right)_{new} = \left(\frac{\Delta CPR}{ICPR}\right)_c + AF$$

This equation can be simplified to:

$$ICPR_{new} = \frac{SL}{1 - \left[\left(\frac{\Delta CPR}{ICPR}\right)_c + AF\right]}$$

Where SL = Safety Limit MCPR

It should be noted that in both the Option A and Option B cases, the ICPR is defined as Safety Limit plus ΔCPR for the event being analyzed.

If you have any additional questions or comments, please contact me or H. C. Pfefferlen on (408) 925-3392 of my staff.

Very truly yours,

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