BWROG ECCS Suction Strainers SAFER LTR Blockage Presentation

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Topics

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NEDC-33608-P Development / Inputs

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Introduction and Background to NEDC-33608P

Objective to define a limiting LOCA scenario to serve as acceptable basis for fuel blockage tests whereby results can be applied to different plants, fuels and debris to confirm compliance.

The proposed approach was for a generic compliance of similar nature as current Long Term Cooling, whereby a set of requirements are defined that assures acceptable LTC (e.g. NEDE-20566P Section III.a.5).

Four separate LOCA phases were identified, Refill, Reflood, Natural Circulation and LTC, to demonstrate acceptable cooling performance compared against reference (w/o debris) LOCA analyses.

NEDC-33608P Development / Inputs

BWR Fleet Basis / Characteristics

Worst case maximizes stored energy and decay heat combined with blockage, therefore reference case applies a BWR with **DELETE**, thus maximizing the effect on PCT for given blockage. All other cases, **DELETE**, Steamline, Feedwater, ECCS pipe breaks lead to more conservative blockage functions to achieve similar PCT.

Test specification covers flow and driving pressure encompassing the BWR fleet for each of four LOCA phases to determine blockage (DP) characteristics, breaks and system combinations.

GE 14 Selection / Fuel Design

Reference LOCA analysis not significantly affected by fuel type, GE14 and GNF2 (current fuels) have similar cooling characteristics and power performance. Selection of GE14 based on **DELETE** considerations, NRC reviewer not convinced that geometrical differences would translate in greater collection of debris. BWROG agreed to consider testing more fuels after initial testing of reference fuel if application to different geometries not successful.

SAFER Analysis

Hot Channel Blockage Ratio

Concept is that blockage history is directly proportional to flow and debris concentration, up to a maximum value. Maximum inlet and outlet blockages derived that are set such as to yield non-limiting PCT compared against typical short term PCT (prior to first level recovery).

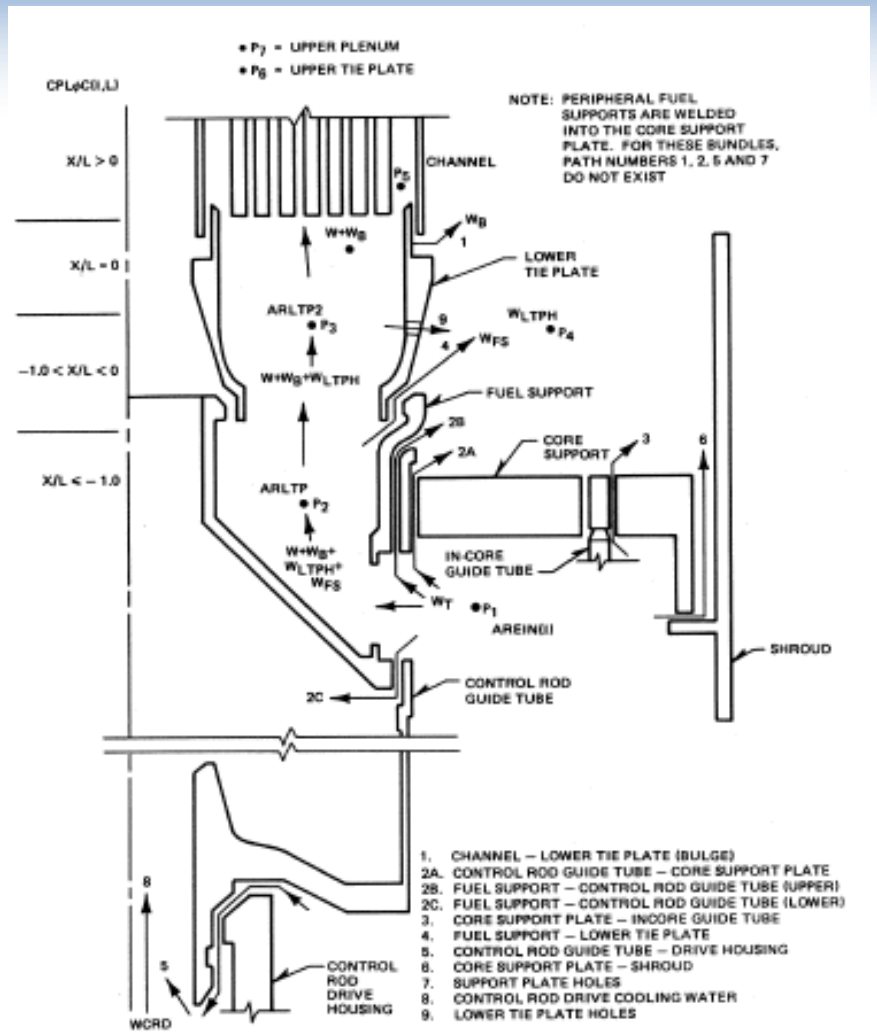
The inlet blockage used is 100% because of the debris filter designs. If inlet blockage does not reduce flow to less than **DELETE** then adequate cooling is assured and flow will remain upwards until level collapses from low decay heat.

The outlet blockage used is a compromise between maximum blockage degree and timing. Higher blockage possible with lower decay heat to produce same results as lower blockage with higher decay heat.

Realistically all fuel channels will block inlet (provided sufficient debris present), however, minimum flow in hot bundle calculated when only hot bundle is blocked, because of lower DP, upper plenum condition highly dependent on plant type. The TRACG studies were used to derive the blockage history, however the timing was adjusted to produce the target non-limiting PCT. Same concept applied in SAFER with different timing for outlet blockage history.

SAFER Analysis (continued)

Hot Channel Figure



SAFER Analysis (continued)

Hot Channel Blockage Timing

Inlet selected at minimum acceptable of **DELETE** after injection (conservative as little flow until Reflood and Natural Circulation), Outlet selected at **DELETE** after flow reversal. Refill and Reflood, **DELETE**. Set maximum blockage at selected time for a target PCT **DELETE .** Debris and Plant configuration will determine concentrations and flows, testing determines blockage.

Number of Assemblies Affected

Discussed above blockage a function of flow, so hot channels inlet block first then average channels and low power peripheral channels last. The full core blockage proved to lead to a higher PCT in SAFER. However, this unexpected result is the conservative treatment by SAFER on the **DELETE**. Also, if all channels are assumed to block, the in-shroud region becomes a bucket where level is maintained high.

SAFER Analysis (continued)

Long-Term Cooling

LTC can be defined several ways, as early as core is quenched, or after 10 minutes when operators manually control ECCS (pool cooling), or as late as two phase level collapse and uncover top third of core. For the LTR, LTC steady state is achieved once core is quenched, level may be above core region as two phase mixture or below the fuel under core spray cooling. Both of these LTC conditions lead to a quenched core, same as the no debris condition but later in time.

Several variables influence the behavior of secondary PCT increases. The difference in these phenomena are **DELETE**

SAFER Analysis (continued)

Nominal SAFER Model

The SAFER LTR allows the complete break analysis to be based on nominal assumptions, **DELETE**. Any break/failure condition that is potentially limiting is evaluated under Appendix K bases and with model and plant input uncertainties (upper bound) to show compliance.

The SAFER blockage studies are based on nominal analysis basis since they do not represent a limiting condition.

Indeed features in the reference plant model are not bounding to all BWRs, however, the total behavior of the selected plant is such that it yields the limiting PCT with the reference blockage basis, this was confirmed by the sensitivity cases of other BWRs.

SAFER Analysis (continued)

Test Acceptance Criteria

The LTR's objective is that the consequences of blockage be approved as meeting all licensing criteria. It is not expected that the test results will conform exactly as assumed in the analysis, but rather that a test report will evaluate the test results and relate them to the reference LOCA analysis. Also, individual plants would provide a basis that their individual characteristics do meet both analysis and test inputs/assumptions.

Depending on the test results, the evaluation may take several paths, could be as simple as demonstrating that blockage is less limiting than assumed in analysis, or as complex as separating various plant and debris characteristics in more detailed LOCA analyses.

Untested fuel types would require evaluation based on existing test results or additional testing.

The blockage will be derived based on the test DP data and that used in the confirmation calculations.

SAFER Analysis

Summary

Objective of LTR is to define a limiting condition that yields acceptable (non-limiting) PCT results

Test results evaluated to demonstrate conformance

LOCA evaluation can be refined depending on test results and margins.